2025 Ontario Paving Report

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ontario asphalt pavement council
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1.1 Message from stakeholders

Good Roads recognized the need to obtain accurate and current data on paving practices, trends, and quantities of materials used in municipal asphalt paving to be able to better monitor and assess the impact of current practices and specifications on the consumption of paving materials, including RAP. This report captures the dedicated collaboration among stakeholders in the road and infrastructure sector. The initiative leading to this report started in 2019 with RAP quantity estimation from satellite images by Good Roads, then evolved to be a collaboration study between **Good Roads GR**, Ontario Asphalt Pavement Council (**OAPC** – a Council of Ontario Road Builders' Association, **ORBA**), and the Municipal Engineers Association (**MEA**), to highlight RAP and paving metrics and quantities, and to identify best practices of RAP stockpiling in Ontario. In this report, Ontario is divided into four geographical zones (Northern, Southeast, Southwest, and Central) as presented in **Figure 1.**

1.2 Report Objectives

- Report annual municipal HMA paving tonnage to facilitate strategic planning.
- Document material availability of RAP compared to municipal paving needs across Ontario.
- Document the historical background of RAP use in Ontario.
- Report vital metrics on RAP stockpiling inventory in Ontario.
- Present an Ontario state of the practice on municipal paving.
- Synthesize information on best practices for RAP processing, stockpile management and identify the most relevant documents for further details.
- Provide a platform for sharing and documenting long lasting successful applications of RAP paving in Ontario municipalities.
- Build a sound evidence base for promoting the economic and environmental benefits of using RAP in road building across Ontario.

1.3 History of RAP in Ontario

The earliest efforts in recycling asphalt concrete into new pavement constructions consisted of pulverizing existing pavements to use in new subbase layers. Earliest records of this recycling practice date back to the 1960s in Nevada and Ontario, and 1975 in Texas (Clark et al., 1978; McLuckie et al., 1987). Since then, the use of recycled hot mix asphalt has gained widespread acceptance in the infrastructure industry in North America. In 1979, the Ministry of Transportation Ontario (MTO) implemented its first efforts to adopt recycled hot mix asphalt as a standard pavement recycling alternative (McLuckie et al., 1987). The rapidly increasing prices of crude oils in the 1970s were the main driving force behind reusing the existing asphalt binder in aged flexible pavements (Copeland, 2011). According to

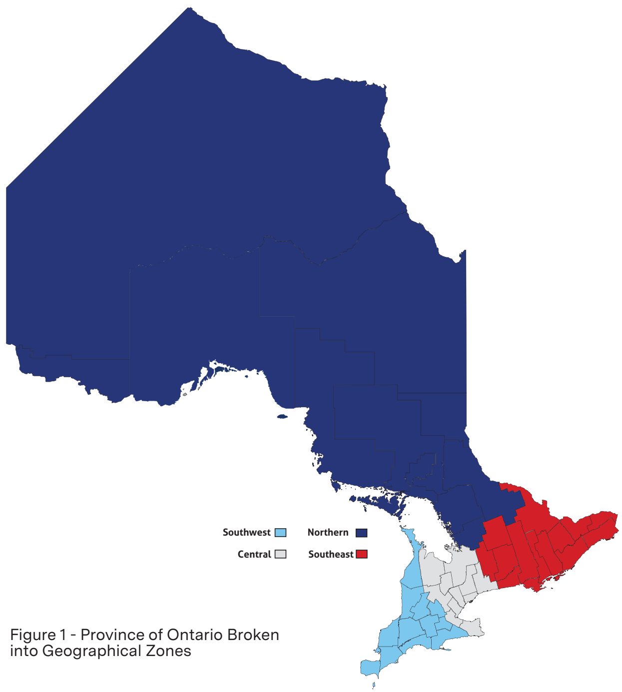

Figure 1 - Province of Ontario Broken into Geographical Zones

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The Ontario Aggregate Resource Corporation (2014), approximately 153 million tonnes of aggregates are produced each year in Ontario, out of which 50% is used in the maintenance and construction of infrastructure in Ontario. This gives RAP the potential to be a significant contributor to aggregate sustainability. In addition to saving valuable diminishing aggregate resources, using RAP in infrastructure contributes to the following:

- Recovering non-renewable petrochemical resources
- Reducing road building costs
- Diverting a large amount of solid waste from landfills
- Reducing greenhouse gas emissions

1.4 Municipal Paving Forecast Survey

The Municipal Paving Forecast is a longstanding initiative spearheaded by Good Roads with the first round of the Forecast going back to 2016. Working in partnership with the Ontario Asphalt Pavement Council (**OAPC** – a Council of Ontario Road Builders' Association, **ORBA**) through the GR/OAPC Municipal HMA Liaison Committee. The survey collects information from Municipalities on projected paving tonnage, RAP usage, and other road building practice matters. The results of the survey are subjected to thorough scrutiny, ensuring reliability and precision in the data collected. Through this collaborative effort, the Municipal Paving Forecast serves as a vital resource for informed decision-making and strategic planning in Ontario's municipal road construction and maintenance.

1.5 Ontario RAP Survey

The Ontario RAP Survey initiative started in 2019, where Good Roads conducted a study on RAP quantity estimation using satellite images, which was published in the 2019 TAC Conference proceedings. The initiative then gained momentum and evolved to be a collaboration study between **Good Roads GR**, and the Ontario Asphalt Pavement Council (**OAPC** – a Council of Ontario Road Builders' Association, **ORBA**)to produce current and historical spatial data on RAP stockpile quantities in Ontario. Starting in 2025, Concrete Ontario joined the collaborative effort to include quantification of Recycled Concrete Aggregates (RCA).

2.1 Hot Mix Asphalt (HMA)

This section will discuss the trends in HMA production quantities, locations, and municipal paving consumption of HMA.

2.1.1 Total Produced HMA

Although municipal asphalt paving projects account for a large share of the total HMA produced in Ontario, monitoring the total HMA production trends and locations is still important. **Table 1** presents a reported summary of the HMA production facilities locations and their annual production in the past years. No data was collected on HMA production quantities for 2024.

2.1.2 Consumed HMA in Municipal Paving

Based on survey responses from 77 municipalities, 2.05M tonnes of HMA is estimated to be used in municipal paving projects for the 2025 construction season. A summary of the HMA paving quantities per year is presented in **Table 2** and **Figure 3**. The quantities are summarized as per geographical zones. It is noted that the Central Zone typically accounts for most of the municipal paving tonnage, with an average annual share of 55% of the total municipal HMA tonnage. Through an extrapolation from the Municipal Paving Forecast data 2017-2021, it was estimated that Ontario municipalities pave between 4.9M and 5.2M tonnes of HMA in any given year. These estimates counter the popular opinion

