

**Technical Literature Review on Properties and Beneficial Use of
Reclaimed Asphalt Pavement in NYC**

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The Cooper Union for the Advancement of Science and Art

December 30, 2025

1. Introduction and Scope of Study

New York City's construction and infrastructure sector generates one of the largest construction and demolition (C&D) waste streams in the United States, with C&D debris accounting for almost 60% of the city's solid waste.¹ Asphalt pavement is a mixture of crushed stone aggregate and liquid asphalt binder often used in New York City infrastructure for roads, highways, and sidewalks. Due to its common usage on roadway resurfacing, reconstruction, and utility access work across the five boroughs, asphalt pavement represents a major portion of the demolition waste stream. Once it is broken up and removed, the material undergoes crushing, screening, and contaminant removal before being classified and joining the general C&D waste stream regulated under 6 NYCRR Part 360.²

Reclaimed Asphalt Pavement (RAP) is the resulting material from this process. RAP contains aggregates coated in an aged bituminous binder. Prolonged service life, oxidation, and traffic loading alter the binder's chemical and mechanical behavior, creating higher stiffness, reduced penetration values, and increased viscosity relative to virgin asphalt. These material changes directly affect performance and determine which beneficial use applications are technically appropriate and which require regulatory review.

In recent years, RAP has become increasingly important to New York City's decarbonization goals. In 2019, asphalt mix production emissions created a total of 21.7 million metric tonnes of CO₂ emissions.³ By substituting virgin binder and aggregate with RAP, embodied carbon and material costs lower significantly. The New York Department of Transportation (NYC DOT) also reports that its asphalt mixes contain an average of 40% recycled asphalt pavement, and in fiscal year 2024 the agency incorporated approximately 256,392 tons of recycled asphalt back into pavement production.⁴ Based on resurfacing output and typical milling, the actual quantity produced citywide likely falls between 300,000 and 1.3 million tons per year, indicating that RAP is not a marginal waste stream but a recoverable material resource with circularity potential. This range demonstrates that RAP is not a minor or incidental waste stream but a significant, recoverable material within New York City's construction and demolition sector.

This review evaluates RAP generated from roadway resurfacing, reconstruction, and utility cuts within New York City. RAP is defined as milled or crushed asphalt pavement consisting of mineral aggregate coated in aged asphalt binder, around 3-7% by mass. The scope is limited to horizontal infrastructure applications and does not include consumer products or architectural reuse, vertical building materials, roofing shingles, coal-tar products, or projects outside New York City. Included reuse options are hot mix asphalt (HMA), cold mix and recycling, granular base and subbase, cement-stabilized base, and general fill and embankment usages. Ultimately,

¹ NYC EDC. n.d. "CLEAN and CIRCULAR: Design & Construction Guidelines."

<https://edc.nyc/sites/default/files/2024-03/NYCEDC-Circular-Construction-Guidelines-03-07-2024.pdf>.

² NYS DEC. n.d. *6 CRR-NY IV B 360 Notes NY-CRR*.

<https://extapps.dec.ny.gov/fs/projects/part360/July2023/part360fulltextadopt2023.pdf>.

³ Ciavola, Ben et al. 2022. "GHG Emissions Inventory for Asphalt Mix Production in the United States: Current Industry Practices and Opportunities to Reduce Future Emissions." <https://trid.trb.org/View/1992922>.

⁴ NYC DOT. n.d. *Sustainability & Resiliency | NYC Street Design Manual*.
<https://www.nycstreetdesign.info/material/sustainability-resiliency>.

this report will determine which applications are most appropriate for New York City based on technical performance, regulatory status, and practical feasibility.

2. Material Properties

RAP has properties that are largely divided into three categories; physical, chemical, and mechanical. These properties, identified and outlined by the Federal Highway Administration (FHWA), provide context for the performance of RAP in practice.

During processing, all RAP produced is milled or crushed down to 38 mm (1.5 in) or less, with max top size of 51 mm (2 in) or 63 mm (2.5 in). The grading of RAP varies depending on milling/crushing method, aggregate type of original pavement, and whether base/subbase aggregates were mixed into during removal. The gradation of milled RAP is usually finer and denser than virgin aggregates. While crushed RAP is usually not as fine as milled RAP, it is still finer than virgin aggregates crushed using the same types of equipment. RAP is usually a well-graded coarse aggregate, with a variability somewhat higher than natural aggregates.

The unit weight of milled or processed RAP depends on the type of aggregate in the reclaimed pavement and the moisture content of the stockpiled material. The unit weight of RAP ranges from 1940-2300 kg/m³ (120-240 lb/ft³), which is slightly lower than natural aggregates. As unit weight of RAP increases, compacted density tends to decrease, due to the presence of aged binder and fines. The strength of blended mixtures improves over time as the aged asphalt binder contributes additional cohesion.

Stockpiled RAP normally contains up to 5% of moisture but can reach 7-8% if stored for long periods or exposed to rainfall. Moisture control is important because prolonged exposure increases water absorption in aged asphalt.

