

RECLAIMED ASPHALT PAVEMENT (RAP) USE UP TO 25%

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ABSTRACT

In this guidance document we will detail options for local agencies to substitute up to 25% virgin aggregate for reclaimed asphalt pavement (RAP) in hot mix asphalt (HMA).

The use of 25% RAP as a replacement to virgin aggregate in HMA offers several economic and environmental benefits while still producing a high quality HMA product. Increasing RAP use up to 25% of the total aggregate blend is a relatively straightforward process that can be implemented by agencies of all sizes regardless

of the standard specifications utilized. This guidance document serves as a reference for local agencies interested in increasing their RAP use in HMA products so they can take advantage of the many sustainability benefits as well as prepare for a regulatory environment which may mandate increased RAP use in the future.

PROBLEM STATEMENT

Current aggregate use is outpacing available reserves and increasing construction costs.

Aggregate is used by numerous industries and is considered an essential raw building material for everything from concrete to HMA. Estimates developed by the California Department of Conservation (CDC) indicate that aggregate reserves in San Diego County may run out as soon as 2030. According to CDC, as much as 30% of the aggregate used in San Diego County is already being imported which has caused aggregate prices to increase significantly over the past couple of decades. If this trend continues, aggregate prices will continue to increase leading to higher construction costs for numerous industries. At the forefront are road maintenance and rehabilitation activities where 93% to 96% of HMA consists of aggregate. This, along with a significant increase in road maintenance

spending as a result of Senate Bill 1 (2017), and limited development of new local aggregate sources has exacerbated the regional aggregate shortage.

Key Issues:

- Demand for virgin aggregate is high due in part to the relatively low percentage of RAP currently used in HMA mix designs
- Virgin aggregate reserves in San Diego County may run out as soon as 2030
- Higher RAP use in HMA has been proven to be effective, but modifications to Greenbook and Caltrans specifications are needed to better guide agencies

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Traditionally, aggregate used in HMA production has consisted of virgin rock mined from natural supplies. The majority of grindings from the removal of deteriorated roads (i.e. RAP) were typically reused as aggregate base material or disposed in landfills. Until recently, only a small percentage, typically 15% or less as allowed by California State Department of Transportation (Caltrans) and Greenbook specifications, was reused in new HMA. This approach requires additional hauling and disposal of unused RAP which increase costs and impacts on the environment. While most agencies have had to pay to dispose of RAP in the past, current technologies and approaches are finding ways to increase the percentage of RAP reused in HMA where the benefits of both the aggregate and the residual binder can be used.

More recently, RAP use has increased throughout the US and the world where, in some cases, RAP has been reported to successfully replace up to 80% of virgin aggregate. Caltrans and Greenbook standards have historically only allowed up to 15% RAP in HMA, however starting in 2012 Greenbook began allowing greater than 15% RAP and in 2015 Caltrans followed suit by allowing up to 25% RAP. Specification modifications have been successful in addressing potential issues associated with higher RAP use in HMA, including the development of mixes that are resistant to cracking and rutting. Regardless of the approach utilized, some modifications to the respective specification may be required, and for those utilizing Caltrans specifications navigation of the SuperPave process is also required.



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SOLUTION

Modifications to existing specifications can allow the successful implementation of up to 25% RAP.

The two primary specifications utilized for HMA production in California are Caltrans and Greenbook. Each offers a relatively straightforward approach for utilizing RAP up to 25% in HMA. These approaches address common issues that have been identified in HMA with greater than 15% RAP, such as premature cracking as a result of the binder in RAP and monitoring RAP binder content which differs significantly between the high binder containing fine aggregate and the lower binder containing coarse aggregate. Since these two specifications utilize different approaches, this guidance document will summarize each separately. It is important to note that all references to RAP use in this guidance document are referring to aggregate replacement as opposed to binder replacement in accordance with Caltrans 2018 standard specifications and current FHWA guidance. The actual binder replacement percent may differ from the percent of RAP aggregate depending on several factors including the gradation of RAP used (fine or coarse).