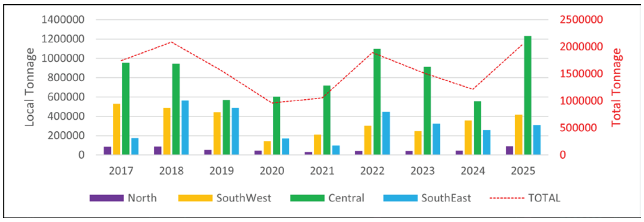

Figure 3 - Annual Reported Municipal HMA Paving Tonnage

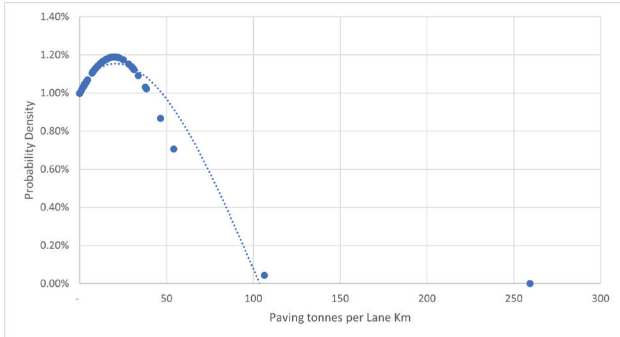

Figure 4 - Statistical Distribution of the HMA Tonnage per Lane Km

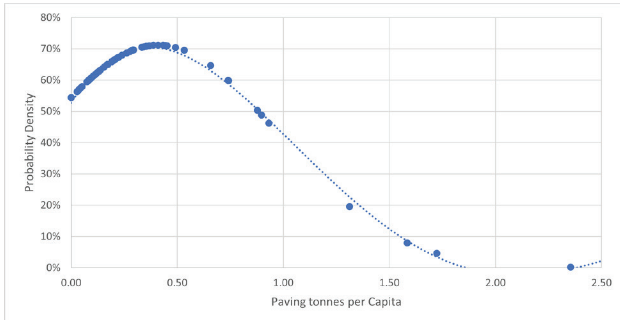

Figure 5 - Statistical Distribution of the Paving Tonnage per Capita

Total HMA Production (Tonnes)

Year	Facilities	North	SouthWest	Central	SouthEast	TOTAL
2022	72	459,756 (8%)	1,100,611 (19%)	3,781,868 (66%)	648,700 (11%)	5,690,935
2023	94	171,000 (2%)	1,222,444 (17%)	4,840,826 (66%)	1,110,881 (15%)	7,345,151
2024	109	Data not coollected	Data not collected	Data not collected	Data not collected	Data not collected

Table 1 - Total HMA Production Tonnage in Ontario

Municipal HMA Paving (Tonnes)

Year	Municipalities	North	SouthWest	Central	SouthEast	TOTAL
2017	54	87400 (5%)	531289 (30%)	952400 (55%)	174836 (10%)	1, 745, 925
2018	44	90300 (4%)	487810 (23%)	944905 (45%)	564807 (27%)	2,087,822
2019	58	54446 (4%)	443525 (29%)	569815 (37%)	486765 (31%)	1,554,551
2020	40	44925 (5%)	143680 (15%)	601915 (63%)	169341 (18%)	959,861
2021	43	30100 (3%)	207988 (20%)	718399 (68%)	97453 (9%)	1,053,940
2022	57	44150 (2%)	303530 (16%)	1097509 (58%)	448105 (24%)	1,893,294
2023	64	43010 (3%)	246377 (16%)	913288 (60%)	323486 (21%)	1,526,161
2024	54	45307 (4%)	357245 (29%)	553773 (46%)	260018 (20%)	1,216,343
2025	77	93,270 (5%)	416,269 (20%)	1,231,314 (60%)	311,694 (15%)	2,052,547

Table 2 - Municipal Hot-Mix Paving Quantities in Ontario

that MTO is the largest user of HMA at 2.5-3M tonnes/year. In the past eight years (2017-2025). The Paving Tonnage / Lane Km and Paving Tonnage / Capita are two important metrics presented in **Figure 4** and **Figure 5**. The distributions of HMA tonnage per lane kilometre and paving tonnes per capita provide insight into municipal road maintenance practices and available funding levels. Higher HMA tonnage per lane kilometre may indicate a greater intensity of resurfacing activity or heavier road usage demands. In contrast, higher paving tonnes per capita can reflect a municipality's relative ability to fund paving works through local resources. Together, these metrics help characterize differences in infrastructure investment strategies across municipalities.

2.2 Recycled Aggregates (RAP and RCA)

2.2.1 Total Available RAP

Table 3 presents a summary of facilities containing RAP in each geographical zone and their total reported unprocessed RAP inventory per year. The RAP quantities in the table do not include RAP that is stockpiled in municipal facilities. It was found that RAP stockpiles in municipal facilities represented only 5% of the total inventory, and therefore, it was not included in the study scope. Notably, satellite imagery was used to investigate 16 of the 109 facilities to estimate RAP and RCA stockpile quantities as per Mneina & Smith, 2019 methodology. In this study, the quantification effort was expanded to include processed RAP. A total of

RAP Inventory in Ontario (Tonnes)

Year	Facilities	North	SouthWest	Central	SouthEast	TOTAL
2019	57	868,418	263,007	1,901,174	1,280,015	4,312,614
2020	39	299,000	287,296	1,434,510	260,000	2,280,806
2021	60	27,500	370,269	1,815,253	739,899	2,952,920
2022	72	229,993	413,435	1,839,396	791,342	3,274,166
2023	94	245,000	684,177	1,909,738	836,061	3,606,461
2024	109	366,570 (13%)	157,915 (4%)	1,787,544 (48%)	603,242 (16%)	2,915,270

Table 3 - RAP Inventory in Ontario as Reported in the Ontario RAP Survey

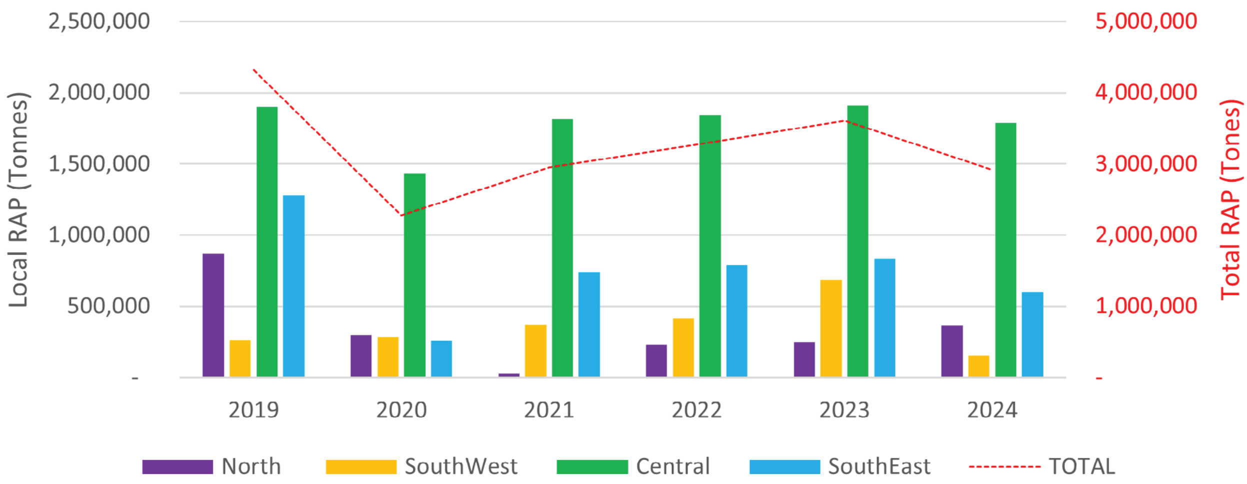

Figure 6 - Annual Reported RAP Quantities

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802,384 tonnes of processed RAP were recorded, representing 22% of the 3.7 million tonnes of total RAP, which consists of both processed and unprocessed materials. The availability of crushed RAP varies across geographic zones, with the Central zone having the highest proportion at 29% of its total RAP inventory. In comparison, the North, Southwest, and Southeast zones reported crushed RAP at 1%, 2%, and 10% of their respective total RAP inventories.