RAP typically contains 3-7% or 4.5-6% asphalt binder depending on the original mix. The recovered asphalt is significantly aged and hardened due to prolonged oxidation and weathering. At 25°C (77°F) RAP has penetration values of around 10-80, indicating stiffness, and at 60°C (140°F) RAP has viscosity values of 4000-25000 poises, which is much higher than fresh asphalt. The aging of RAP increases stiffness and viscosity gradually over time as the oils in binder oxidize, form resin, and develop into asphaltenes.

RAP is typically composed of 93-97% mineral aggregates and 3-7% asphalt. The mineral component is essentially the same as natural aggregates. Asphalt binder consists of two major groups which are asphaltenes (resins) and maltenes (oils). Oxidation and exposure to weather, environmental heat, and traffic, RAP binder is always more viscous than fresh asphalt.⁵

RAP generally has heavy metals, which can pose undesirable impacts on the health of animals and plants after prolonged exposure. However, batch and column leaching tests show that the release of these contaminants is low or non-detectable, and when detected, concentrations are typically below environmental and toxicological limits. Most prior research, however, has not

⁵ U.S Department of Transportation, Federal Highway Administration (FHWA). n.d. "Reclaimed Asphalt Pavement – Material Description - User Guidelines for Waste and Byproduct Materials in Pavement Construction - FHWA-RD 97-148."

<https://www.fhwa.dot.gov/publications/research/infrastructure/pavements/97148/046.cfm>.

fully examined the effects of chemical leaching out of aged RAP, and due to variability in RAP materials, further evaluation is necessary for concrete conclusions.⁶

Tables 1 and 2 summarize the physical and mechanical properties of RAP as well as what beneficial usage option each property affects.

Table 1. Physical and Mechanical Properties of RAP (FHWA, 1997).

Type of Property	RAP Property	Typical Range of Values
Physical Properties	Unit Weight	1940 - 2300 kg/m ³ (120-140 lb/ft ³)
	Moisture Content	Normal: up to 5% Maximum: 7-8%
	Asphalt Content	Normal: 4.5-6% Maximum Range: 3-7%
	Asphalt Penetration	Normal: 10-80 at 25°C (77°F)
	Absolute Viscosity or Recovered Asphalt Cement	Normal: 4,000 - 25,000 poises at 60°C (140°F)
Mechanical Properties	Compacted Unit Weight	1600 - 2000 kg/m ³ (100-125 lb/ft ³)
	California Bearing Ratio (CBR)	100% RAP: 20-25% 40% RAP and 60% Natural Aggregate: 150% or higher

Table 2. RAP Property-Impact Matrix (FHWA, 1997; Copeland et al., 2011; NYC OER, 2021).

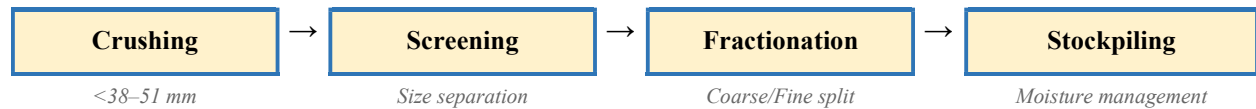
Property	Why It Matters	Affected Reuse Options
Binder Content (3–7%)	Determines available binder for blending; affects mix economics	HMA, Cold Mix (higher value with higher binder)
Binder Stiffness (aged)	Increases cracking susceptibility; requires grade adjustment	HMA (limits max RAP %), Cold Mix
Gradation Variability	Affects volumetric properties and QC consistency	All applications; fractionation improves control
Moisture Content	Impacts mixing at elevated temps; affects workability	HMA (requires drying), Granular Base
Contamination Potential	May limit applications near groundwater	Fill/Embankment (placement restrictions apply)
Angular Aggregate Shape	Provides excellent shear strength and stability	Granular Base, Fill (beneficial)

⁶ Ali, Ayman et al. 2017. “Environmental Impacts of Reclaimed Asphalt Pavement (RAP).” <https://www.nj.gov/transportation/business/research/reports/FHWA-NJ-2017-008.pdf>.

STAGE 1: RAP Generation



STAGE 2: Processing & QC

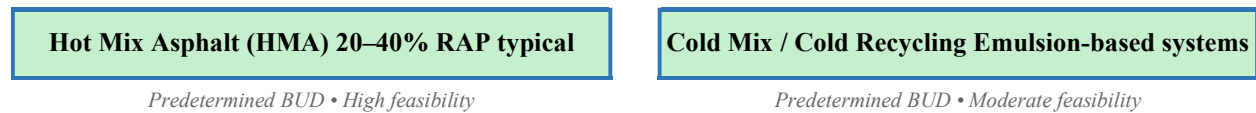


Quality Control Testing

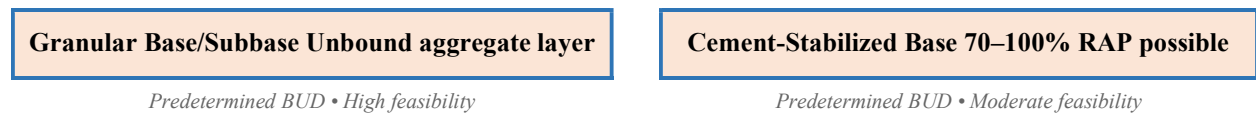


STAGE 3: Beneficial Use Pathways

High-Value Applications (Binder Recovery)



Structural Applications (Aggregate Value)



Fill Applications (Volume Diversion)



Note: Application selection depends on RAP quality (binder condition, gradation, contamination level). Premium material should be directed to high-value uses; lower-quality material to base/fill applications. All pathways shown have Predetermined Beneficial Use status under 6 NYCRR Part 360.12.

