The Cooper Union for the Advancement of Science and Art

Reusing and Recycling Construction and Demolition Debris:
Beneficial Use Potential of Dimensional Lumber in NYC

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1. Introduction

Dimensional lumber is wood, often softwood, cut and milled into standardized and consistent sizes. Because of this standardized size, ease of use, and affordability, in the United States, 93% of single-family homes and 90% of apartment buildings that are 4 stories or less use dimensional lumber as frames. In addition to framework, dimensional lumber is used in carpentry, decking, and interior design in both residential and commercial buildings. These applications, which include low-rise residential constructions, interior renovations, and temporary frame or fit-out work, are examples of vertical construction in the setting of New York City. Dimensional lumber is widely used not only in buildings but also in the construction of horizontal infrastructure throughout NYC. These applications are mostly temporary and include concrete formwork and falsework, construction staging and cribbing, excavation support and timber lagging, sidewalk sheds, and pedestrian protection structures needed for utility and roadway projects. Thus, in the construction and demolition of residential and commercial buildings, lumber is the most prominent debris material found in both full building teardowns and interior demolition. In its C&D characterization report*,* the Environmental Protection Agency (EPA) found that 67% of new construction debris and 42% of demolition debris were wood (EPA, 1998).

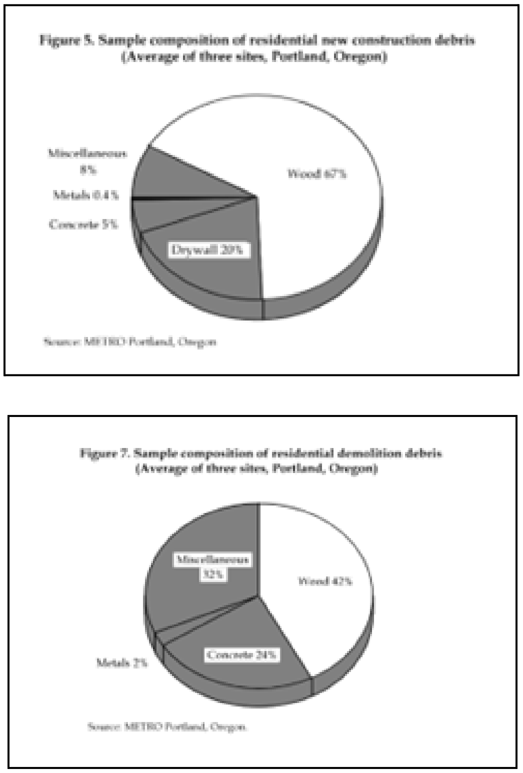


Figure 1*. Pie charts from the Characterization of Building-Related Construction and Demolition Debris in the United States report by the EPA on residential construction and demolition debris*
Source: *EPA. (1998).*

It is possible to estimate the yearly amount of dimensional lumber in New York City's C&D stream, but only with explicit assumptions and constraints on uncertainty. New York City produced about 6 million tons of construction and demolition (C&D) trash in 2019 (NYC EDC, 2024); this amount is considered an estimate of all NYC C&D waste, not national C&D generation. Since NYC building uses more concrete, masonry, and steel than the national average, applying the national EPA wood percentages (42–67%) directly to the city creates uncertainty. Therefore, rather than a specific value, it is ideal to depict wood waste in NYC's C&D stream as a range bounded by national data. According to these estimates, wood may make up between 2.5 and 4.0 million tons of NYC C&D trash. However, this amount should not be directly compared to reusable dimensional lumber because it represents total wood waste, which includes pallets, packing, engineered wood products, and fines. The recoverable material quantity is significantly less than the overall amount of wood waste since only a portion of this wood—mainly frame members from low-rise buildings, renovations, and temporary construction—can legitimately be categorized as dimensional lumber.

Another EPA report states that 52% of C&D waste was dumped in landfills in 2003 (EPA, 2009). The market is still mostly dependent on recently harvested wood due to the scarcity of recovered lumber. It takes about 27.2 kWh of power and 1,000 kg of rough logs to produce 1,000 board feet of 1.5-inch × 5.5-inch timber (Milota, West, & Hartley, 2005). Deforestation, carbon dioxide emissions, soil erosion, and habitat degradation are all impacted by this need for raw logs. Furthermore, Horne-Brine and Falk (1999) found that reclaiming just 25% of lumber from 2% of decommissioned buildings could supply approximately 25% of the lumber market. These results emphasize how crucial it is to reuse and recycle dimensional lumber because doing so lessens the need for virgin wood resources and lessens the negative effects of fresh timber extraction on the environment.