2.2.2 Total Available RCA

RCA (return concrete and demolition RCA) quantities were collected as part of the Ontario RAP survey. 109 facilities were included in the scope, encompassing HMA production, ready mix plants, and aggregate quarries. A total of 2,942,033 Tonnes of RCA were reported, 69% of which is demolition RCA and the remaining 31% comprises of returned concrete.

2.2.3 Consumed RAP in Municipal Paving

The availability of information on local quantities and RAP practices in HMA paving is a key resource for the continuous improvement and growth of this industry's stakeholders.

Municipal RAP consumption was estimated using the Municipal Paving survey results and simplified calculations/ assumptions. The 2025 survey collected information on how much municipal paving projects incorporated RAP in each municipality. Conservative assumptions were made that 15% RAP in HMA was used in projects that incorporated RAP. The estimated consumed RAP was then calculated based on that assumption and based on the known paving tonnage of 77 municipalities. Although this estimate represents only 77 out of 444 municipalities, it is considered an accurate estimation as these municipalities represent 83% of the total population of Ontario, which strongly correlates to the road building activity and network distribution around the province. The bubble diagram in **Figure 8** presents the 2025 projected RAP consumption locations and quantities alongside the RAP inventory locations and quantities.

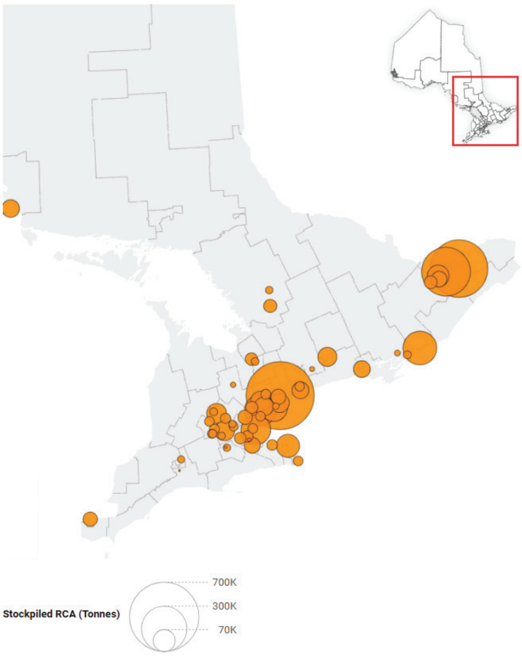

Figure 7 – Available RCA Stockpile Quantities for 2025

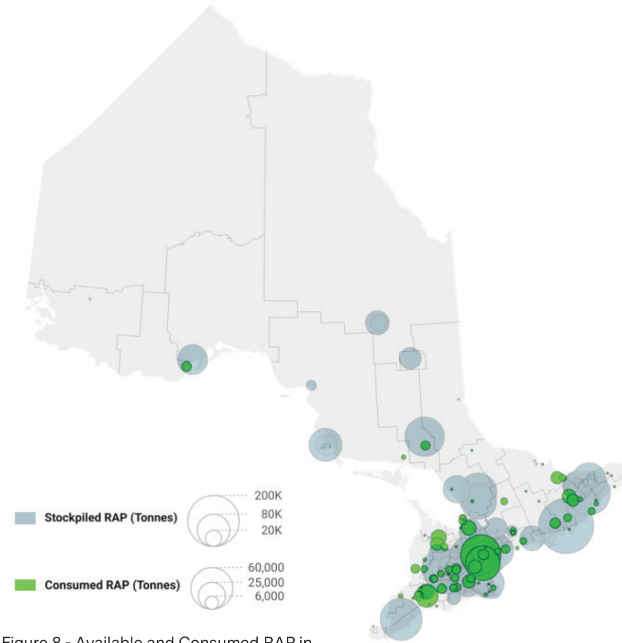

Figure 8 - Available and Consumed RAP in 2025 (not including MTO's consumption)

RCA Inventory in Ontario (Tonnes)

Year	Facilities	North	SouthWest	Central	SouthEast	TOTAL
2024	109	39,031	28,91	1,700,568	1,173,533	2,942,033

Total Municipal RAP Consumption (Tonnes)

Year	Municipalities	North	SouthWest	Central	SouthEast	TOTAL
2023	**64**	4,000	22,000	104,000	33,000	**163,360**
2024	**54**	3,468	28,961	65,231	15,504	**113,145**
2025	**77**	2,475	25,784	132,906	33,114	**194,279**

Table 4- Municipal Consumed RAP

2.3 Warm Mix Asphalt (WMA)

Warm Mix Asphalt (WMA) represents a revolutionary advancement in road construction, offering a more sustainable and environmentally friendly alternative to traditional Hot Mix Asphalt (HMA). WMA technology allows for the production and placement of asphalt mixtures at lower temperatures compared to conventional methods, resulting in reduced energy consumption, lower greenhouse gas emissions, and improved workability. By incorporating additives or technologies that enable mixing and compaction at reduced temperatures, WMA is used to achieve one or a combination of the following benefits:

- Extending the paving season (late season paving)
- Reducing GHG emissions during production
- Reducing energy consumption during production
- Enhancing compaction

In the 2025 paving season in Ontario, an estimated 25% of the municipalities use WMA in their paving operations. A breakdown based on geographical zone is presented in **Figure 6**. Out of the 12% that use WMA, a portion of those use it year-round, while others allow it only after a prescribed date. It is also worth noting that the municipalities that are currently not using it have mostly reported that they are either considering it for future projects, or they deal with it on a project-by-project basis during the design phase. A total of 388,000 tonnes of WMA is projected to be used in the 2025 construction season by Ontario municipalities. A breakdown of the total 2025 WMA tonnage is also presented in **Figure 9**.

2.4 In-Place Recycling (HIR/CIR)

In-place recycling, encompassing Hot In-Place Recycling (HIR) and Cold In-Place Recycling (CIR), represents a sustainable and cost-effective approach to rehabilitating municipal roads while minimizing environmental impact. Both methods offer significant advantages over traditional road rehabilitation techniques, including reduced material consumption, shorter construction times, reduced excess soil generation, and improved pavement performance of the existing structure. In-place recycling techniques have gained popularity among municipal authorities seeking efficient and eco-friendly solutions for maintaining and upgrading their road networks.