Figure 1. RAP Generation, Processing, and Beneficial Use Pathways (FHWA, 1997).

3. Beneficial Use Options

Beneficial use is defined as the substitution of an industrial non-hazardous material for either some or all virgin materials in a way that provides a functional benefit, meets product specifications, and does not harm human health or the environment. The New York State Department of Environmental Conservation (NYS DEC) regulates beneficial use within New York City primarily through Beneficial Use Determinations (BUDs) under 6 NYCRR Part 360.⁷ This designation may determine that certain materials ordinarily regulated as solid waste are no longer considered solid waste when they are used beneficially in specific ways, which exempts the material from being solid waste and allows it to be directly reused without additional solid waste permits.

Asphalt pavement has multiple beneficial uses under Part 360.12, where it is considered for both standard beneficial uses and predetermined beneficial uses. Two factors which are used to consider the applications of recycled asphalt pavement are the material's technical limitations and lifecycle performance.⁸

Technical and Operational Limitations

The technical limitations of asphalt pavement lie in its inherent properties as crushed stone aggregate coated in aged asphalt along with polymers, anti-strip chemicals, fines, and contamination from filling which severely limit beneficial uses. Asphalt binder melts and can release volatiles at high temperatures, meaning it is restricted to applications that don't involve high-temperature processes. The binder also cannot be easily separated from the aggregate, which limits its particle size to mainly millings, gradations, and blended granular material. Aesthetics also play a role in the beneficial use limitations of asphalt pavement, as its intense color, inconsistent shape, and weight are influences on asphalt pavement's lack of market for most consumer reuse applications.

The lifecycle performance of asphalt pavement directly limits the quantity and quality of potential beneficial uses. In most cases, reclaimed asphalt pavement already undergoes a full service life and degrades the material. The high oxidation, UV exposure, and traffic loading develop an aged binder with reduced adhesivity and flexibility and limit how many times it can be recycled into new performance-grade materials. RAP also becomes progressively lower-quality with each recycling cycle as the binder gets stiffer, gradation becomes finer, and performance reliability decreases. As a result, RAP is either mixed with additives or restricted to certain uses.

Despite its limitations, however, RAP also has very strong advantages that make it ideal for certain beneficial uses. Even after its service life, RAP contains high-quality, angular aggregates

⁷ U.S. Environmental Protection Agency (EPA). n.d. "Frequent Questions About the Methodology for Evaluating the Beneficial Use of Industrial Non-Hazardous Secondary Materials and the Beneficial Use Compendium."

<https://www.epa.gov/smm/methodology-evaluating-beneficial-uses-industrial-non-hazardous-secondary-materials-and>.

⁸ NYS DEC. n.d. "Beneficial Use Determinations (BUDs)."

<https://dec.ny.gov/environmental-protection/recycling-composting/businesses/beneficial-use-determinations>.

and residual asphalt binder, which gives it excellent compaction, good shear strength, reduced permeability, and high stability under traffic. This allows it to outperform plain gravel in many base and shoulder applications, and also reduces transport emissions, carbon footprint, and production costs. National usage data indicate the asphalt industry reclaimed approximately 98.1 million tons of RAP in 2022, with a national average RAP content of about 22.2% in mixes.⁹

The limitations associated with RAP which include stiffness, aging, and clumping are manageable as well. Additives such as virgin binder and rejuvenators, and grading control allow for safe RAP usage while staying within performance limits, which ultimately make it extremely effective for high-value, well-matched applications.

3.1 Hot Mix Asphalt (HMA)

When used as an ingredient in new hot mix asphalt (HMA), RAP functions as a direct substitute for both virgin aggregate and a portion of the asphalt binder. In this application, RAP is processed through crushing and screening to achieve a controlled gradation, and in many cases fractionated into coarse and fine components to reduce variability. Standard mix design procedures require extraction testing to determine the existing binder content and the stiffness of the recovered binder so that the final mix can be adjusted with softer virgin binder or rejuvenators as needed. Moisture testing is routinely performed to ensure safe and uniform mixing at elevated plant temperatures.

Including these adjustments maintains volumetric consistency and prevents mix instability at higher RAP percentages. Rather than fundamentally changing mix design, these processes align RAP with NYC DOT performance expectations, which is why RAP-based HMA has become standard in municipal resurfacing work.

