Properties and Beneficial Use of Flat Glass Waste

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Introduction

Infrastructure is a central component of urban identity. For New York City, continual developments rise as the need for maintaining aging structures, expanding housing options and supporting new attractions grows. These factors contribute to the mass amounts of construction and demolition (C&D) work that goes on in the city, and with that, large amounts of C&D waste is generated. One construction material that is used in most projects involving building structures is flat glass, which is important in its use to allow natural light into buildings as well as trapping heat. In buildings flat glass, molten glass floated on tin with uniform thickness, is most commonly used for applications like windows, doors, countertops, and other architectural uses. Outside of buildings, flat glass is also seen in projects like pedestrian bridges where glass is used as part of handrail systems and in walkways/observation decks where glass is used as flooring. In the city, flat glass is also seen in infrastructure design such as in skylights/canopies as seen in transportation stations like Moynihan Train Hall, Penn Station and other train station canopies. The use of flat glass is an integral aspect of design for these structures as it introduces natural light into the stations and therefore reduces the usage of energy at these centers.

Flat glass used for construction is often not produced in NYC. Though there are local companies that can produce flat glass, urbanization and construction in the city leads to high demands that local production cannot meet. Most flat glass is produced out of the country where large flat glass imports to the United States come from Mexico and Vietnam with some more local glass production occurring in states like Ohio and Pennsylvania. The production of glass is a both labor and resource intensive task, which is why it is important to explore the means and methods that will reuse this material as it can be 'infinitely' recycled material without losing any of its material properties.

DSNY's draft Solid Waste Management Plan 2026 states that C&D waste makes up about 5.3 million tons of material that goes into NYC wastestream. [1] C&D waste is made up of a mix of material like soil, gravel, rock, concrete, asphalt and brick, so glass waste breakdown isn't clearly defined in the study or in construction and demolition debris handling and recovery facilities (CDDHRF) reports. Though glass makeup in C&D waste isn't clearly defined, it can be estimated that glass waste is roughly 265,000 tons of the NYC wastestream if glass makes up roughly 5% of the waste, similar to the glass makeup from residential recycling. Some ways glass waste enters the NYC wastestream include façade/window replacement, tenant fit-outs, full demolition. Façade and window replacements typically yield intact glass units that can often be reprocessed or reused with minimal processing, whereas tenant fit-outs and full demolition generate mixed shards and debris that require extensive sorting and cleaning. Manufacturing and installation offcuts usually consist of relatively clean fragments or uniform pieces, which are easier to collect and recycle efficiently. Due to the fact that glass waste is mixed with other debris, it makes recycling glass from C&D waste difficult as the glass will be contaminated and the cleaning process isn't the easiest. Another reason is due to difficulties at recycling facilities where the presence of mixed-colour glass with varying chemical compositions makes it hard to recycle as the process of sorting glass is required. These challenges have led to a high accumulation of waste glass and low recycling rates, thus highlighting the need for alternative application.

Recycling glass is important as it diverts non-biodegradable waste from landfills and conserves natural resources (aggregates, sand, limestone). There is a high demand of natural aggregates 40-50 million metric tonnes of crushed rock, sand and gravel, annually which is used for construction purposes. [2] While data from this paper explores specifically the beneficial use options of glass particular to C&D waste, it is important to note that large amounts of glass waste do come from elsewhere and mostly in the forms of glass bottles. Much research explored in this paper uses recycled glass bottles as there is a very clear and easy way for consumers to recycle their glass bottles as per regulations by DSNY. In contrast, the contamination with demolition debris makes it difficult to clearly separate the glass from other debris making it less likely to be recycled in the same means. In addition, glass wastes like broken glass are not to be put in recycling bins, making it harder to recycle these types of glass waste. However, all properties explored in this paper will still be able to apply to the flat glass used in construction pathways as these properties of glass explored can be reflected in flat glass that is used in construction.

Glass waste is an important focus in NYC's wastestream as seen in New York City Economic Development Corporation (NYCEDC)'s Circular Construction guidelines that aim to have NYC be carbon neutral by 2050. C&D waste makes up roughly 60% of NYC's local wastestream as well as contributes to 13% of carbon emissions [3]. The Clean Construction Executive Order 23 of 2022 55 commits all City capital project agencies to develop action plans to incorporate low-carbon concrete specifications, which can be applicable to the reduction of glass waste being discussed later in the paper.