Recent legislation that dimensional lumber is subject to is the A3029 Assembly Bill that is in committee. This legislation will allow for the reuse of deconstructed building materials. Importantly, standards regarding reused lumber must be set by the building codes, and the secretary of state must develop a program to grade reclaimed lumber. In New York City, the Materials & VOCs Committee proposed amendments to the NYC Building Code and Administrative Code to use a certain percentage of reclaimed lumber as dimensional lumber, plywood or flooring (Material & VOCs Committee).

2. Material Properties Summary

Understanding the physical, chemical, and morphological characteristics of reclaimed dimensional lumber is essential for evaluating its applicability in both structural and non-structural applications. Because reclaimed wood can contain the effects of prior service life, its properties can differ significantly from newly milled lumber. This section summarizes the key material attributes of reclaimed lumber, outlines the conditions in which it is typically recovered, reviews the standards used to classify and evaluate it, and highlights the primary environmental and health considerations associated with its reuse.

2.1 Physical, Mechanical, and Morphological Characteristics

Reclaimed dimensional lumber shares the same basic cellulose composition as virgin softwood frame timber, but its mechanical behavior is modified by moisture cycling, service history, and damage from fasteners and deconstruction.

Wood strength and stiffness are strongly influenced by moisture content. As moisture content increases, there is loss in strength properties. Once fiber saturation point (FSP) is reached, 25-30%, excessive moisture content does not impact mechanical properties (Davis, 2012). Wood adjusts to the relative humidity of its environment. Variation in moisture content leads to changes in dimension, insect, and fungus attacks (Davis, 2012).

From a strength and stiff standpoint, reclaimed lumber typically retains most structural capacity; however, it may show some reduction relative to mill-produced lumber. In their multi-site Douglas-fir study, Falk, Cramer, and Evans compared reclaimed 2x lumber with in-grade data, and reported that for No. 2 and Select Structural grades, mean MOR (bending strength) values for reclaimed Douglas fir (DF) are approximately 17%-23% lower than those for mill-produced DF (Falk, 1999).From a strength and stiff standpoint, reclaimed lumber typically retains most structural capacity; however, it may show some reduction relative to mill-produced lumber. In their multi-site Douglas-fir study, Falk, Cramer, and Evans compared reclaimed 2x lumber with in-grade data, and reported that for No. 2 and Select Structural grades, mean MOR (bending strength) values for reclaimed Douglas fir (DF) are approximately 17%-23% lower than those for mill-produced DF (Falk, 1999).

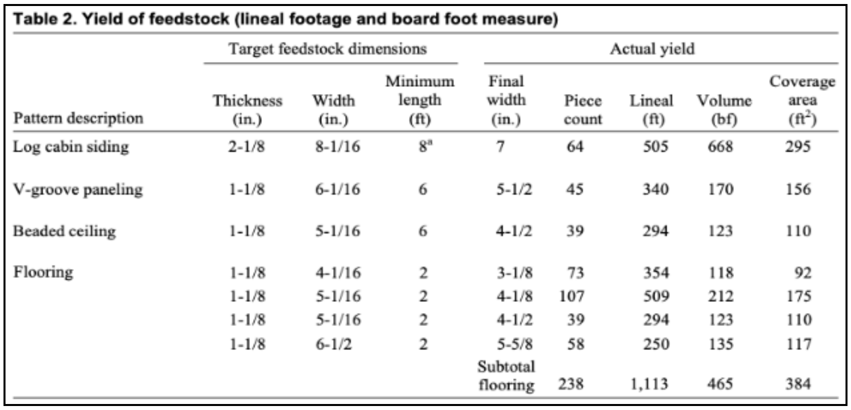


Table 2. Yield of feedstock (lineal footage and board foot measure)

	Target feedstock dimensions			Actual yield				
Pattern description	Thickness (in.)	Width (in.)	Minimum length (ft)	Final width (in.)	Piece count	Lineal (ft)	Volume (bf)	Coverage area (ft^2)
Log cabin siding	2-1/8	8-1/16	8[a]	7	64	505	668	295
V-groove paneling	1-1/8	6-1/16	6	5-1/2	45	340	170	156
Beaded ceiling	1-1/8	5-1/16	6	4-1/2	39	294	123	110
Flooring	1-1/8	4-1/16	2	3-1/8	73	354	118	92
	1-1/8	5-1/16	2	4-1/8	107	509	212	175
	1-1/8	5-1/16	2	4-1/2	39	294	123	110
	1-1/8	6-1/2	2	5-5/8	58	250	135	117
				Subtotal flooring	238	1,113	465	384