The performance benefits become most evident when comparing direct material substitution. Because RAP retains both mineral aggregate and residual asphalt binder, each ton of material recovered displaces a proportional amount of virgin binder production and aggregate extraction. This explains why NYC has been able to achieve RAP blends of approximately 20–40% in standard mix designs without compromising specification compliance. The reported 256,392 tons of RAP incorporated in fiscal year 2024 demonstrates that this is not a pilot-scale initiative but an established practice capable of operating at a citywide volume.¹⁰ The environmental benefit is substantial, as this practice decreases the need for quarrying and virgin binder production while diverting large volumes of material from landfills. In this context, RAP is not supplemental but functionally embedded in NYC’s asphalt production stream.

NYSDOT specifications tightly regulate the allowable RAP percentages to maintain performance, limiting RAP to 20–40% depending on the mix type and traffic category. Despite

⁹ National Asphalt Pavement Association. 2024. *Asphalt Pavement Industry Survey on Recycled Materials and Warm-Mix Asphalt: 2022, 13th Annual Survey*.
https://www.asphaltpavement.org/uploads/documents/IS138-2022_RAP-RAS-WMA_Survey_WITH_APPENDICES_508.pdf.

¹⁰ Thorpe, Ben. 2024. “NYC Tests 50% Recycled Asphalt Mix for Durability.”
<https://www.equipmentworld.com/roadbuilding/article/15706986/nyc-tests-50-recycled-asphalt-mix-for-durability>.

this regulatory support, limitations persist. RAP's aged binder is significantly stiffer and more brittle than virgin binder, requiring binder grade adjustments to mitigate cracking susceptibility. These limitations originate from the engineering behavior of the aged binder rather than from the aggregate itself. In addition, highly variable stockpiles can introduce inconsistency if fractionation and QC protocols are not followed. Thermal constraints also apply; excessive heating further oxidizes the binder, restricting the maximum allowable production temperatures.¹¹ The binder's oxidation increases viscosity and reduces penetration values, which elevates cracking susceptibility if RAP proportions become too high without compensating adjustments. This is why fractionation and binder grade modification are necessary to realign RAP with expected performance. In short, the properties do not prevent beneficial use but define the thresholds and QC measures required for proper implementation.

The physical, chemical, and morphological properties of RAP directly influence its value in HMA as well. The aggregates remain structurally strong and angular, but the binder coating is oxidized, hardened, and difficult to strip from the mineral surface. This limits the availability of "clean" aggregate but still allows RAP to meet volumetric and performance criteria when properly blended with virgin materials. In New York City, where dense-graded HMA is standard for high-traffic pavements, the use of RAP is already an established construction practice and fully compatible with local production infrastructure.

Under 6 NYCRR Part 360.12, the use of RAP in HMA is classified as a predetermined beneficial use, meaning it is not regulated as a solid waste when incorporated into compliant asphalt mixtures and does not require case-by-case Beneficial Use Determinations. This places HMA in the strongest regulatory position of all the options evaluated in this report. Given these factors, HMA remains the most practical and immediately scalable pathway for RAP reuse in NYC. The following sections evaluate other applications that offer additional value but introduce more conditional performance requirements, logistical constraints, or regulatory specificity.

3.2 Cold Mix Asphalt and Cold Recycling

In cold mix asphalt and cold recycling applications, RAP serves as a principal aggregate component in asphalt emulsions or foamed asphalt systems that cure at ambient temperatures. Unlike HMA, this process does not require high heat, so RAP is only crushed and screened sufficiently to meet cold mix gradation envelopes. Additional testing evaluates moisture content and emulsion–RAP compatibility, ensuring that the emulsion breaks properly, coats the aggregate uniformly, and provides adequate curing and strength development. For cold-in-place or full-depth recycling, supplementary stabilizers such as cement or lime may be tested to achieve the desired structural properties.¹² This level of preprocessing is sufficient because cold applications rely on emulsion bond and compaction rather than thermal binder blending.

The key benefit of cold mix and cold recycling is the significant reduction in embodied energy and emissions since the process eliminates the need for asphalt heaters and reduces hauling volumes by performing recycling on-site. This creates a cost-effective alternative for low- and

¹¹ FHWA (n 5)

¹² FHWA. 2018. *Overview of Project Selection Guidelines for Cold In-place and Cold Central Plant Pavement Recycling*. <https://www.fhwa.dot.gov/pavement/asphalt/pubs/hif17042.pdf>.

medium-volume roadways and a sustainable method for extending pavement life with minimal material movement. Cold recycling is also advantageous when underlying layers need structural reconditioning, as it blends RAP with stabilizers to form a uniform, compacted base.

Regulatory treatment under Part 360 considers the use of RAP in cold mix and cold recycling as a standard beneficial use when it is applied directly back to pavement structures. However, limitations are more pronounced compared to HMA. Because the binder in RAP is highly aged and cannot be reactivated without heat, bond strength and early-age durability depend heavily on emulsion chemistry and moisture conditions. Cold mixtures also exhibit slower strength gain and reduced fatigue resistance relative to hot-mixed materials, restricting their use to specific roadway classifications.¹³ Variability in RAP gradation and contamination can further affect mix uniformity.

As a result of these material behaviors, the properties of RAP strongly influence its behavior in cold systems. The stiff binder film prevents significant blending with the emulsion, meaning the residual RAP binder primarily contributes as a stiff, coated aggregate rather than an active binder component. This interaction limits the total structural performance achievable compared to hot-mixed products but remains acceptable for reclaimed base layers and temporary surfaces.