Material Properties

Flat glass is classified as inert and nonbiodegradable, emphasizing the need to explore its properties for beneficial waste reuse pathways. It is a hard yet brittle material, with varying properties depending on the types and levels of processing. The general composition is silica (SiO_2, ~70-75%) for structure, soda (Na_2O, ~12-16%) to lower melting point, and lime (CaO, ~8-12%) for hardness and durability, with smaller amounts of magnesia (MgO, ~3-4%) and alumina (Al_2O_3, ~1-2%) for stability, sometimes including trace elements like iron oxide. These components come from raw materials such as silica sand, soda ash, limestone, and dolomite. Additionally, laminates, sealants, adhesives, and additives are often added during production and manufacturing to enhance the performance of architectural flat glass units. These units consist of single-pane window glass, double or triple-glazed insulating glass units (IGUs), laminated safety glass, curtain walls, and architectural glazing panels. These flat glass units end up in different conditions during demolition. During a full teardown, common forms include demolition shards, broken glass, and manufacturing scraps. In selective demolition, intact units are removed and collected from buildings, often being salvaged and assessed for reuse. The pre-processing of flat glass waste from demolition involves multiple stages, including segregation, contamination removal, and crushing. After pre-processing, the glass is commonly recovered as clean flat glass cullet, sorted by color, glass type, and particle size. There is also a mixed cullet that contains combinations of coated glass, tempered glass, and annealed glass, along with traces of sealants or adhesives.

Evaluating the quality of flat glass waste is crucial to determine the best recycling pathway, as its condition and properties vary significantly after demolition. The American Society for Testing and Materials (ASTM) helps govern the standards used in manufacturing and design. Many codes can help with quality assessments and reuse pathways, as glass plays an abundant role in construction. The ASTM E708 (Standard Specification for Waste Glass as a Raw Material for the Manufacture of Glass Containers) defines quality requirements for waste glass when it is reused as a feedstock in glass container manufacturing. [4] This code highlights the reuse of recycled glass, where it can be smelted into new glass material, like glass bottles. Both ASTM E3199 (Recycling and Reuse Life-Cycle Assessment) and ASTM C1866 (Ground-Glass Pozzolan for Concrete) talk about the evaluation of recycled glass for pozzolan and cement use. ASTM E3199 assesses the whole life cycle of products, like glass, and supports sustainable management, which can then be used in reuse pathways. [5] ASTM C1866 helps define glass as a supplementary cementitious material (SCM) in concrete, offering sustainability benefits by diverting waste glass from landfills and reducing concrete's carbon footprint while improving concrete performance against sulfate attack, chloride penetration, and freeze-thaw damage, and helping manage alkali-silica reactivity. [6] These pathways for reusing flat glass waste and their respective properties will be further explored in depth and Table 1 serves as a guideline for pathway selection.

It is also essential to consider how the demolition and pre-processing stages introduce environmental and health concerns. Because flat glass consists primarily of silica, mechanical size reduction during crushing and grinding, particularly when processing fine cullet for cementitious or pozzolanic applications, produces crystalline silica dust. These fine particles present an inhalation hazard and require careful control during pre-processing operations. In architectural flat glass, contaminants such as surface coatings, polymeric interlayers from laminated glass, and sealants or adhesives can affect mixed cullet streams. These materials can degrade the quality of the cullet, interfere with the efficiency of the remelting process, and limit its reuse in closed-loop applications, such as the production of new flat glass. High purity cullet intended for remelting is subject to contamination limits under ASTM E708 [4], while cullet used for SCM under ASTM C1886 may tolerate residual non glass components [6]. For cullet intended for filtering or applications involving water or alkaline environments, there is an elevated concern for leaching of trace metals from coatings.

