Preventive Maintenance Using Recycled Asphalt: Review

Aishah H. O. Al Shehhi, Gul Ahmed Jokhio, and Abid Abu-Tair

Abstract The article addresses the importance of using recycled asphalt with the integration of road maintenance procedures in the road network. The road network is considered the main element of any national infrastructure development plan. The research aims to study and highlight the using recycled asphalt as a suggested sustainable method for road maintenance procedures. Therefore, the study elaborates on the historical use of recycled asphalt, its advantages, and disadvantages. Besides that, maintenance process categories to ensure the suitable type that helps provide the best quality of the network. Since roadway pavement assessment is based on quality as well as different characteristics parameters such as rutting, cracking, pavement quality Index, and roughness in addition to other parameters. The primary method used in this study is the review of existing literature. It can be concluded that the use of recycled asphalt in road maintenance can become a viable and sustainable alternative to current road maintenance practices.

Keywords Recycled asphalt · Roadway maintenance · Pavement Parameter · Condition Index

1 Introduction

Roadways are one of the significant important elements in infrastructure because they are characterized simply as the point of interaction between societies and peoples. the country needs to create roadways so that citizens and visitors may travel easily and smoothly. Additionally, roadways and highways have been the main source by which whole economies and societies have emerged and developed over the years. They

A. H. O. Al Shehhi (✉)
The British University in Dubai, Dubai, United Arab Emirates
e-mail: ayshalshihi@gmail.com

G. A. Jokhio · A. Abu-Tair
Structural Engineering, The British University in Dubai, Dubai, United Arab Emirates

K. Al Marri et al. (eds.), *BUiD Doctoral Research Conference 2022*,
Lecture Notes in Civil Engineering 320,
https://doi.org/10.1007/978-3-031-27462-6_18

also made a positive contribution to the distribution of ideas, cultures, languages, discoveries, goods, and services (Koch and Ksaibati 2010).

The history of roadways started with the Ancient Egyptians carrying log rollers used to build the pyramids with huge stones. In avoiding the friction between rocks and dirt, these rollers were strong. Later, the Egyptians invented the wheel, which was considered a transport tool to reduce the need to reposition the log rollers and reduce the need for human power in moving materials. As a result, of minimizing the contact area, they discovered the need to build a hard strong surface to reach their destination. This was the first step in constructing the roadway (Byrne BEng 2005).

On the other hand, Babylon built the first bitumen pavement in the early of 600BC. The new material was used to support the strength of the stone slabs to prevent any further collapse. The roadway was over 1 km in length and besides that, history witnesses the first roadway that linked the big catchment area was King Darius I of Persia, which was built over 60 years. This roadway is a transaction of a straight path that connects two points. Another brilliant road scheme was Chandra-gupta's in India, which took around 30 years to execute with 2400 km in length. The main aim of this road was to enhance the traveling period. Besides that, the concept of roadway has been expanding in British with coverage of 78,000 km throughout Europe by establishing 5,000 km roads (Rosyidi 2015).

Roman became famous for their abilities and skills as roadways constructors over five centuries. They began the road network system among 80,000 km of main roadways and 320,000 km of inner roadways. The roadways covered about 62,000 miles, which were made of natural materials of lime, stone, and concert which were considered binders. Via Appia was the oldest Roman roadway constructed in 312 B.C (Asphalt Pavement History | Washington Asphalt Pavement Association 2010).

2 Recycled Pavement History

The beginning of recycled pavement was dated to 1915, but a dramatic increase in the price of asphalt binder during the 1970s Arab oil embargo sparked renewed interest in asphalt recycling. RAP was originally used by the industry for its economic benefits. Providing RAP is just one way the asphalt industry is attempting to become more sustainable. It is economically, environmentally, and socially beneficial. Using RAP reduces the cost of virgin material, emissions of carbon dioxide, and use of non-renewable resources.

The triple-bottom-line approaches are becoming increasingly ingrained in all aspects of life. The pavement community will continue to emphasize the use of recycled materials. A few difficulties that recently frustrated the progression of higher RAP amounts in blend plans were the absence of rules connected with blend plan and handling just like the accessibility of field execution information to show how these combinations act in the field. While these obstructions were the case a couple

of years prior, late exploration and examination show that RAP blends can have identical execution contrasted with virgin combinations (Transportation Research Board 2014).