A total of 832 kilometres of road is expected to be treated with HIR or CIR by municipalities in Ontario during the 2025 construction season. A breakdown of the number of municipalities using in-place recycling, as well as the breakdown of the total HIR/CIR kilometres, is presented in Figure 10. It is worth noting that 33% of the municipalities in the 2025 survey are expecting to use HIR or CIR during the 2025 construction season.

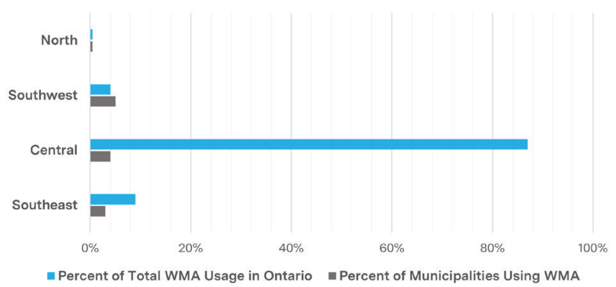

Figure 9 - Geographical Breakdown of Municipalities using WMA and the Total 2025 WMA Tonnage

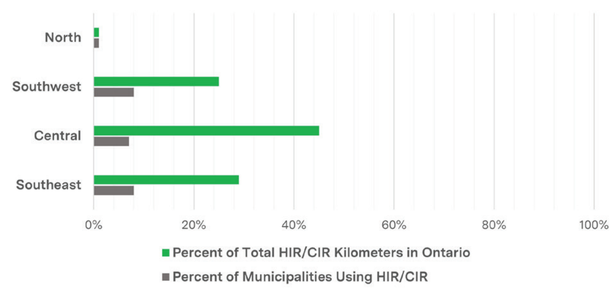

Figure 10- Geographical Breakdown of Municipalities using HIR/CIR and the Total 2025 HIR/CIR Kilometres

3.1 Municipal Paving and Maintenance Trends

According to the Municipal Paving Survey, a total of 529,496 potholes were reported to be fixed in 2024. About 27% of the responding municipalities reported that they do not record the number of fixed potholes. On average, each municipality fixed 4,613 potholes. The largest number of fixed potholes reported by a single municipality was 285,000 potholes. When compared to the number of lane kilometres, the average becomes six (6) potholes per lane kilometres. Figure 11 shows the statistical normal distribution of the potholes per lane kilometres.

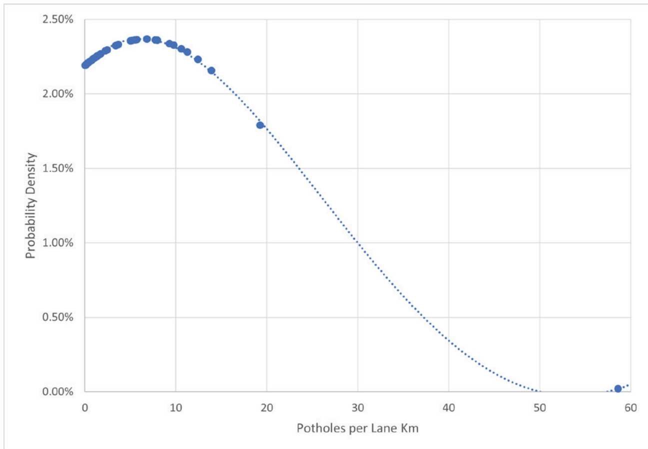

Figure 11 - Statistical Distribution of Potholes per Lane Kilometres

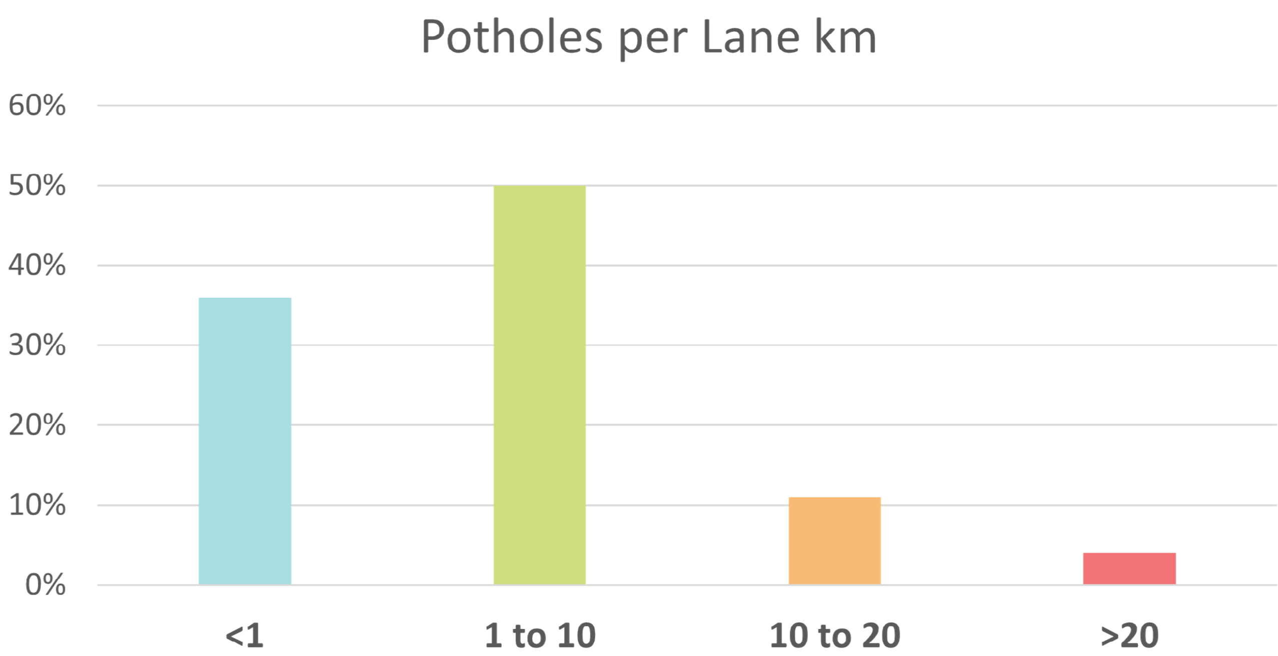

Figure 12 - Potholes per Lane Kilometres

3.2 Municipal RAP Specifications

Through the GR/OAPC Municipal Paving Forecast survey, a total of 148 municipalities' responses were analyzed and resulted in a better understanding of municipal specifications of RAP across Ontario. According to our data, 79% of the municipalities have indicated that their specifications allow the use of RAP in the HMA layers in their paving projects. The geographical breakdown of this data is presented in **Figure 13**, showing that RAP intake is equally popular across Ontario except the North geo-zone. The collected data also showed that at least 15 municipalities have moved from not allowing RAP to allowing the use of RAP in their specification language in the past five years. **Figure 14** demonstrates the distribution of pavement recycling technologies implementation in Ontario municipalities.

3.3 RAP Stockpile Management (Industry and Municipalities)

It is common knowledge that the most significant reason behind limiting the use of RAP in new asphalt concrete mixes is material variability (variability in RAP aggregate gradation and characteristics, as well as variability in RAP asphalt content and characteristics). Since RAP is usually reclaimed from different sources with different material characteristics and reclamation methods, it is vital to focus on achieving homogeneous stockpiles by applying best practices in managing and processing. The following paragraphs present information on the current state of practice with RAP management, which was collected as part of the 2021 Ontario RAP Survey, conducted by GR, OAPC, and MEA.