Table 1: Summary of How Properties Drive Reuse & Recycling Options		
Property	**Effects/Purpose**	**Reuse or Recycling Options**
Particle size	Controls surface area, reactivity, and melting behavior; affects alkali-silica reactivity (ASR) in concrete	Fine particles enable SCMs, filters, and glass fines applications; blocks flat-to-flat or container glass recycling if particles are too fine or inconsistent
Coatings, laminatives, sealants, adhesives	Introduce organic and metallic contaminants that affect melting and chemical performance	Enables limited downcycling (aggregate, SCM if finely ground); often blocks flat-to-flat recycling unless removed
Color mixing	Affects optical clarity and melt chemistry	Mixed color cullet unsuitable for architectural flat glass; acceptable for container glass, foamed glass, or concrete
Specific gravity	Allows physical separation from non-glass debris	Enables gravity-based separation during processing; does not limit reuse but affects processing and efficiency
Angularity	Influences handling, compaction, and workability in concrete	High angularity may increase ASR risk in concrete; limits use as aggregate unless finely ground
Silica content	Determines melting compatibility and chemical reactivity	High silica content enables reuse in glass furnaces and SCM applications; requires control in cementitious systems
Condition at removal (intact vs. broken)	Determines the feasibility of direct reuse versus material recycling	Enables the direct reuse or salvage of intact flat glass units removed during selective demolition; blocks direct reuse when glass is broken during full demolition
Glass type (annealed, tempered, laminated)	Different glass types behave differently during crushing and melting	Enables downcycling into SCMs, fillers, or container glass; blocks flat-to-flat recycling when mixed glass types cannot be adequately separated

Beneficial Use Options

1. Open-loop Recycling of Waste Glass in Cement-based Materials

Due to contamination and color mixing, one effective way to minimize flat glass C&D waste is outlined in The New York State Department of Environmental Conservation (NYSDEC) Circular Construction guidelines which recommends open-loop beneficial glass reuse strategies in cement-based materials. To support this, several studies have been conducted to investigate the applications of glass waste in concrete, with two notable examples.

A 2020 study examines the potential of using waste glass as a partial replacement for clinker or as a cement additive in the production of Portland cement blends, due to its chemical composition and pozzolanic activity. The researchers collect post-consumer glass, as it contains the most SiO_2, the key component in the pozzolanic reactions where calcium hydroxide is released during cement hydration. The waste glass is then mechanically ground by milling into fine particles to activate pozzolanic behavior and reduce potential for alkali-silica reactivity risks (ASR). The typical size reported ranged from <100 µm to 10-20 µm. [7] At this stage, particle size distribution and fineness would be verified using ASTM C136 [18] and ASTM C204 [19], while chemical composition would be verified using ASTM C114 to identify residual coatings or contaminants that could affect hydration behavior. [20]