Figure 2. *Comparison of nominal dimensions and material yield for reclaimed Douglas-fir lumber relative to mill-produced stock, illustrating reductions in usable cross-section due to prior service life and deconstruction damage. This figure demonstrates how recovery processes affect material efficiency and must be accounted for in reuse design and grading decisions.* ***Source:*** *Falk, R. H., Cramer, S. M., & Evans, J. W. (2013).*

In contrast, stiffness degradation is comparatively modest. Evaluations of reclaimed Douglas-fir show modulus of elasticity (MOE) values that remain within historical ranges for the same grades, suggesting that reclaimed lumber often meets conventional serviceability assumptions even when strength reductions must be accounted for (Davis, 2012). Together, these results indicate that reclaimed lumber can perform acceptably in structural applications when designed with conservative strength adjustments.

Long-term performance of reclaimed lumber is governed by load duration, creep, and environmental exposure. Using Forest Products Laboratory data, Davis (2012) summarizes that sustained loading over decades can reduce effective strength to roughly 9/16 of short-term capacity, a relationship embedded in the National Design Specification through load-duration factors. Under permanent loads, allowable stresses are reduced, while short duration loads such as wind or seismic events permit higher design values, making duration effects especially relevant for salvaged members entering a second service life. Environmental exposure primarily affects near-surface material: temperature extremes influence strength and stiffness, but weathering progresses slowly, with erosion limited to only a few millimeters over a century. As a result, even very old timbers typically exhibit surface degradation with minimal impact on core structural properties (Davis, 2012).

The primary limitations of reclaimed dimensional lumber arise from localized defects and biological or chemical degradation rather than uniform material loss. Visual grading studies show that fastener holes, edge damage, checks, and splits frequently reduce assigned grades, with nail holes and mechanical damage being the most common causes of downgrade in salvaged 2× members (Falk et al., 1999). More severe losses occur when decay or chemical exposure is present; brown-rot and white-rot fungi can significantly reduce bending strength and toughness once decay is established (Davis, 2012). Nevertheless, many reclaimed members originate from old-growth timber with dense grain structure and low moisture content, contributing to dimensional stability and high-quality finishes when defects are trimmed. Remilling studies demonstrate that, despite reduced yield, the remaining material can be successfully repurposed into value-added products such as siding, flooring, and paneling, supporting selective structural and non-structural reuse (Janowiak et al., 2007; Falk et al., 1999).

2.2 Common Recovery Forms and Conditions

Reclaimed lumber is typically recovered from residential deconstruction, military buildings, pre-1950 industrial structures, and utility systems. U.S. demolition generates "...thousands of tons of waste earmarked for incineration or landfill disposal," (Davis, 2012), much of which is reusable lumber Falk et al. (1999) report that structural 2x4, 2x6, 2x8, and 2x10 members – studs, floor joists, and roof rafters – constituted roughly 40% of total lumber inside of buildings, a percentage that was "quite consistent regardless of building type" (p. 72). Their Table 1, "Lumber size distribution," shows that 2x8 floor joints accounted for 50% of pieces and about 63% of total board volume, showing how reclaimed lumber is heavily concentrated in floor and roof framing.

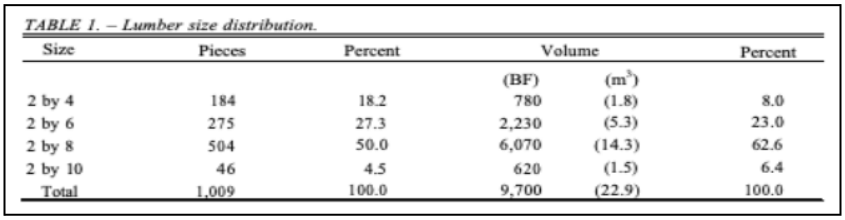
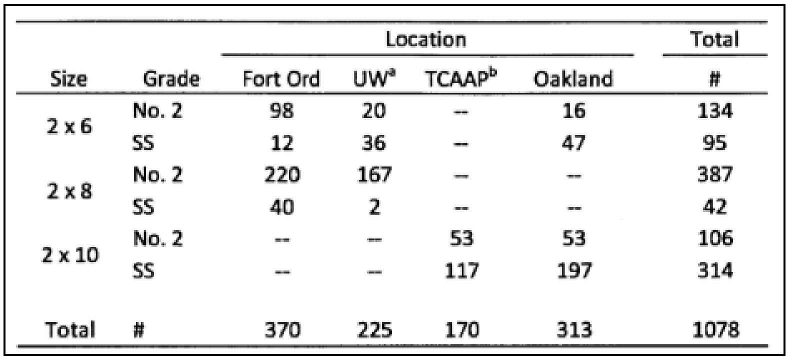