Decisions made at the beginning of the RAP stockpiling and processing activity play a significant role in creating a quality homogeneous RAP product for use in HMA for road construction. **Figure 15** shows how facilities manage their stockpiles and whether they put all incoming RAP materials in one pile or create separate stockpiles for RAP coming from different sources. It is found that most municipalities use a single stockpile for their collected RAP. The reason is that these municipalities only collect RAP millings from their own roads or millings from adjacent provincial roadways. The similarity in material justifies the decision to hold only single stockpiles for all collected RAP in this situation. Multiple factors are considered when deciding on whether to collect RAP in single or multiple stockpiles. **Table 5** provides a description of these decision factors. It is common practice for Ontario contractors/HMA producers to inspect incoming RAP for potential contamination, as shown in **Figure 16**. Another common way to guarantee clean RAP is accepting incoming RAP based on pre-approved contractors, given that the contractor has clear instructions on the expected quality of collected RAP.

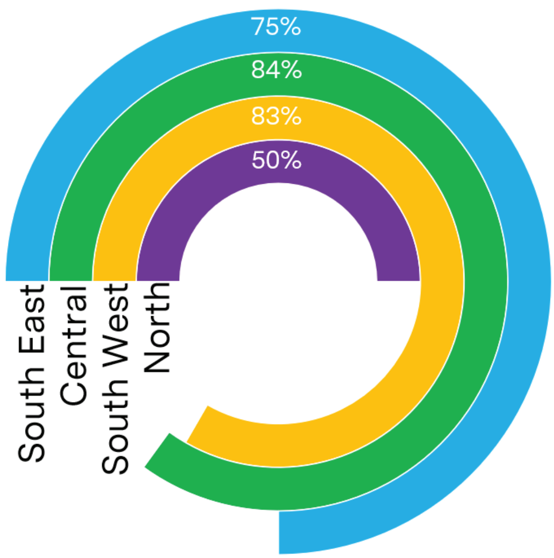

Figure 13 - Municipal Specs on RAP Use in Ontario (Percentage refers to municipalities that allow the use of RAP in their specifications).

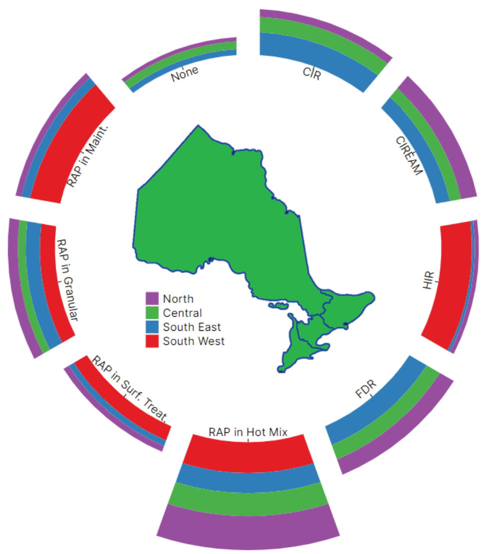

Figure 14- RAP and Pavement Recycling Technologies Implementation in Ontario

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Factor	Comments
Availability of space	Based on the Ontario RAP Survey, RAP stockpiles take an average space of 600m2 in Municipal yards and 4000m2 in contractors/HMA production facility.
Municipal QA Specs	Facilities serving multiple Municipalities may need to have multiple stockpiles if one or more Municipalities require that RAP be from Classified or Captive stockpiles to be accepted in their projects, which may be challenging with limited space, especially in the Greater Toronto Area.
Contaminated RAP	In the event that a facility accepted RAP that was likely to be contaminated (soil, vegetation, geosynthetics), it is common practice that contaminated RAP be kept in a separate stockpile and used only in road bases or shoulders. Contaminated RAP is not fit to be included in new asphalt mix production.
Consistency of Source	If large quantities of RAP are being brought from a single project or jurisdiction (especially if it is reclaimed through milling), it is most cost-effective to store the material in a separate stockpile. This approach minimizes processing efforts, as the material is likely to be highly consistent in quality and composition.

Table 5 - Decision Factors on Number of RAP Stockpiles in a Facility

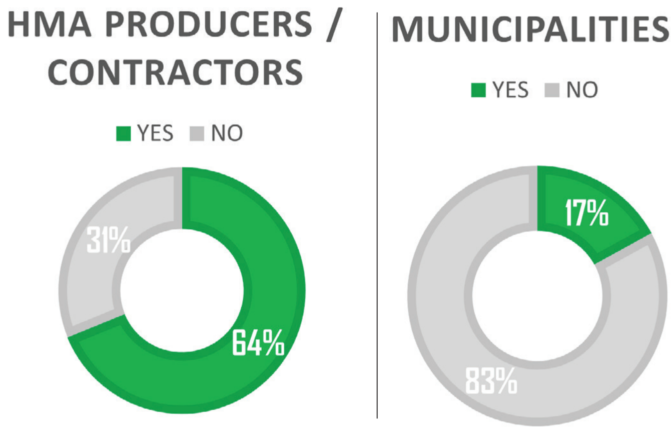

Figure 15 - 2020 Ontario RAP Survey - Do you Separate RAP Based on Source?

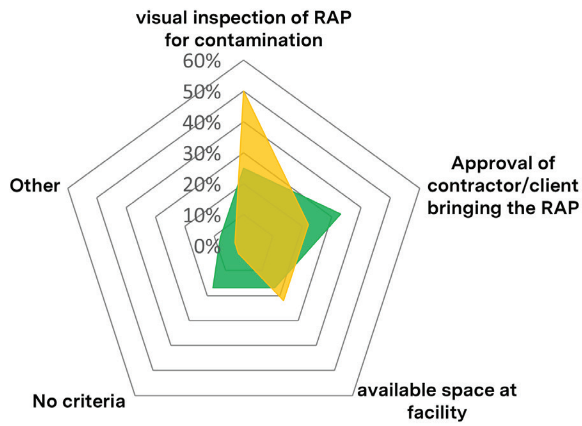

Figure 16 - Incoming RAP Quality Inspection at Municipal and HMA Producers / Contractors Facilities

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3.4 RAP Processing (Industry and Municipalities)

RAP is usually reclaimed from different sources with different material characteristics. The main objective of processing RAP is to limit variability and create a uniform and homogeneous stockpile through breaking apart agglomeration of RAP particles, reducing maximum aggregate size as desired, and screening RAP piles into different sizes for more controlled mix design.

During the processing operation, key precautions can significantly affect the quality of the RAP. **Figure 17** provides a bigger picture of the precautions taken by Ontario municipalities and private sector facilities when processing RAP. The only two municipal responses were “Stockpiling unprocessed RAP into layers” and “N/A”. This can be explained by the fact that RAP in most municipal yards is collected through millings from road projects built by the same municipality under similar material specifications; therefore, it requires less separation of stockpiles (**Figure 10**) and less processing efforts.