Additionally, (Koch et al. 2013) adapted that RAP is the term given to eliminated and reprocessed asphalt materials. These materials are acquired when asphalts are taken out for remaking, remerging, or to get sufficiently close to covered utilities. Therefore, RAP is being utilized in roadway network with the functionality of base or surface material. Road network is a main recycling infrastructure feature in the USA. Not many individuals understand that pavement recycling interstates are among the world's top recycled materials. Around 80% of asphalt is being reused in the roadways. That is contrasted and just 28% of reused post-purchaser merchandise in the city's strong waste stream. As per industry specialists, the recycled asphalt industry is the world's new treasure. Every year, 73 million tons of RAP are implemented in roadway constructions, saving citizens nearly $300 million yearly. The volume of RAP is 13 times more than papers, 27 times more than glass, and 267 more than plastics. Most of the original asphalts are reused within the location of the roadway. It can be utilized in various this way decreasing the interest in asphalt concrete in new or reused pavement containing RAP. At the point when utilized in black-top clearing applications (hot blend or cold blend), RAP can be handled either as hot in place or cold in place.

2.1 Hot in Place Recycled Pavement

This type of recycled pavement has considered as a promising approach and suitable solution for pavement restoration due to the ability of utilizing in place of the roadways . According to Asphalt Recycling and Reclaiming Association (ARRA) defines it as an on-site, in-place technique for restoring deteriorated pavements while reducing the need for new infrastrutucre materials whichfix surface distresses that aren't caused by structural flaws. A new wearing course is applied after recompacting the RAP materials in a multi-step technique, whereas the virgin materials are combined with the recovered reclaimed asphalt pavement (RAP) material in a single-pass operation. This type of recycled asphalt provides the advantages of conserving elevations and overhead clearances while also being very efficicnally in monitoring and controlling traffic volume.Recoat stripped aggregates, re-establish crown and drainage, change aggregate gradation and asphalt content, and increase surface frictional resistance may all be done using this technique. This type of recycled pavement is done to a depth of 20 mm to 50 mm (3/4 in to 2 in), with a typical depth of 25 mm (1 in).The amount of RAP is often extremely high. Whereas 15–20% RAP is prevalent in hot mix recycling, 80–100% RAP is common in hot in-place recycling. It is not essential to calculate any combination gradation of RAP and virgin aggregates if 100% RAP is employed. In hot in-place recycled mix, air voids can be as high as 4%. In Canada, higher design air voids (up to 6%) have been utilized effectively in hot in-place recycling (Kandhal and Mallick 2017).

2.2 Cold in Place Recycled Pavement

Various methods of recycled asphalt have been used to restore and maintain pavements in the United States since the 1930s. As a consequence of an ever-present focus on cost-cutting, as well as a growing emphasis on "green practices," contractors have started using these sustainable processes more regularly (Lombardo 2018). It is defined by (AASHTO 1998) as the process with bituminous and /or chemical additives of existing HMA pavement without heating to produce a restored pavement layer. It is an on-site treatment for moderate- to low-volume roadways that do not have significant underlying structural with a repair distresses 2 in. to 6 in. into the existing pavement.

Instead, for roads with raveling, weathering, bleeding, corrugations, pushing, sliding, rutting, cracking, and small craters, this approach is recommended. This process eliminates damaged layers, leaving a crack-free layer that may be used to install a new HMA overlay or surface course on top of it. If the pavement requires more substantial repairs and an overlay, CIR should be considered. CIR begins by milling 2 to 6 inches of old pavement, which is then processed, combined with a recycling agent (emulsified or foamed), repaved, and compacted (Lombardo 2018).