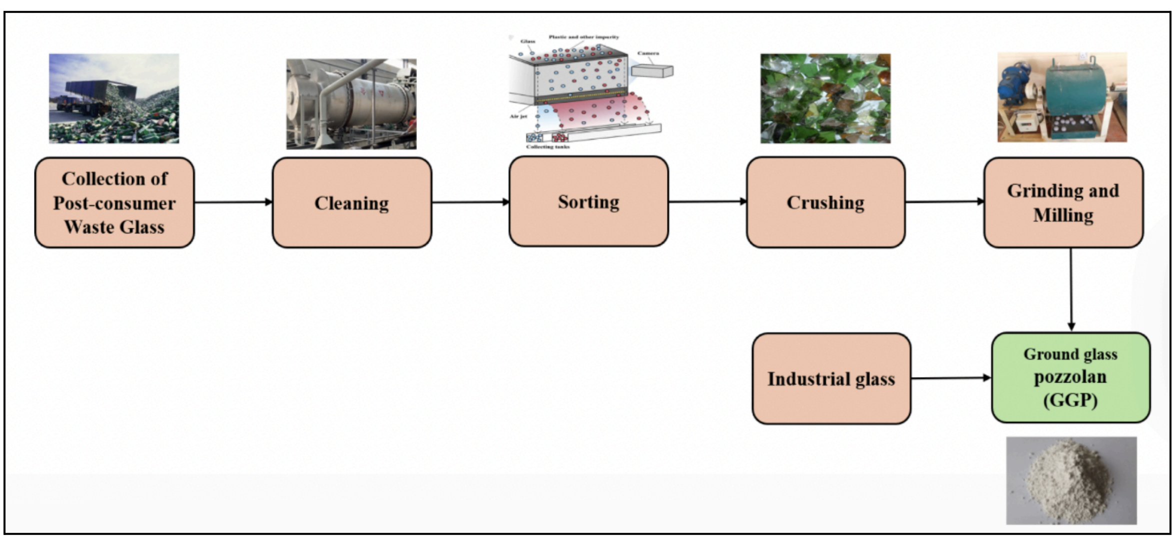

Figure 1: Flow Chart for Production of Ground Glass Pozzolan from Post-Consumer Waste Glass [21]

Portland cement blends containing ground waste glass and clinker were produced, and paste specimens were tested for mechanical performance. Tests were conducted with multiple clinker replacement levels using glass powder by weight. The results showed that replacement levels of 7.5% and 15% had higher compressive strength than the control samples after 28 days of curing. [7] It was also found that replacements higher than 30% can cause negative impacts, as insufficient amounts of $Ca(OH)_2$ remain to react with the silica, known as the dilution effect. [7] Additional limitations include a lack of explicit approval of waste glass as pozzolans in ASTM C618 code [22]; this requires project-specific approvals and adds regulatory risks for producers. Despite this, a reduction in clinker demand provides several benefits, such as reducing CO_2 emissions and lowering the total cost. [7] The cement industry contributes to 8% of global emissions, with 90% of that being due to the production of clinker, as it requires intense heating to facilitate calcination. [7]

Another option for the utilization of waste glass in cement-based materials is for the replacement of fine aggregates. In a study, the waste glass is processed into sand-sized particles and replaces natural fine aggregates at varying proportions in mortar or concrete mixes cured at standard conditions. The performance was evaluated through compressive strength testing supplemented by flexural strength and splitting tensile strength tests. From these tests, a replacement using glass at 20% produced the highest strength in concrete at 7 and 28 curing days. [7] However, at 28-56 days, the concrete showed a lower compressive strength than the control sample, revealing that the glass substitute exhibits early strength in the concrete. [7] Substituting 10-30% of natural aggregates with cullet can improve the compressive and flexural strength of concrete while simultaneously reducing water absorption and drying shrinkage. [7] However, when the replacement of fine aggregates with waste glass exceeds 20%, the mechanical properties begin to decrease proportionally [7]. Additionally, because waste glass has a lower specific gravity than natural aggregates, concrete samples that include waste glass as an aggregate tend to have lower slump density, making them well-suited for use in pavements and hydraulic structures. Key limitations arise when inspecting the microstructural properties. In the interfacial transition zone, the smooth and non-porous glass particles lead to weaker paste-aggregate bonding compared to natural sand. [7] Furthermore, without intensive milling to mitigate ASR, there is an increased risk of concrete swelling, which can lead to cracking. Long term durability would require verification through sulfate resistance testing ASTM C1012 [23], freeze-thaw resistance testing ASTM C666 [24], and chloride penetration testing ASTM C1202 [25], depending on exposure conditions.

This use of glass in the production of concrete can be seen locally in companies like KLAW Industries (Binghamton), creating cement replacements (Pantehon ™) from recycled glass for stronger, greener concrete. KLAW's glass cement alternative, called Pantheon, is being adopted in municipal projects within the city of Binghamton. KLAW's Pantheon is a partial cement replacement; KLAW removes unwanted materials from waste glass and creates a high-quality replacement for traditional cement. [8] It strengthens the concrete by reacting with cement to add additional crystal structures in the concrete. Their patent-pending process is able to handle high levels of contamination of glass. This initiative helps with lowering cement demand and helps lower carbon emissions. KLAW's Pantheon passed all requirements of ASTM tests and standard as air content, and the slump remained consistent when compared to mixes containing slag. [8] To facilitate widespread adaptation in NYC, it is important to address the bottlenecks. The city's glass waste streams are highly heterogeneous, creating challenges in ensuring a consistent supply of cullet without extensive preprocessing to control contamination and particle fineness. In addition, producing flat glass powder suitable for SCM applications requires energy intensive fine grinding and milling infrastructure, which is limited at a local scale. Regulatory barriers further constrain implementation, as waste glass is not recognized as a pozzolon and NYC agencies prefer standardized materials with demonstrated performance benefits.