In practice, cold recycling is increasingly practiced in New York due to limited street closure windows and the high cost of importing virgin aggregate. Thus, the method aligns well with local construction constraints and sustainability goals.

3.3 General Fill and Embankment Material

When RAP is used as general fill or embankment material, it functions as a granular construction material rather than a pavement component, meaning its performance is governed by soil mechanics rather than asphalt behavior. In this application, RAP typically undergoes minimal preprocessing beyond crushing, screening, and removal of oversized debris. No binder recovery or asphalt-specific testing is required; instead, compaction characteristics, shear strength, and gradation are evaluated similarly to other engineered fill materials.

RAP provides benefits in this context because its angularity and residual binder coating create a material with high shear strength, excellent compaction, and reduced permeability relative to conventional gravel.¹⁴ These properties make it suitable for shoulder backing, embankment stabilization, and non-structural fills. Its environmental advantage is also considerable, as large quantities of RAP can be beneficially reused without being landfilled, and the reduced permeability can mitigate infiltration in certain engineered applications.

Under Part 360.12, the use of RAP as general fill or embankment material is permitted but subject to more conditions than its reuse in asphalt mixtures. The material must be free of excessive contamination, placed above the groundwater table unless otherwise approved, and restricted from sensitive land uses. Technical limitations stem from the aged binder and fines content, which can create clumping, drainage restrictions, or frost-susceptibility depending on

¹³ FHWA (n 5)

¹⁴ Dager, Catherine H. et al. 2023. "Review of Geotechnical Properties of Reclaimed Asphalt Pavement for Reuse in Infrastructure." <https://doi.org/10.3390/geotechnics3010003>.

placement conditions. RAP's dark color may also absorb additional solar heat, which can be undesirable in some contexts. Because RAP cannot be cleanly separated into aggregate and binder, its particle morphology limits its suitability for applications requiring well-graded, draining aggregates or where visual consistency in surface appearance is required.

As a result of these conditions, the physical and morphological characteristics, specifically the asphalt-coated surfaces, are key drivers of its performance as fill. While the binder film increases stability, it also reduces interparticle drainage, making RAP less suitable for free-draining subbase layers unless blended with clean aggregate. The material is used in New York primarily for roadway shoulders, temporary access roads, and non-critical embankment applications, where performance expectations align with its engineering properties.¹⁵ When used strictly within these contexts, RAP fill is generally approved under a predetermined beneficial use, when used in accordance with placement restrictions and project-specific specifications, though large-scale fill projects may require additional review.

3.4 Cement-Stabilized Base Course

Loose RAP can serve as a high-strength foundation layer after it is chemically bound to become cement-stabilized base course. The process involves crushing RAP to a specified gradation, typically under 19 mm, followed by screening and blending it with 3-7% Portland cement and water.¹⁶ The mix design follows soil-cement protocols, where technicians must determine the optimal moisture content (OMC) and maximum dry density (MDD). Quality control typically relies on Unconfined Compressive Strength (UCS) testing, with project-specific strength targets commonly referenced in the 2-5 MPa range. Because the RAP aggregates are coated in aged asphalt, studies show that these mixes often require slightly higher cement contents and approximately 1-2% additional moisture to achieve comparable hydration and density.¹⁷

The primary advantage of cement stabilization is its ability to utilize 70-100% RAP content, far exceeding the limits of surface pavement layers¹⁸. If implemented at scale in New York City, cement stabilization could substantially increase landfill diversion and significantly reduce the carbon footprint associated with mining and transporting virgin aggregate, which is a major cost driver. Structurally, the chemical bonding between aggregate particles creates a stiffer layer that better resists rutting under heavy truck traffic compared to unbound aggregate bases that rely on mechanical interlocking, because chemical stabilization creates interparticle bonding rather than relying solely on frictional contact, a critical benefit for the city's major roads.

However, limitations include the rigidity of cement-stabilized bases, which makes them susceptible to shrinkage and reflective cracking. These mechanisms often require the inclusion of

¹⁵ FHWA (n 5)

¹⁶ FHWA. 1997. *User Guidelines for Waste and Byproduct Materials in Pavement Construction*. <https://www.fhwa.dot.gov/publications/research/infrastructure/structures/97148/>.

¹⁷ Ceratti, J.A. et. al. 2021. "Flexural strength, stiffness and fatigue of cement-treated mixtures of reclaimed asphalt pavement and lateritic soil." https://www.researchgate.net/publication/335615600_Flexural_strength_stiffness_and_fatigue_of_cement-treated_mixtures_of_reclaimed_asphalt_pavement_and_lateritic_soil.

¹⁸ Gupta, Ankit et. al. 2021. "Performance analysis of cement treated base layer by incorporating reclaimed asphalt pavement material and chemical stabilizer." <https://doi.org/10.1016/j.conbuildmat.2021.123852>.

stress-relief interlayers to prevent propagation of cracks to the asphalt surface. Furthermore, research indicates that the stiffness of these layers fluctuates with temperature due to the viscoelasticity of the residual asphalt binder on the RAP particles, requiring complex modeling for NYC's variable climate.