To reduce material variability and achieve the main objectives of the RAP processing operation, multiple options are available in the industry. RAP processing can be achieved through crushing, mixing, screening, or fractionation. **Figure 18** shows the Ontario state of the practice in RAP processing as collected from the 2020 Ontario RAP Survey. One observation that can be concluded by looking at the Municipal data in **Figure 18** is that RAP collected by Municipalities is usually pavement millings that come from consistent projects constructed under similar specifications, and therefore it would require minimum processing and stockpile separation efforts to maintain minimum material variability. Choosing the appropriate one or combination of processing methods depends on the following factors:

- Availability of tools and equipment
- Type of RAP available at a particular facility (milling, demolished pavement, Unknown Composition stockpiles).
- Agency specifications.
- Desired RAP gradation properties

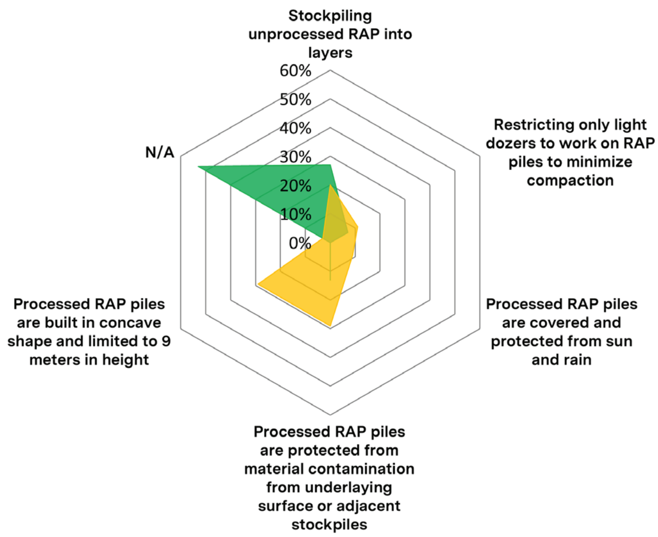

Figure 17 – RAP Processing Operational Precautions in Ontario

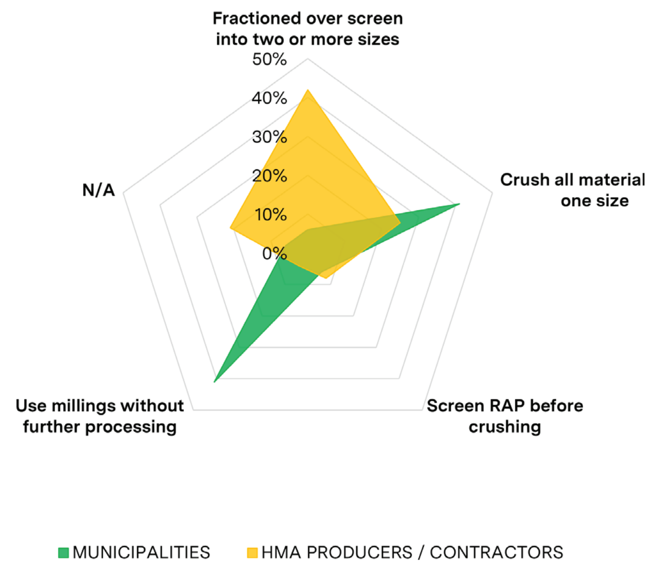

Figure 18- RAP Processing Methods in Ontario

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High variability of the RAP is commonly known as one of the major hindrances for incorporating higher amounts of RAP in the production of new hot and warm mix asphalts. Akin to many other areas, addressing an issue at its source can render considerable economic and engineering benefits compared to post-treatment of the symptoms. Improving the RAP management strategies in the following aspects can, therefore, contribute to lowering the variability of the RAP and improving the quality of incorporated mixes.

4.1 Stockpiling

Methods (Truck & Loader vs. Stacking Conveyor)

- **Ensuring Safety While Using Truck & Loader Method:** With traditional truck stockpiling methods for RAP, it is recommended that the small berms be formed on the stockpile paths at the upper perimeter to the height of the truck axle to mitigate accidents of trucks rolling over on top of stockpiles. The truck and loader method is usually used for stockpiling unprocessed RAP.

- **Improve Work Efficiency Through Stacking Conveyor:** It is highly recommended that incoming RAP millings or processed RAP be stockpiled through a stacking conveyor. Using crushing or screening plants with discharge conveyor systems presents opportunities for improving safety and increasing the possible stockpile size while reducing the time and cost of stockpiling RAP. However, some considerations need to be taken in consideration to prevent material segregation.

Protect from contamination

- **Paved Ground Surface**
  Having a paved surface under the stockpiles helps prevent contamination and sinking and assists in drainage. OPSS.MUNI.1150 requires that the surface under RAP stockpiles be paved or be constructed of compacted aggregates to limit contamination.

- **Avoid Using The Bottom Of The Stockpile**
  OPSS.MUNI.1150 requires that the bottom 0.3m of a RAP stockpile shall not be used if the sub-surface is not paved to avoid contaminating the mix.

Minimize Trapped Moisture

RAP holds water and does not drain as well as an aggregate stockpile, so efforts should be made to handle and store RAP in such a way as to minimize moisture content. Trapped moisture in RAP can cause the plant fuel consumption to significantly increase during production. Trapped moisture can also alter the true weight of materials going through the cold feeds and eventually affect the AC content in the final mix in continuous mixing plants. In batch plants, trapped moisture will affect the mixing required to remove the moisture from RAP, increasing energy consumption.

- **Stockpile Orientation:**
  The sun is a big, radiant heater. Meeker Equipment Co. Inc. found through their operations that they could reduce stockpile moisture content by half with managing the stockpile's orientation with respect to the sun, resulting in an overall fuel cost savings of 6-12%. - SOURCE
- **Pave & Slope:**
  • OPSS.MUNI.1150 requires that the surface under RAP stockpiles be sloped at a minimum of 3% to facilitate drainage and thus reduce drying time and cost during mix production. When moisture is present in the RAP source, it will naturally take more thermal energy to remove this variable, which causes strain on an asphalt plant producing the asphalt mix.

  • OPSS.MUNI.1150 also requires the surface under the stockpile to be either paved or compacted granular pad.

  • According to Simmons, 1996, a 4ft slope in a 75' wide RAP stockpile would lead to a decrease in moisture content by 2.1% between the front and the sloped back of the stockpile.

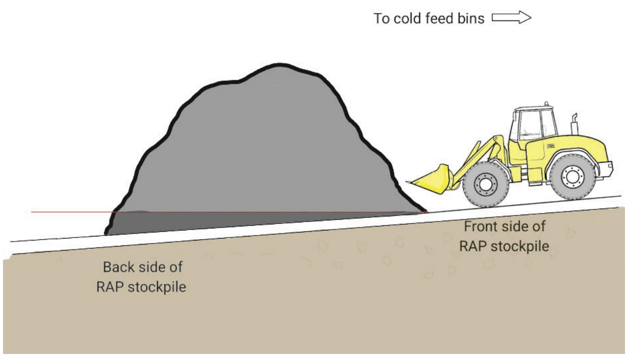


Figure 19- Managing Stockpile Moisture Through Sloping and Paving the Ground Surface

Material Type	Front Side Ground Level	Front Side 4' Level	Back Side Ground Level	Back Side 4' Level	Avg. Moisture Use Level
Sand	5.6%	5.2%	23.3%	5.8%	5.4%
Screen-ing	7.0%	6.0%	14.0%	7.2%	6.5%
No. 78	1.4%	-	4.4%	-	1.4%
No. 67	0.5%	-	1.5%	-	0.8%
No. 5	-	-	-	-	-
RAP (-1/2")	5.7%	5.6%	9.6%	5.7%	5.7

Table 6- Moisture in Stockpiles from HMA Plant in NC, USA (Simmons, 1996)

Small Individual Stockpiles:
Having separate daily processed RAP stockpiles in an order that allows the oldest RAP stockpiles brought from extraction to be put through the asphalt plant first would help stockpiles to dry more efficiently than if they were combined.