Overall, open-loop recycling of waste glass in cement-based materials represents the most realistic pathway for NYC, leveraging existing concrete demands while reducing landfill disposal, lowering clinker demand, and cutting carbon emissions. With targeted investments in processing capacity, this pathway could be scaled across NYC sidewalks, pavements, and capital construction projects.

2. Glass as Secondary Filter for Wastewater Treatment

Speaking of waste in NYC, waterstreams in the area are also affected by waste which emphasizes the need for wastewater treatment so that clean water can be returned into the environment as well as waterstreams in New York. Research has been conducted to help explore the use of crushed glass material in water filters as means to assist with cleaning dirty or contaminated water. Through the testing, it was found that the crushed glass can be used as a substitute for sand in the filtration system. [9] It was observed that glass media dealt very well with wastewater with a high concentration of nutrients and bacteria and removed 90% to 95% of solids and chemicals in wastewater. [9] The glass filter performed much better than the sand filter in terms of total nitrogen reduction, at 1.5 times. In contrast, phosphorous removal was higher in the sand filter than the glass filter, at 51% and 40% reduction. [9] One drawback was noticed where if any residue or debris that might be left on the glass may affect its effectiveness. In the case of reusing construction material, because of the nature of construction sites, it is likely that debris and filth will catch onto the glass and the cleaning process will be a hindrance in the efficiency and likeliness of reusing glass.

Alternate research shows that recycled glass was more effective than silica sand at removing total suspended solids (94 % vs. 90 %) and turbidity (90.6 % vs. 86.0 %), likely due to its higher porosity and angular particle shape, however, silica sand outperformed recycled glass in removing phosphates (83.5 % vs. 46.7 %). [10] The research suggests that recycled glass can serve as a sustainable filter medium to improve water quality while reducing reliance on natural sand resources. Additionally, different sized glass cullets being used together in water filtration displays improved both permeability and turbidity reduction, achieving up to ~96.9 % turbidity removal and significant E. coli log removal, especially when used with coagulant pretreatment. [11] The results demonstrate that crushed recycled glass sand can be an effective and configurable filtration medium for improving water quality.

Crushed glass is seen as a viable material in filtration systems as outlined by the New York State Department of Transportation (NYSDOT) where as long as the recycled crushed glass fits the required specific sizing (100% passing 1/2 inch, 0-5% passing #200 sieve) [12]. Though the standard is a state level regulation and talks about using glass in filtration of geotechnical purposes, this standard shows that crushed glass is already a highly considered material when it comes to filtration systems. This initiative/precedent can mean that processes and methods can also be implemented into city level operations. Currently, most recycled glass in water filtration systems are most present and implemented in pool water filtration systems, not in large scale water filtration systems for the city. Most of NYC's drinking water source is being filtered at Croton Filtration Plant which uses sand filtration media. Since these studies show that the glass filtration systems can be as effective as sand media, slow integration of new material can be a good step forward to relieve the reliance of the natural resource of sand while not sacrificing water filtration quality as long as effective cleaning processes of glass is performed before its use on filtration systems.

3. Recycled Glass in Ceramic Manufacturing

For aesthetic purposes oftentimes material like tiles and other ceramics are used in construction. If glass can be used in the ceramic manufacturing to contribute to this process, it would display an example of circular economy that helps reduce the use of raw materials. Studies have been conducted to question the feasibility of using recycled glass in ceramics and how it affects its chemical and mechanical properties. Glass can influence sintering behavior and densification in ceramic batches. By incorporating different ratios of glass waste into clay-based ceramic bodies, the research evaluates variations in bulk density, porosity, water absorption, shrinkage, and strength after standard firing cycles. Testing shows that moderate glass additions (up to ~25 wt%) improve density, reduce water absorption, and enhance strength, while higher amounts can weaken mechanical performance and surface quality. [13] Firing shrinkage increases with glass content and temperature, whereas thermal expansion decreases. This study shows the testing of different concentrations of recycled glass contents in ceramic behavior and highlights how the material properties can be manipulated with the change of glass content in the ceramics.