2.3 Full Depth Reclamation

Infrastruture authorities either local of government are entrusted with rehabitaion nation's infrastructure as it matures. Full-Depth Reclamation (FDR), a sustainable engineering solution for pavement restoration, might be the answer for these authorities to ensure the best quality of infrastructure to taxpayers while also being responsible stewards of public funds. Its a type of rehabilitation in which an existing asphalt pavement and its underlying layers are recycled into a new layers. The process begins with the use of a road reclaimer to pulverize an existing asphalt pavement as well as a part of the underlying pavement layers . The crushed layer is generally evenly blended with an extra stabilizing agent such as Portland cement to make an enhanced, homogenous composition. Finally, the stabilized material is crushed into place by rollers. The base is now strong and secure, ready for a new rigid or flexible surface course. This manual covers project selection, design, building, testing, quality control, and the FDR with cement technique, among other topics. is a pavement rehabilitation procedure in which an existing asphalt pavement and its underlying layers are recycled into a new foundation layer.

This is especially beneficial in urban communities and sattlements, in order to have smooth access to residential and commercial driveways is important during construction. Reclaiming in-place materials enhances staging while simultaneously shortening the construction schedule and minimizing traffic disruption. Full-depth reclamation using cement can be done in a way that enhances the geometry of the

road. This process is molded with new mix materials to reach the desired cross-section after the older asphalt is combined with the other pavement layers. At this stage, minor profile and superelevation changes, as well as roadway widening, can be undertaken (Reeder et al. 2019).

2.4 Shoulder Surfacing and Widening

Over time, the role of shoulders adjacent as base bond of pavements. An additional temonologies of modern roadway shoulders are to accommodate an increasing encroachment of traffic, expedite water runoff from travel lane pavement, provide additional spaces for construction and maintenance activities such as establish dynamic surraoundings that ensure happenancess and welfare through walking paths, bicycle paths or slow-moving vehicles and equipment lanes, to reduce edge stresses and corner deflections. There must be paved shoulders on all Interstate routes.

Paved shoulders are justified by enhanced and smoother traffic operations, as well as the expectation of higher pavement performance, extended life cycle of roadways, increased highway safety, and cheaper maintenance costs. TRB Special Report 214, "Designing Safer Roads - Practices for Resurfacing, Restoration, and Rehabilitation," and FHWA/RD-87/094, "Safety Cost-Effectiveness of Incremental Changes in Cross-Section Design - Informational Guide," both claimed lower accident rates. Even if pedestrians aren't always expected in rural highway corridors, it's a good idea to leave enough room for them and future demands. A minimum paved shoulder width of 4 feet is recommended in the American Association of State Highway and Transportation Officials (AASHTO) Guide for the Development of Bicycle Facilities (2011) to accommodate pedestrian activity along rural roadways; however, this width may not be appropriate on high-speed roadways. The shoulder should be made of the same materials as the mainline pavement to make construction easier, improve pavement performance, and save maintenance costs (Shoulder Sealing | Road Safety Toolkit 2022).

3 Research Questions

Most of the previous articles and studies emphasized one pillar of sustainability and determined how the roadway can survive without maintenance. Therefore, the following Chart. 1 illustrates the summary of the research aim, questions, and objectives.

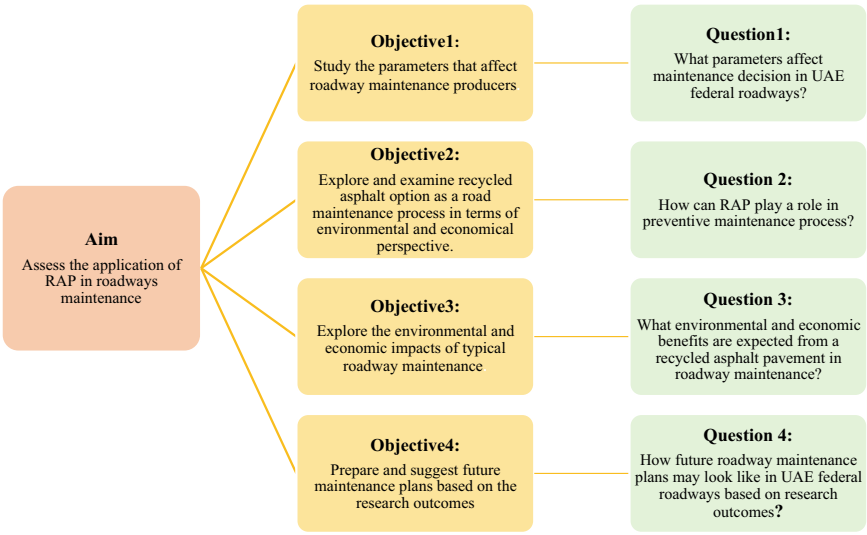

Chart. 1 Research main aim, objectives and questions summary, *sources*; author, 2022