TABLE 1. – Lumber size distribution.

Size	Pieces	Percent	Volume		Percent
			(BF)	(m^3)	
2 by 4	184	18.2	780	(1.8)	8.0
2 by 6	275	27.3	2,230	(5.3)	23.0
2 by 8	504	50.0	6,070	(14.3)	62.6
2 by 10	46	4.5	620	(1.5)	6.4
Total	1,009	100.0	9,700	(22.9)	100.0

Figure 3. *Distribution of reclaimed Douglas-fir structural members by member type, percentage of use, and contribution to total board volume. Floor joists—particularly 2×8 members—dominate reclaimed lumber volume, highlighting their significance as primary targets for structural reuse and engineering evaluation.*
Source: *Falk, R. H., Cramer, S. M., & Evans, J. W. (2013).*

Recovered material frequently contains service-induced defects. During structural life, members accumulate nail holes, bolt holes, split ends, and occasional checking. There were defects in over 1,000 DF pieces during their testing program. Many pieces show preexistent damage, such as nail holes, bolt holes, and splitting, that must be recorded during evaluation (Falk, 1999). Davis also shows this in Table 5 of his report, listing typical size, grade, and defect distributions in reclaimed lumber samples, illustrating how frequently defects influence grading outcomes (Davis, 2012).



		Location				Total
Size	Grade	Fort Ord	UW[a]	TCAAP[b]	Oakland	#
2 x 6	No. 2	98	20	--	16	134
	SS	12	36	--	47	95
2 x 8	No. 2	220	167	--	--	387
	SS	40	2	--	--	42
2 x 10	No. 2	--	--	53	53	106
	SS	--	--	117	197	314
Total	#	370	225	170	313	1078

Figure 4. *Observed size and visual grade distribution of reclaimed Douglas-fir lumber tested in structural evaluations. The figure illustrates how service-induced defects influence grading outcomes and emphasizes the need for conservative design assumptions when reusing salvaged members.*
Source: *Davis, J. B. (2012).*

In addition, visual discoloration, weathered surfaces, and variations in moisture content are also common. Yet interior structural quality often remains strong. As Davis explains, weathering is primarily a surface effect, with structural fibers remaining “relatively unchanged” even in timbers exposed for centuries (Davis, 2012). Because reclaimed wood often originates from slower-grown, old-growth forests, it may contain higher density and narrower growth rings than modern plantation lumber, partially offsetting loss from accumulated damage.

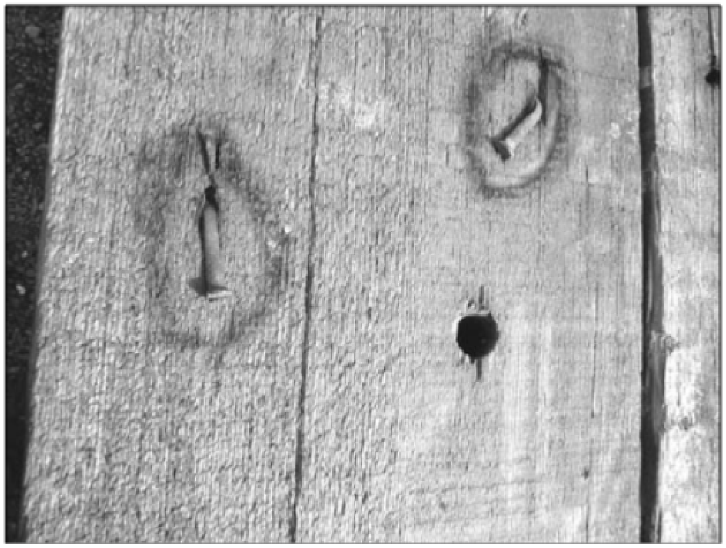


Figure 5. *Typical fasteners encountered in reclaimed dimensional lumber, including nails and spikes remaining from prior construction. These fasteners contribute to localized defects, grading reductions, and processing challenges, underscoring the importance of thorough inspection and de-nailing prior to reuse.*
Source: *Janowiak, J. J. (2007).*