Design standards of recycled glass ceramics include consideration of particle size distribution to ensure proper packing (0.1–50 µm) , homogeneous mixing, and predictable sintering behavior. [14] Verification of mechanical strength including ultimate tensile/hoop strength (29,000–58,000 psi) and flexural/modulus of rupture (22,000–73,000 psi) performance is critical to confirm that recycled glass ceramics will perform comparably under load and meet design requirements. [14] For coatings or surface layers, practical adhesion strength and abrasion resistance (scratch testing with defined indenter loads) are assessed to ensure durable wear resistance and to characterize failure modes related to hardness, fracture strength, and surface integrity. [15] Monitoring of impurities (metals, organics, or alkali content) and contaminant phases that could adversely affect firing behavior, densification, phase development, or long-term performance is also important.

Despite the high waste inclusion, the resulting tiles maintained technological properties comparable to conventional porcelain tiles in vitrification, low water absorption, and mechanical strength. These researches help with bringing notice to the applicability of a path toward more sustainable and circular manufacturing in the ceramic industry by valorising glass and ceramic wastes.

4. Reuse of Glass as Abrasives

Glass abrasives are rough glass, crushed and recycled, that is used to clear a surface of texture or grime without causing extra material damage. This can be seen in construction methods such as sanding ceramics, cleaning a surface, stripping paint, removing grease, etc. As the abrasives are being used, the material wears down which prompts for more use of the abrasives. Using recycled glass in the production of this material can be significant as it can reduce the use of raw materials like sand. Recycled glass can be reused where it is milled to super fine powder-like size that can then be used to make abrasives.

The glass cullet, crushed & recycled glass,with lower melting temperature, sample exhibited low density and high surface hardness, making it suitable for lightweight abrasive applications. Its irregular, sharp-edged particle morphology enhanced abrasive efficiency, while providing moderate surface roughness. [16] However, the sample showed relatively higher water absorption, attributed to weaker particle–matrix bonding and micro-voids within the composite. The glass cullet also demonstrated lower thermal conductivity compared to composites containing snail shell particles, indicating potential benefits where reduced heat transfer is desired [16]. Recycled glass has also proven to be an effective substitute for silica sand and other blasting media with coarser grades suited for heavy surface build-up removal and finer grades for industrial cleaning. Post-industrial glass cullets have shown to match or outperform silica sand, achieving higher cleaning rates and, in some cases, lower consumption rates. [17] However, due to medium breakdown during use, recycled glass abrasives are generally not suitable for multiple reuse cycles. Overall, the results confirm that recycled glass cullet is a material to create sustainable and economically viable abrasives, contributing to waste reduction and resource efficiency in manufacturing. Key acceptance checks for recycled glass abrasives include: controlling particle size distribution to ensure uniformity and abrasion behavior to confirm performance. Recycled glass abrasives are generally not suitable for multiple reuse cycles due to medium breakdown during use, but proper quality control ensures consistent cleaning efficiency and durability.

This practice is seen in many companies in the NY area that use recycled glass to make glass abrasive. Companies like GlassOx Abrasives™ and TruAbrasives use post consumer glass for abrasive blasting applications. Both companies use 100% recycled glass to create their abrasives that can be purchased by manufacturers or for applications that need to to abrasive material. Research and practice shows how this reuse pathway has already been implemented in our production lines. This highlights the need for more recycling of glass as there is a market that relies on this material to help with construction applications.

5. Recycled Glass as Photovoltaic (PV) Glass

One implementation that has been rising in application is the use of solar panels in NYC due to the amount of rooftop space available in the city. This helps with reducing carbon footing and reducing the reliance on other methods of non-renewable energy. Solar panels use glass to generate electricity without producing greenhouse gases which can be used for powering utilities in buildings, as well as other machinery or batteries.