Good Roads

Protection From Rain
• Although more costly, covering the stockpiles where rain is very prevalent. Nevertheless, air circulation should not be prevented; therefore, directly covering with a plastic tarp is not recommended.

• According to J. Don Brock, 2007, the cost of building a cover structure for processed stockpiles would be paid back within 2.6 years due to increased production rates observed from lower moisture levels in the stockpiled materials.

Advantages Of Having Low Moisture:
• According to J. Don Brock, 2007, the fuel consumption for drum mixers would decrease by 25% for aggregates and RAP that has 6% moisture compared to one having 9% moisture. "A 1% decrease in moisture in your stockpile decreases your costs by 12% because your dryer doesn't have to work as hard," Bill Garrett, director of training at Meeker Equipment. SOURCE

• In addition to the benefit of decreasing fuel consumption, a decreased moisture content in stockpiles leads to higher production rates. According to Simmons, 1996, an overall increase in production rate of 83 tonnes per hour for Double Barrel mixer plants and 80 tonnes per hour for Counterflow Dryer mixer plant are observed when the ground below the stockpile is paved and sloped.

• Managing RAP source moisture is a crucial step in producing a consistent RAP material for the asphalt plant and field operations. A variable amount of moisture in materials going through the cold feeds can affect the AC content in the final mix in continuous mixing plants.

Minimize compaction

- **Protect From Rain:**
  Compaction due to rain can be avoided if the producer has a protective structure over the stockpiles.

- **Protect From Heavy Equipment**
  • Using scrapers or trucks (truck & loader stockpiling) compacts the stockpile with every lift, which is not desired.

  • When economically feasible, using stacking or radial conveyors reduces compaction while increasing productivity, stockpile capacity, and safety.

- **Adverse Effects Of Stockpile Compaction:**
  Compaction in the stockpile by any cause can affect materials costs. If a stockpile is 45 percent compacted, that same percentage is expected to be subtracted from any profit. - SOURCE

Minimize Segregation

- **Adverse Effects Of Material Segregation**
  Segregation occurs when different-sized particles separate, leading to inconsistencies in the mix composition. This can result in uneven distribution of aggregates and binder, compromising the structural integrity and durability of the pavement.

- **Mitigation Through Stacking Conveyor Systems**
  • When a variable height stacking conveyor is used, it should be set so that the drop point is as low as possible, and then raised as the stockpile is built.

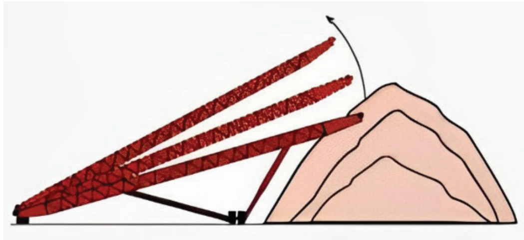


Figure 20- Variable Height Conveyor Best Practice Segregation (Jerry Nohl, 2000)

  • Radial stacking conveyors offer improved material distribution compared to traditional conical stockpiles by sweeping left and right to reduce segregation within the pile. However, some segregation of coarse materials may still occur along the outermost edges of the stockpile.

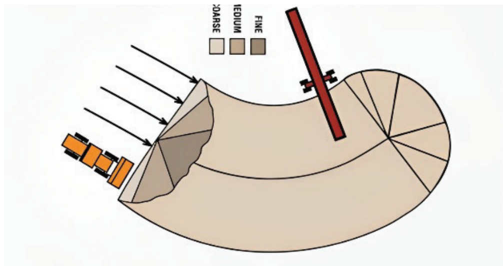
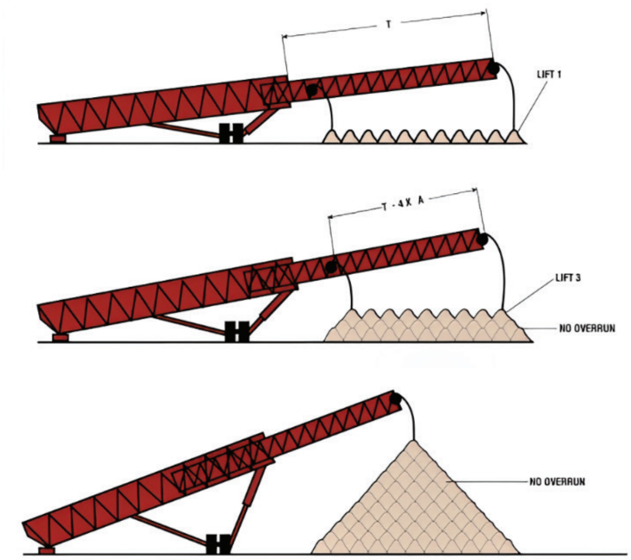


Figure 21- Radial Stacking Conveyor Limits Segregation (Jerry Nohl, 2000)

  • o Telescoping conveyor systems offer better results in limiting material segregation by building a stockpile through creating many small windrows. The segregation pattern in each small windrow will be repeated throughout the larger stockpile, leading to a more overall blending of materials.



Other Stockpiling Considerations

- **Strategically placing the stockpiles between the plant and concerned neighbours presents a sound barrier to keep the noise of daily operations from drifting into new neighbourhoods.**

- **Many producers elect to place their least-used materials furthest from the plant and closest to the edge of their property to cut down on equipment-operation noise.**

- **By planning the placement of material piles, aggregate suppliers and plant owners would have the opportunity to map out where stockpiles will be in relation to power lines.**

- **It is recommended to have a clearance of at least 10 feet from the apex of the stockpile and live power lines.** SOURCE

- **By pre-planning areas for RAP stockpiles, the facility manager can provide signage that eliminates confusion for loader and haul truck operators bringing in incoming RAP. This helps prevent material contamination.**

- **It is advantageous to collect and record material information on the RAP being collected/milled.**
  • Type of Grinding, resurfacing, full depth etc.
  • Excavation of Roadways, Parking lots, Driveways, Etc.
  For example, milling from resurfacing jobs could be FC2, FC1, 12.5 Superpave, HL3HS, HL3, etc. which all have higher AC contents, while full depth Grinding could have Surface Course mixes and Base course mixes blended together. Plants are encouraged to separate these piles if there is enough land space.