4 Roadway Maintenance Process

Roadways can quickly deteriorate if they are not properly maintained regularly. Despite the initial investment in roads, this infrastructure deteriorates with time, necessitating not only regular roadway maintenance services to keep the existing roads in good repair, but also additional investments to improve and expand the system. Roadways will continue to deteriorate without this ongoing maintenance and development, requiring costly repairs or perhaps replacement after only a few years. A failing transportation infrastructure, soaring expenditures, and a large financial cost to the local economy and population arise from a lack of road maintenance services in a given location. Inadequate roadway maintenance impacts in reduction the level of services and sefety (Why Road Maintenance Is So Important 2019).

The purpose of maintenance is to keep the asset in good performance working order, not to enhance it. It's seen as a long-term investment that protects against costly maintenance and premature breakdowns. At the very least, maintenance extends the life of the transportation infrastructure by treating wear and degradation caused by traffic and the environment constantly. Minor fixes and modifications are occasionally included to address the source of issues and avoid unnecessary maintenance efforts. It also aims to maintain all highway infrastructure operational at the lowest possible cost and with the least amount of disturbance to the traveling public (Highway Maintenance Manual 2017).

5 Study Significance

The World Highways Organization set a target to have 70% of recycled infrastuture materials by 2020. This occurred in Europe where around million tons of recycled materials are used in the pavement that are producing valuable sustain scenarios at a lower rate of waste landfills. It should be noted that the number of materials that contribute to roadway pavements production such as gravel, and other aggregates of gravel is limited as raw materials and vital in different other industries as well such as building construction which means it shall be reserved and consumed with caution to ensure efficiency and sustainability (Balaguera et al. 2018). Therefore, this research serves a significant role in addressing the sustainability approach in different categories all at once by exploring new potential techniques for the roadway pavement industry. Studying the current situation of the pilot project in UAE and exploring the advantages and disadvantages of the RAP system according to UAE needs and potential will widen the possibilities of implementation of different recyclable materials in different other industries and encourage the development in pavement related businesses and industries to apply higher sustainable standards that will be reflected on all 3 pillars of sustainability. Previose researchs were done based on theoretical aspects which discuss disadvatanges of using recycled pavements however this research is the first on a national level that covers the main roadway which links high populated emirates with high traffic volume, especially on weekends. The results and outcomes will be taken into consideration for future policies and frameworks since the researcher already works at the Ministry of Energy and Infrastructure.

6 Methodology and Approach

The methodological Chart. 2 below presents data collection methods with an empirical perspective of qualitative and quantitative.

The research case study selection is Dibba – Masafi E89 with deep information such as length, traffic volume, type of maintenance, and others gave the author to analysis the need of maintenance through site experimental tests, LCCA, and Road Assets Management System. A comparison between the proposed maintenance

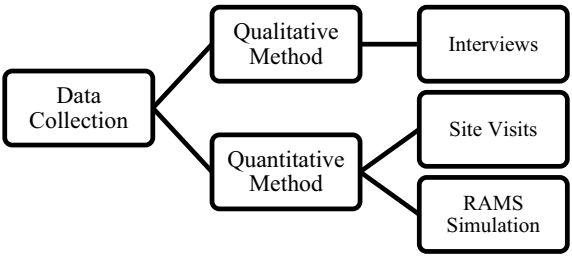

Chart. 2 Data collection, *source*: author, 2022

procedure of recycled pavement and current maintenance procedures in terms of environmental and economic impacts contribute with The findings and outcomes set the foundation for future maintenance.

For the qualitative method, the author holds a group of interviews with engineering experts from government authorities and the private sector. The objective of the interviews is to have clear comprehensive data and knowledge about the following:

- Type of maintenance process.
- Simulation tools that support the use of the recycled pavement.
- Group of parameters that affect the performance and quality of the roadway.
- Work producers of implementation recycled pavement with comparasion of duration.