The regulatory pathway for this beneficial use option is established under Part 360 for ground or milled asphalt pavement when used in subbase, backfill of utility cuts, or in pavement mixes.¹⁹ Stabilized base aggregate is also recognized as an approved beneficial use category.²⁰ Given the mandates of Local Law 71 and the precedent of neighboring jurisdictions like New Jersey, which permits RAP in "Transportation Allowed Uses" and provides a regional precedent rather than a direct regulatory match, cement-stabilized base represents a promising strategy for NYC infrastructure, with expanded use offering many benefits.²¹ However, large-scale implementation in NYC would still require project-level specification approval and performance validation under local pavement design criteria.

3.5 Granular Base Layer

RAP that is recovered, crushed, and screened can be used as granular base or subbase material in a wide variety of pavement applications including roadways, shoulders, and parking areas, and this practice has been implemented by multiple state transportation agencies with satisfactory outcomes.²² A research study compared crushed natural stone with three RAP types (RAP 1, RAP 2, and RAP 3) and performed five groups of tests including optimization/material characterization, bearing capacity, permanent deformation, permeability, and full-scale box testing. The differences in RAP types were gradation, residual binder content, density, and asphalt penetration and softening points. The findings showed that RAP exhibits performance comparable to, and in some cases even better than traditional aggregates under controlled gradation and moisture conditions due to its residual asphalt binder, which enhances cohesion and stiffness. The study also highlighted the environmental benefits of RAP, such as reduced need for virgin aggregate extraction and decreased waste sent to landfills, and overall supported RAP as a structurally applicable and sustainable construction material, though proper gradation control and moisture management are needed for optimal performance.²³

RAP can function as a granular base material when treated and placed in accordance with project specifications, and in practice is partially blended with natural aggregate to optimize bearing capacity and reduce variability, aligning with common FHWA and DOT recommendations for base course design practice.

The material demonstrates favorable compaction behavior, lower permeability, and strong resistance to permanent deformation, making it suitable for use as a base or subbase layer. Standard AASHTO pavement design methods can still be applied in these cases, but layer coefficients or stiffness values may be adjusted when high RAP percentages are used to reflect

¹⁹ NYS DEC (n 2)

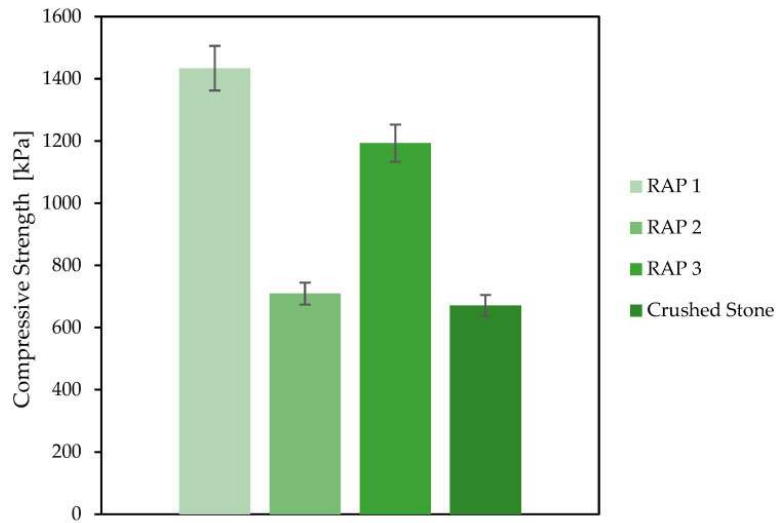
²⁰ FHWA (n 5)

²¹ NJ DEP. n.d. *Recycling Centers and General Permits for Certain Classes of Recycling Centers*.
<https://www.nj.gov/dep/dshw/resource/njac726a1.pdf>.

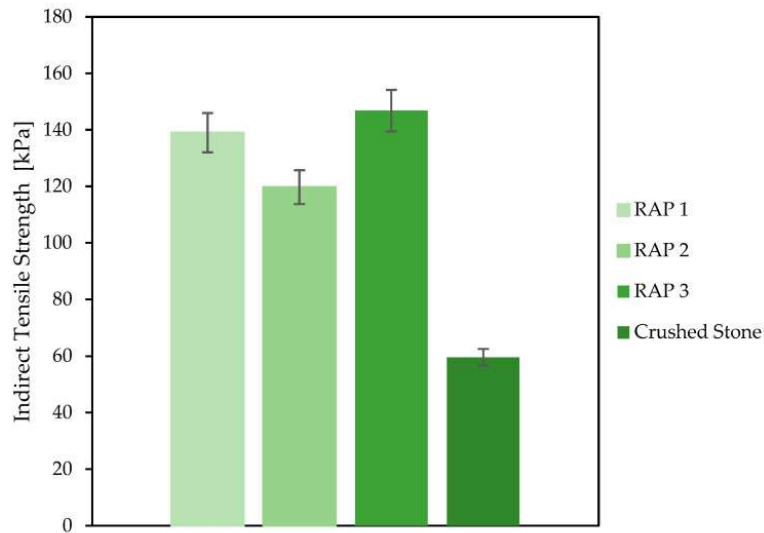
²² FHWA (n 5)

²³ Guerrero-Bustamante, Oswaldo et. al. 2025. "Suitable Granular Road Base from Reclaimed Asphalt Pavement."
<https://doi.org/10.3390/ma18040854>.

changes in modulus and drainage behavior. However, consistent field performance depends on moisture sensitivity control, fines management, and verification that the RAP source material is free from contamination or deleterious debris before placement.