Caltrans Approach

In 2016, Caltrans issued interim guidance and revised standard specifications for the allowance of up to 25% RAP in HMA. One major issue identified when increasing RAP use over 15% was premature cracking. RAP use greater than 15% introduces additional binder that must be accounted for when developing a mix design. High RAP mixes have a propensity to become stiff which can lead to premature cracking. To combat this, Caltrans' specifications require that the binder grade be decreased by 6 degrees Celsius for both the upper and lower temperature classifications to account for the stiffer binder associated with RAP, a requirement that mirrored FHWA guidance 3. When RAP with a stiff binder is blended with the softer grade of virgin binder the resultant mix should exhibit similar rut and crack mitigation properties when compared to a virgin mix with the standard binder. Another significant modification Caltrans requires is fractionating (segregating) RAP into two piles if both fine and coarse sizes are used. The fine aggregate RAP pile contains material that is 3/8 inch or less and includes a higher binder content due to the greater surface area of these particles. The coarse aggregate RAP pile contains material that is greater than 3/8 inches and if properly processed has a lower binder content associated with these particle's



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lower surface area. Fractionating RAP and thoroughly testing each pile's binder content helps HMA plants maintain the higher precision necessary to consistently produce high quality HMA. If these tolerances cannot be maintained a new mix design must be developed.

Stockpile management is critical to successful production of 25% RAP HMA. Not only should the RAP stockpiles be completely separated from the virgin aggregate, but the fractionated stockpiles of RAP should be kept separate from each other as well. Comingling of the RAP stockpiles defeats the benefits of fractionation. All testing should be performed on the virgin aggregate prior to the introduction of RAP aggregate.

Based on guidance from Caltrans and FHWA and following a detailed review of the current state of practice for producing high RAP mixes, the County of San Diego developed a modified Caltrans specification which allows up to 25% RAP in HMA mixes. The design team developed a draft specification that included two additional requirements when RAP content is between 15% and 25%. Consistent with Caltrans specifications, the PG binder grade was decreased at both limits by 6 degrees Celsius to address potential cracking concerns and RAP was fractionated into at least two piles (fine and coarse) and tested frequently to monitor binder content. Following a peer review process the specification was implemented in resurfacing contract documents. This specification was implemented

for over 250,000 tons of HMA associated with resurfacing projects which began in 2019 and can serve as a roadmap for other agencies looking to increase RAP use.

Greenbook Approach

The 2018 Greenbook specification currently allows for up to 25% RAP within the standard specifications and allows for greater percentages with a modified special provisions. While the maximum RAP percentage is not specified, additional requirements are only triggered when the RAP percentage exceeds 25%.

As with Caltrans, there are a few specification modifications that are recommended when using RAP up to 25% as follows; 1) Greenbook also does not require a binder grade adjustment as specified by FHWA and Caltrans guidelines for RAP use up to 25%, but this is an important step to combat premature cracking, 2) section 203-6.5.3 and the associated quality control requirements in Greenbook should also be modified to require RAP to be fractionated and to limit RAP variability to 1% without exceeding a total of 25%, 3) the requirements of Section 203-6.4.3(e) should be omitted as this is only recommended for RAP use exceeding 25% and the binder modification approach does not require it, 4) consider requiring a project start up evaluation similar to the Caltrans approach to ensure that the submitted mix design can be consistently produced by the supplier at required production rates.

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Agencies considering the use of RAP between 15% and 25% should modify the requirements associated with the specification they utilize to incorporate FHWA and Caltrans guidelines. In addition, agencies should consider independent verification of the mix design, inclusion of project start up requirements, implementation of routine quality control testing and periodic HMA plant inspections to confirm the supplier is consistently producing high quality HMA that meets identified specification and performance criteria.

Key Take-aways

- Greenbook and Caltrans specifications offer guidance for using up to 25% of RAP in HMA, including ways to address common challenges like premature cracking and managing binder content that can occur in HMA with higher RAP content
- The County of San Diego adopted Caltrans specifications to address the challenge of controlling binder content in 15-25% RAP mixes by requiring RAP to be stored in separate course and fine piles, and to account for the stiffer binder associated with RAP by decreasing allowable binder grade temperature classifications
- For agencies using 2018 Greenbook specifications, it is recommended they incorporate specification modifications through special provisions to yield the best results when using 20-25% RAP mixes

CONCLUSION

RAP use up to 25% in HMA is attainable for local agencies and has many environmental and economic benefits.

The use of RAP between 15% and 25% in HMA is attainable for local agencies and provides economic, sustainability and environmental benefits to all sectors of the industry including suppliers, contractors and agencies. Many of these benefits can be realized today such as

decreased pollution and materials and trucking costs while others will support the HMA industry and agencies into the future including a sustainable aggregate market and supporting agency diversion and climate action plan targets.

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REFERENCES

- National Asphalt Pavement Association, Federal Highway Administration Highway Statistics Report data.
- The California Department of Conservation
- Reclaimed Asphalt Pavement in Asphalt Mixtures: State of Practice, Federal Highway Administration Publication #FHWA-HRT-11-021
- 2018 Standard Specifications for Public Works Construction. (The Greenbook), 2018 Edition- Section 203-6
- The California Department of Transportation Standard Specifications Section 39 Asphalt Concrete