Research has been done to display the use of recycled glass to help make new photovoltaic (PV) glass, a glass that generates electricity from sunlight, to be used in solar panels. It is important to note that most research shows the reuse of glass from decommissioned solar panels, not C&D waste. However, the materials of the PV glass are the same contents of waste that is seen in C&D waste of flat glass, soda-lime glass. Because of this, the use of C&D waste glass is a strong consideration that can be implemented into making new solar panels. This implementation also helps with sustainability in the solar industry, by reducing the reliance on virgin resources, lowering manufacturing emissions, and promoting a more sustainable lifecycle for solar technology. [18] This development underscores the importance of innovation in recycling processes and material recovery, paving the way for a more circular and environmentally responsible solar industry. A study compares the use properties of recycled PV glass to commercial glass and it can be seen that the recycled glass has a higher optical transmittance than commercial glass. [19] This heightened property is important as it can make the glass more durable, corrosion resistant, prevent degradation, and improve extreme temperature durability.

To meet PV applications, recycled glass must satisfy high optical purity and low-iron requirements because standard architectural glass contains significantly more iron impurities that reduce solar transmittance, whereas PV glass is manufactured with very low Fe_2O_3 content (often below

~0.015–0.015 wt% or ~150 ppm) to maximize transmission of sunlight across the solar spectrum. [20] Screening is also necessary to remove coatings, laminates, adhesives, and tempered layers from reclaimed panels before remelting, since these contaminants can degrade optical clarity and interfere with manufacturing of high-performance PV modules. [20]

Initiatives around actuating this application are already seen in companies like SolarCycle®, who use old and decommissioned solar panels from across the U.S.A. and have recycling facilities in Arizona and Texas that help with the recycling process of 95% of the whole solar panels, not just including the glass. SolarCycle® also participates in testing of the solar panels that will help with extending the life of the solar panels and aims to reduce the amounts of waste that is going to landfills. This stands as a great example in how recycled glass can be used to help reduce emissions and ties back to circular economy.

NYC Specific Context

New York City currently generates millions of tons of C&D debris annually, with a large share hauled out of the city and unevenly documented as material flows. This lack of comprehensive tracking results in lost opportunities for reuse and recovery. C&D waste in New York is regulated at the state level, with the NYSDEC collecting data from private waste haulers, transfer stations, recycling facilities, and landfills through mandatory reporting requirements. These datasets form the primary basis for understanding C&D waste streams within the state.

New York Senate Bill S5202 in 2025, to be in effect in 2026, directly addresses C&D waste by proposing a requirement for contractors in cities with populations of one million or more to recycle at least 50% of construction and demolition waste generated on-site, signaling a state-level shift toward higher diversion targets and accountability within the construction industry. If implemented, this policy would significantly increase demand for recycling infrastructure and markets for recovered materials such as glass, concrete, and metals.

The draft New York City 2026 Waste Management Plan from the DSNY outlines initiatives for reducing C&D waste. [21] A central component is the expansion and coordinated implementation of the Clean Construction Executive Order (EO23), which requires city agencies managing capital projects to increase recovery of C&D materials, minimize disposal, and prioritize sustainable materials management practices. These measures seek to identify more opportunities to incorporate recycled materials into infrastructure projects and explore options for low carbon building materials or materials with recycled content for construction.

DSNY plans to collaborate with C&D processors and other agencies to remove barriers to reuse and recycling, improve data on C&D flows, and identify vendors interested in remanufacturing or repurposing materials. Through this, it can be seen that the plan aims to develop incentives for reuse and recycling of C&D materials among industry players and reflect a shift toward better material tracking, circular reuse opportunities, and strategic use of recycled content in city projects. [21]

Local Law 97 establishes strict greenhouse gas emission limits for large buildings, requiring emissions reductions of 40% by 2030 and 80% by 2050. While the law does not explicitly mandate the recycling of glass waste, its emissions reduction targets indirectly incentivize material choices that lower embodied carbon and operational energy demand. Recycled glass contributes to these goals, as it displaces energy-intensive virgin-glass production and supports building materials, insulation, and renewable energy technologies such as solar panels, which rely on glass components. Strengthened recycled glass markets align waste diversion efforts with climate action goals, reinforcing the interconnected relationship between C&D recycling, circular materials management, and greenhouse gas reduction.