(a) Simple Compression Test



(b) Indirect Tensile Strength Test

Figure 2. Indirect tensile strength and compression test results of RAP 1, RAP 2, RAP 3, and Crushed Stone. The results illustrate the effect of aged binder on stiffness and compressive behavior, supporting RAP's suitability for specific base and pavement applications when moisture and gradation are controlled (Guerrero-Bustamante, 2025).

Table 3 summarizes the beneficial use options discussed above as well as the regulatory status of each option.

Table 3. Part 360/BUD Status by Application (NYCRR; NYSDEC, 2025; FHWA, 1997).

Application	BUD Status	Regulatory Cite	Notes
Hot Mix Asphalt	Predetermined	360.12(c)(3)(ix)	Strongest regulatory position; routine approval
Cold Mix/Recycling	Predetermined	360.12(c)(3)(ix)	May require project review for high-traffic applications
Granular Base/Subbase	Predetermined	360.12(c)(3)(ix)	Standard approval for subbase use
Cement-Stabilized Base	Predetermined	360.12(c)(3)(ix)	Large projects may need spec approval
General Fill/Embankment	Predetermined w/ Conditions	360.12	Placement restrictions apply; above water table

4. NYC-Specific Context

4.1 Policy Framework

New York City has established a regulatory framework that positions the city as a leader in sustainable infrastructure. Local Law 71 of 2011 mandates a minimum of 30% recycled asphalt content in all new asphalt mixtures used in city projects.²⁴ This requirement exceeds national averages of approximately 15% for surface courses, 30% for binder courses, and 35% for base courses.²⁵

4.2 Current Initiatives

Green Asphalt Facility: The NYC Department of Design and Construction, in partnership with the Green Asphalt facility in Long Island City, has developed the only asphalt plant in NYC and one of very few nationwide that is producing 100% RAP hot mix asphalt.²⁶

50% RAP Pilot Program: In September 2024, NYC DOT launched a pilot program in Brooklyn testing asphalt mixes with 50% RAP on low-traffic streets. The program monitors 6.64 lane miles for durability and operational impacts, with potential to divert over 200 tons of waste daily if implemented citywide.²⁷

²⁴ New York City. 2011. *Local Law 71 of 2011*. https://www.nyc.gov/assets/buildings/local_laws/ll71of2011.pdf.

²⁵ Plati, Christina et. al. 2024. "A Critical Overview of Using Reclaimed Asphalt Pavement (RAP) in Road Pavement Construction." <https://www.mdpi.com/2412-3811/9/8/128>.

²⁶ NYC DDC. 2016. "DDC Features: Green Asphalt." <https://www.nyc.gov/site/ddc/resources/features/july-2016-green-asphalt.page>.

²⁷ NYC DOT. 2024. "Climate Week: NYC DOT Will Test New Asphalt Mixes Containing 50 Percent Recycled

4.3 Practical Constraints

Table 4 summarizes NYC-specific constraints affecting RAP beneficial use implementation.

Table 4. NYC Implementation Constraints (Copeland et. al, 2011).

Constraint	Description and Impact
Stockpile Space	Limited space for covered RAP storage; processed RAP retains 5–8% moisture and forms crust that complicates handling (FHWA, 1997) ²⁸
Plant Capacity	Only Green Asphalt facility currently produces 100% RAP HMA; other plants require upgrades for high-RAP processing ²⁹
Underground Utilities	Complex utility network limits in-place recycling; frequent street cuts disrupt recycled base layer integrity ³⁰
Winter Conditions	Freeze-thaw cycles and de-icing salt exposure require performance validation for high-RAP mixes ³¹
Street Closure Windows	Limited work windows restrict applications requiring extended curing (e.g., cement-stabilized base) ³²

5. Comparative Summary of Beneficial Use Pathways

When compared across technical performance, regulatory flexibility, and applicability to New York City’s operating conditions, RAP in Hot Mix Asphalt (HMA) presents the most established and scalable pathway due to its alignment with 6 NYCRR Part 360 predetermined beneficial use status and routine approval in resurfacing work. Cold mix and cold recycling offer sustainability advantages and reduced energy demand, but their field performance is more sensitive to moisture and curing conditions, limiting their use to specific roadway classifications and maintenance applications. Cement-stabilized base provides the highest potential for landfill diversion and structural capacity; however, it introduces stiffness and cracking risks that require stress-relief layers and project-specific review, particularly on high-volume traffic corridors. Granular base and subbase applications offer practical reuse with manageable QC requirements, but moisture sensitivity, fines content, and drainage behavior must be controlled to ensure consistency. Overall, the comparative assessment indicates that RAP is not a single-use material but a spectrum of viable options, with selection dependent on location, performance expectations, and regulatory compliance.