Figure 6. *Example of edge decay and fiber separation in reclaimed lumber resulting from prolonged environmental exposure and prior loading conditions. While surface deterioration is evident, such damage is often localized, reinforcing the need to distinguish superficial degradation from core structural integrity.*
Source: *Janowiak, J. J. (2007).*

2.3 Relevant Standards for Classification, Reuse, and Structural Evaluation

Reclaimed dimensional lumber lacks formal recognition in many current standards, creating regulatory challenges. Falk et al. (2013) state plainly that reclaimed lumber is not officially recognized by engineering design or grading criteria, which unfortunately leads to inconsistent job-site approval (p. 492). This deficiency affects both grading agencies and building officials, resulting in reclaimed lumber sometimes being rejected despite having adequate strength. ASTM D1990 (structural lumber sample techniques), D198 (static bending tests), and D245 (mechanical property estimations) are ASTM standards that are pertinent to the examination of recovered timber. Prior to testing, Falk et al. (2013) chose parts that satisfied Select Structural or No. 2 visual grades to specifically align their testing of recovered Douglas-fir with ASTM D1990 standards. Ensuring that reclaimed lumber may be assessed with the same engineering rigor as new lumber; these standards enable equivalent characterization of strength and stiffness. Allowable design values continue to be governed by the National Design Specification (NDS) published by the American Wood Council. To ascertain whether adjustment factors are necessary, performance-based reuse systems frequently compare the MOE/MOR values of recovered lumber with NDS reference data. Figure 7 illustrates this by contrasting historical MOE/MOR averages with small-clear test data, revealing that reclaimed Douglas-fir stayed within a predictable statistical range (Davis, 2012). Although not yet standardized, the ASTM and NDS frameworks work together to offer a mechanism to use salvaged dimensional lumber into official engineering design.

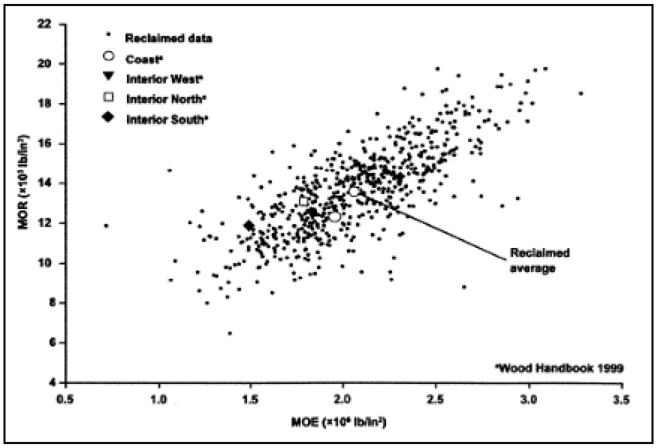


Figure 7. *Comparison of modulus of elasticity (MOE) and modulus of rupture (MOR) values for reclaimed Douglas-fir lumber against historical averages and small-clear specimen data. The figure demonstrates that reclaimed lumber generally falls within predictable statistical ranges, supporting its potential use in engineered structural applications with appropriate adjustment factors.*

Source: *Davis, J. B. (2012).*

2.4 Environmental and Health Considerations

Reclaimed lumber has many environmental benefits, but there are several health and safety issues to consider. When material is recovered from specific structural systems, chemical preservatives pose a risk. According to Davis, chromated copper arsenate (CCA) and other preservatives are present in utility poles and certain industrial timbers. A cross-section of a CCA-treated pole is shown in Figure 15 (p. 35). Reuse uses for these compounds are restricted to non-residential or non-interior settings due to handling and disposal issues.