Furthermore, site visits to the research case study to understand the following:

- Identify the roadway as location, and pavement layers.
- Kind of lab tests used to ensure the strength of the new asphalt.

While the second method of quantitative is a simulation which is described through RAMS which is considered as a dashboard for displaying road status information based on auscultation parameters, employing graphs, histograms, to illustrate the data. It produces group of reports probably difficult to list since they can be formed by a single or combination of parameters, however, the database can be graphically, numerically presented as well as mapped to indicate different topics such as bridges, rock slopes, assets in right of way, pavements, traffic volume.

The system was introduced first in 2012 by an external consultant under the supervision of the Ministry's engineers. The Consultant had the responsibility of installing, collecting, and updating the system with all its related data. To keep this system running properly it is necessary to keep the database updated continuously and for that purpose some high-performance equipment is used such as LiDAR (laser cloud point data collection) which is a 360° photogrammetric. In order to clarify the main objective of installing RAMS is to assess the administration to reach a point where the big part of assets management can be achieved and quantified from the preventive perspective (by modeling and forecasting) and maintaining the less of the constituting points of the RAMS on the corrective side, for example, the daily maintenance performed in which the incidents was unexpected) since it shows that on long term, performing preventive actions can lead to the reduction of payment by 3–5 times compared to the corrective works on conventional method.

7 Conclusions

This paper has explored the importance of using recycled asphalt from a wide perspective to ensure excellent quality of infrastructure, especially roads network. Recycled asphalt is a tool that is used during the preventive maintenance process which monitors and evaluates the pavement conditions. This can recognize the level of failures

in the current situation and suggest new maintenance forecasting for the following years. This supports the idea of establishing new processes and techniques that can associate new business markets that empower the economy of any country.

References

Koch, S., & Ksaibati, K. (2010). *Performance of Recycled Asphalt Pavement In Gravel Roads*. The University of Wyoming.

Byrne BEng, D. (2005). Recycling of Asphalt Pavements in New Bituminous Mixes. Ph.D. Napier University

Rosyidi, P.S. (2015). Construction Method for Road-Pavement

Asphaltwa.com (2010). Asphalt Pavement History | Washington Asphalt Pavement Association. https://www.asphaltwa.com/welcome-asphalt-pavement-history/. Accessed 1 Nov 2020

Transportation Research Board (2014). Application of Reclaimed Asphalt Pavement and Recycled Asphalt Shingles in Hot-Mix Asphalt. Washington, D.C. 20001: Transportation Research Board, pp. 11–18

Koch, S., Huntington, G., & Ksaibati, K. (2013). *Performance of Reclaimed Asphalt Pavement on Unpaved Roads*. University of Wyoming.

Kandhal, P., Mallick, R. (2017). Chapter 9, 10 - 98042 - Federal Highway Administration. https://www.fhwa.dot.gov/pavement/recycling/98042/10.cfm. Accessed 28 Feb 2022

Lombardo, J. (2018). Should You Use Hot or Cold in Place Recycling for Your Project? For Construction Pros. https://www.forconstructionpros.com/asphalt/article/20984416/should-you-use-hot-or-cold-in-place-recycling-for-your-project. Accessed 2 Apr 2022

Reeder, G., Harrington, D., Ayers, M., & Adaska, W. (2019). *Guide to Full-Depth Reclamation (FDR) with Cement* (pp. 5–11). Iowa State University.

Toolkit.irap.org (2022). Shoulder Sealing | Road Safety Toolkit. https://toolkit.irap.org/default.asp?page=treatment&id=32. Accessed 1 Mar 2022

Balaguera, A., Carvajala, G., Albertí, J. and Palmer, P. (2018). Life cycle assessment of road construction alternative materials: a literature review. 1(3), 37–48

2017. Highway Maintenance Manual. Bureau of Highway Maintenance. Bureau: Bureau of Highway Maintenance, pp.1–5. https://wisconsindot.gov/Documents/doing-bus/local-gov/hwy-mnt/mntc-manual/chapter02/02-10-15.pdf. Accessed 24 Jan 2022