Road Pavement, Helping Reduce City's Carbon Footprint."

<https://www.nyc.gov/html/dot/html/pr2024/climate-week-new-asphalt-mixes.shtml>.

²⁸ NYC OER. 2021. "Asphalt Millings: Physical and Mechanical Properties."

https://www.nyc.gov/assets/oer/downloads/pdf/2021-02-01.Asphalt.Millings.Bank_Factsheet2.pdf.

²⁹ NYC DDC (n 26)

³⁰ NYC DOT. n.d. *Street Works Manual*. <https://streetworksmanual.nyc/>.

³¹ NYC DOT. n.d. *Sustainable Street Resurfacing*.

<https://www.nyc.gov/html/dot/html/motorist/sustainablepaving.shtml>.

³² NYC DOT. n.d. *Rules of the City of New York*.

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Table 5 provides a comparative assessment of all beneficial use pathways across key evaluation criteria.

Table 5. Beneficial Use Options Comparison (FHWA, 1997, 2018; NAPA, 2024; NYS DEC, 2025).

Option	Preprocessing	Key Benefits	Key Limitations	NYC Feasibility	BUD Status
HMA	Crush, screen, fractionate, extract binder test	Highest value; binder recovery; 15-25% binder savings	Max 20-40% RAP; requires grade adj.	High	Predetermined
Cold Mix	Crush, screen, moisture test	50-70% energy reduction; in-place option	Slow cure; moisture sensitive	Moderate	Predetermined
Granular Base	Crush, screen, compaction test	Minimal processing; good strength	Reduced drainage; moisture control	High	Predetermined
Cement-Stab. Base	Crush, OMC, UCS testing	70-100% RAP; max diversion	Cracking risk; cure time	Moderate	Predetermined
Fill/Embankment	Crush, screen, contamination check	Large volume diversion; low cost	Placement restrictions; leaching	Moderate	Pred. w/ Cond.

6. Conclusions

Based on technical feasibility, economic efficiency, and compatibility with existing production capacity, hot mix asphalt (HMA) remains the most viable and immediately scalable beneficial use pathway for New York City. The city's current 50% RAP pilot program and the capacity of local facilities to produce high-RAP mixes demonstrate that this application is ready for wider adoption. Unbound granular base follows as a highly viable secondary option. Because it requires minimal processing beyond crushing and screening, it offers a straightforward solution to the city's scarcity of local virgin aggregate. Cold mix asphalt and general fill and embankment represent conditional use options, viable primarily in niche contexts such as low-volume corridors, bike paths, and utility cut reinstatement where curing constraints and placement limitations can be accommodated. Conversely, cement-stabilized base course applications face logistical and operational constraints in dense traffic environments due to temperature sensitivity, curing windows, and staging limitations, despite offering superior structural capacity in controlled conditions.

Scaling these strategies requires overcoming significant material and operational barriers. The primary technical challenge is the condition of the aged asphalt binder, which becomes stiff and oxidized over time, increasing the susceptibility of high-RAP mixes to cracking. While

rejuvenators can mitigate this risk, consistent performance requires rigorous quality control, which may be a struggle in NYC due to the lack of space for covered stockpiles. A secondary challenge is the lack of long-term performance data for high-RAP mixes in NYC's freeze-thaw conditions. Although the city's 50% RAP pilot program will provide critical data, more monitoring will be necessary before widespread adoption of higher RAP contents in surface courses can be achieved.

Additionally, the material properties of a given RAP stream dictate its potential for beneficial use. Since the quality of a RAP sample depends significantly on the original pavement source and milling method, binder condition acts as the main limiting factor for beneficial use applications. Moderately aged binder is valuable for high-percentage HMA surface mixes, while severely aged binder is better suited for base layers where flexibility is less crucial. At the same time, gradation and cleanliness are equally important in determining potential use options. "Clean" RAP from surface courses should be reserved for premium pavement layers, while contaminated or highly variable material should be directed toward options like unbound base or fill. By implementing quality-based sorting, such as fractionating material to control gradation, NYC can ensure that premium material is utilized for structural pavement while lower-quality streams still find beneficial reuse. This approach prevents performance failures and maximizes the lifecycle value of the material, ensuring that high-quality resources are not wasted on low-demand applications.

To support scaling from pilot implementation to routine practice, three measures appear necessary: (1) multi-year performance monitoring of 50% RAP HMA to evaluate durability through seasonal cycles, (2) development of NYC-specific specifications for applications such as fill and embankment to establish acceptance criteria, and (3) clarification of Beneficial Use Determination pathways to reduce regulatory ambiguity and support contractor adoption.

Overall, the literature demonstrates that RAP is not defined by a single application but by a tiered hierarchy of suitability, with HMA and granular base representing the most dependable uses under current NYC conditions. Cold mix and cement-stabilized applications hold potential but require specification development, performance monitoring, and operational adjustments before widespread adoption. As such, RAP is best understood as a scalable resource whose value increases when material quality, placement conditions, and regulatory pathways are aligned.

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