4.2 Processing & Crushing

Screening before crushing

- **Limiting Dust (P_{200})**
  • It is important to select the top size for the crushing operation. It is popular to select a top size so that the crushed RAP can be used in any type of mix. However, crushing to smaller top sizes will increase the dust content (percentage passing the No. 200 sieve) in RAP, which can limit how much RAP can be used in new mix designs while meeting criteria such as VMA and dust-to-binder ratio.
  • Since crushing RAP into smaller sizes will create significant amounts of dust, screening RAP before it enters any crushing equipment will allow the finer RAP particles to pass through the screen to bypass the crushing process.
  • When you process large amounts of RAP millings with lot of fines, a mobile screen helps to reduce wear costs and increase total production

- **Increasing Efficiency**
  • It is vital to screen off and remove fines before the crushing process to protect the wear parts from getting chewed up quickly, which affects maintenance and operations costs. In this case, the additional investment of a scalping screen can pay for itself.
  SOURCE
  • In cases where there is a need for large amounts of small-finished products such as ½-inch minus material, the onboard screen of a closed-circuit impact crusher might not have enough capacity and can become a bottleneck. In this case, a screening plant after the impact crusher helps increase production and lower wear costs.
  • The smaller the infeed or the finished products gets, the more screening capacity will be needed.

Fractionation

• RAP fractionation is the process of separating RAP based on top size to reduce variability and limit crushing effort as well as dust generated from unnecessary crushing.
• To address material variability, many jurisdictions have been using fractionating practices for RAP from similar sources, to separate the stream into fine and coarse fractions, acknowledging that different fractions can have different mobilized AC contribution (Saliani et., al., 2019). This will help lower the variability of the final mix production, especially concerning the binder content tolerances.

Benefits of Fractionation
• Limiting dust generation from excess crushing
• Allows for more control on the RAP blend to meet volumetrics in different mix designs.
• Reduces variabilities in stockpiles and provides increased consistency within each fraction
  ¬ Coarse fractions contain a lower asphalt cement content, while fine fractions have higher AC contents.
  ¬ Reduces the potential for segregation of the RAP, which can impact asphalt cement content.

Processing of millings

- **Considerations During The Milling Process:**
  • The nature of milling processes can affect the contamination in the reclaimed asphalt pavements. To this end, the milling process should be well controlled to avoid the introduction of any deleterious materials during the process.
  • During milling operations, managing extraction speeds and water control can prevent the addition of excess water in the RAP source.
  • The milling operation should be closely monitored and examined to ensure that the milled material is not contaminated with soil, geosynthetics, or other debris.
  • The truck loads should always be inspected upon arrival at the storage facilities for any deleterious materials resulting from excessive milling depth.
  • Milled RAP that is found to be contaminated, should not be used in Hot-Mix paving.

Good Roads

- **Limiting Dust (P_{200})**
  · It is recommended to limit any further crushing for milled RAP to limit further generation of dust. Milled RAP already contains significant amounts of dust (P200) due to the grinding and milling operations.
  · Screening and Fractionating milled RAP into two piles of coarser than typical NMAS and finer than typical NMAS is a good practice to limit further crushing and dust generation. It also allows for utilizing the milled RAP into HMA with the least processing cost and effort.
- **Millings From Multiple Sources**
  · Blending of material during processing operations is key to achieving a consistent stockpile from multiple RAP sources.
  · A bulldozer, excavator, or similar equipment is good equipment to be used to blend materials from different locations in the multiple-source RAP stockpile as it is fed into the screening and crushing operation to limit variability.
  · It is important to screen the milling products and break down the RAP agglomerations and scalping too large particles before introducing the RAP materials into a new mix production. Typically, this is achieved by postprocessing the millings in a separate space and before moving it to the stockpile, which also creates an additional opportunity of blending the processed millings to achieve better homogeneity in the stockpile and avoid segregation (Rathore et. al., 2021).

RAP Crushing

- **Crusher Types**
  · Horizontal Shaft Impact Crushers are the tool of choice for processing RAP, as it works by breaking down agglomerations of RAP while maintaining the aggregate gradation.
  ·Issues With Using Inappropriate Crusher:
    ¬ Using other types of crushers (such as Jaw or Cone crushers) to process RAP could result in crushing and splitting aggregates and altering the gradation. In addition to generating an excessive amount of dust materials.
    ¬ Using Cone crushers would repeatedly crush RAP particles to break it apart, resulting in stripping the asphalt coating from the RAP, creating white rock which will need additional asphalt to coat it when used in hot mix.
    ¬ The excess heat generated from using a Cone crusher to break down RAP can cause the RAP to harden and increase the stresses on the crusher's bearings, which could lead to extensive maintenance.
- **Reducing Maintenance Needs**
  · Avoid crushing and screening RAP that is wet or that has absorbed a lot of heat. When the RAP is wet or hot, it would become stickier and tend to build up on screen equipment, conveyor belts and clogs crushers, leading to additional equipment maintenance.
  · It is important to screen off and remove RAP fines before the crushing process to protect the wear parts from getting chewed up quickly.

4.3 Sampling & Testing

The properties of crushed RAP in the stockpile must be precisely known in order for it to be used as a component in a new asphalt mix. Material variability such as under/overestimating the binder contribution or degree of blending, can lead to premature distresses in the RAP incorporated paved mix. Determining if the RAP processing provides a consistent material over time requires regular testing and analysis of the RAP to ensure the stockpile variability is within the acceptable limits. The following is the recommended QC on RAP piles according to NCHRP Report 752 and OPSS.MUNI.1003:

Recommended Tests

- Gradation Test of Recovered Aggregates (Sieve Analysis)
  AASHTO T 30
- Consensus Properties of Recovered Aggregates
  AASHTO T 176, LS-629, ASTM D 4791, and ASTM D 5821
- Bulk Specific Gravity of Recovered Aggregates
  AASHTO T 84 and T 85
- Asphalt Cement Content (AC%)
  AASHTO T 164 or AASHTO T 308
- Recovered Binder Properties (PG Grading)
  AASHTO T 319 or ASTM D5404 and AASHTO R 29

Sampling Frequency

- For each stockpile, it is recommended that at least 10 samples be collected to calculate the variability statistics (Mean, Standard Deviation) of the material properties test results.
- When more material is added to the stockpile, it is recommended that minimum sampling and testing be conducted every 1,000 tons of added material, with a minimum of 10 samples.
- For Recovered Binder testing, the testing is recommended every 5,000 tons with one specimen.
- For the Bulk Specific Gravity, the testing is recommended every 3,000 with a sample of three (3) specimens.

Sampling Procedure

- It is recommended that samples be taken as the stockpile is being built to provide a representation of the entire stockpile.
- Samples from different stockpiles should not be combined, as the test results for each sample should reflect the existing variability statistics.
- Obtaining samples of existing sitting stockpiles should be done according to AASHTO T2(section X1.2) or ASTM D-75.03

Recommended Minimum Variability

- The recommended maximum standard deviation for a set of 10 samples is as follows:
    · 0.5% for AC Content;
    · 5% for Gradation on all sieves and 1.5% for the P200; and
    · 0.03 for Specific Gravity.

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Municipalities Consistently Supporting the Municipal Paving Forecast for the Past 5 Years