NYCEDC has issued circular design and construction guidelines that reinforce material recovery and circular objectives for publicly supported projects. These guidelines promote performance-based goals, including diverting at least 75% of C&D materials from landfills, calling for an early evaluation of material reuse and recycling pathways during the design phase [3]. For flat glass waste, this translates to on-site separation and coordination with remanufacturing or repurposing pathways rather than landfill disposal. While not legally binding, these guidelines work as an operational framework to influence contractor practices and materials selection.

Table 2: NYSDEC Part 360 / BUD Status for Flat Glass Reuse Pathways [26]			
Option	**Part 360/BUD Status**	**Conditions/limits**	**Source**
Fine Aggregate Replacement	Predetermined BUD	Must qualify as processed recyclable; used as aggregate; compliance with concrete performance and environmental standards	360.12(c)(4)(i)
Partial Clinker Replacement	Likely Case-specific BUD required	Not explicitly listed; may qualify as manufacturing ingredient but not specified	360.12(c)(4)(i); SCM not mentioned
Secondary Filter Media	Predetermined BUD	Allowed as drainage media; must meet processing and environmental criteria	360.12(c)(4)(i)
Ceramic Manufacturing	Predetermined BUD	High temperature manufacturing ingredient	360.12(c)(4)(i)
Reuse as Abrasives	Unclear	Not explicitly listed	360.12(c)(4)(i); Abrasives not mentioned
PV Glass Production	Not applicable	Requires ultra-high purity manufacturing scrap	Not within 360 BUD scope
Note: Although source material is flat glass, the table reflects the status of the material after processing (crushing, sizing, cleaning).			

Conclusion

This review presents uses of flat glass from C&D waste being a viable and underutilized resource in New York City as seen in the multiple beneficial use options explored. Among the beneficial use strategies examined, there are multiple that are already in practice around NYC as well as in the country. All this can be seen as precedent to help encourage the use and consideration of glass into different reuse pathways that will help align with circular economy guidelines and lower emissions in construction.

Most notably, ground glass used as a SCM or fine aggregate in concrete emerges as the strongest and most immediately applicable strategy that is already a highly practiced option. This use directly aligns with NYC's Clean Construction Executive Order 23, low-carbon concrete initiatives, and ASTM standards such as ASTM C1866. This is well suited to NYC's dense construction environment because they can absorb large volumes of material, reduce embodied carbon, and accommodate glass that is crushed and cleaned but not pristine. Secondary uses such as glass filtration media for wastewater treatment also show promise due to strong performance characteristics, though they are more sensitive to contamination and may be limited to controlled municipal or industrial settings. Higher-value closed-loop reuse pathways, including PV glass remanufacturing and ceramic tile production, demonstrate strong environmental benefits but currently face scalability, market, and geographic limitations that make them less immediately feasible within NYC's existing C&D infrastructure.

Despite this potential, several key challenges and knowledge gaps remain. The most significant barrier is contamination and heterogeneity of C&D glass, which is often mixed with concrete, sealants, coatings, laminates, and other debris during demolition. This limits the feasibility of high-purity reuse pathways and increases preprocessing costs. Moving forward, improved material tracking, expanded pilot projects, clearer BUD guidance, and incentives for local processors and end users will be critical next steps to scale beneficial reuse in NYC.

Across all strategies reviewed, material properties and conditions play a decisive role in determining beneficial use potential. Glass's high silica content, chemical stability, and infinite recyclability make it intrinsically valuable; however, particle size, surface condition, purity, and presence of coatings or contaminants ultimately dictate feasible applications. Finely ground, clean glass is well suited for pozzolanic reactions in concrete, while coarser or more contaminated glass is better matched to open-loop applications such as aggregate replacement or filtration media. Intact or low-iron glass, by contrast, is required for closed-loop applications like architectural or photovoltaic glass, making such pathways highly sensitive to recovery methods and demolition practices.

In conclusion, practical glass recycling/reuse pathways rely on prioritizing contamination tolerant reuse strategies while continuing to invest in standards, and infrastructure that integrate circular uses over time. By aligning material science, policy initiatives, and market development, flat glass C&D waste can shift from a persistent disposal challenge to a meaningful contributor to NYC's circular construction and climate goals.

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