Figure 8. *Cross-section of a chromated copper arsenate (CCA)–treated utility pole, illustrating preservative penetration patterns within treated wood. This figure highlights the health and regulatory concerns associated with reusing chemically treated lumber, which restrict its application primarily to non-residential or exterior uses.*

Source: *Davis, J. B. (2012).*

Other issues include surface pollutants and lead-based paint, especially in dwelling stock built before 1978. During cutting, sanding, or planing, these residues pose a risk to workers even though they are not chemically bound to the wood fibers. There are biological risks as well. According to Davis, brown-rot and white-rot fungi can cause strength reductions of up to 50% (Table 4, p. 15). Lumber rescued from poorly ventilated constructions may potentially develop moisture-related mold, which calls for cleaning before reuse.

When contamination is eliminated, most of the reclaimed dimensional lumber maintains its structural integrity despite these worries. Reclaimed lumber has many positive environmental attributes, such as carbon sequestration and low embodied energy in comparison to new materials, according to Falk et al. (2013) (p. 493). De-nailing, cleaning, grading, and identifying any chemical treatments are all examples of proper preprocessing that guarantees the material is suitable for reuse and avoids cross-contamination on building sites. Reclaimed lumber may reduce landfill waste and play a key role in sustainable construction with the right management.

3. Beneficial Use Options

3.1 Engineered Lumber

a) Engineered wood is man-made wood created by binding, wood fibers, particles or veneers using adhesives. Two common types of engineered wood are glue laminated timber and cross laminated timber. Glue laminated timber (GLTs) has structural timber layered and glued in the same direction as the planks, on top of each other. This orientation allows GLTs to be used as beams, columns, and roof trusses. Cross laminated timber (CLTs) is manufactured the same but, instead, each layer alternates its direction by 90 degrees. CLTs are more appropriate to use in walls, ceiling, and flooring.

b) To ensure structural integrity, any salvaged lumber feedstock must be visually inspected for any defects, knots, fasteners, and coating. Any contamination must be removed before being used in CLTs and GLTs. Trimming edge damage will improve the grade of the lumber by 18% (Falk, 1999). Due to its previous use, each CLT panel must be mechanically graded to ensure that it meets structural standards. However, traditional re-grading requires prior data on the homogenous species of wood (Bergsagel, 2019). Since salvaged wood panels are heterogeneous, a more appropriate test will be to grade using the MSR (machine stress rated) test (Arbelaez, 2019).

c) Using engineered timber opens opportunities to use lower grade reclaimed feedstock, which has little demand in the market, and processes it into a more viable and stronger wood product.

CLTs made from reclaimed lumber matched and even succeeded in the stiffness of E3 grade 3-ply benchmarks (Arbelaez, 2019), thus they are alternatives to CLTs made from fresh lumber.

d) Because CLTs and GLTs are emerging technology in the U.S., manufacturers have not explored using wood waste in CLTs and GLTs. However, by aiding local CLTs and GLTs manufacturers in developing wood waste feed stock programs, there will be less demand for fresh lumber imports (Bergsagel, 2019), leading to an inexpensive material. However, CLTs and GLTs must overcome marketability, as fresh lumber is most likely to be preferred over recycled wood products. There is also concern that older dimensional lumber will be contaminated with hazardous materials such as lead-based paint, Polychlorinated Biphenyls, and asbestos (Davis, 2012). Thus, as previously mentioned, salvaged lumber must be visually inspected for any contamination in preprocessing.

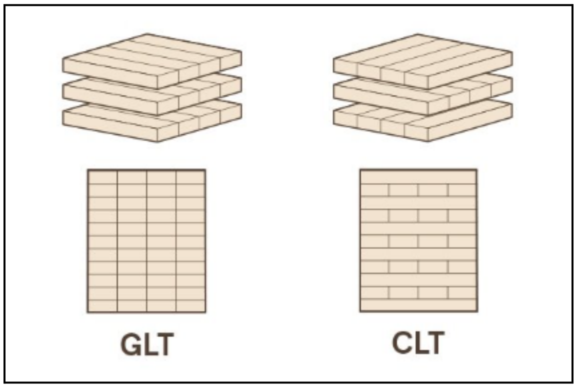


Figure 9. *CLT and GLT manufacturing enables lower-grade reclaimed dimensional lumber to be reconstituted into high-performance structural products. This pathway represents the highest-value reuse option for reclaimed dimensional lumber when contamination and grading requirements can be met.*
Source: *Author-compiled schematic; concepts summarized from Arbelaez (2019) and Bergsagel (2019).*

3.2 Composting

a) Composting represents a biological recycling pathway for certain fractions of construction and demolition wood waste, particularly untreated and finely processed material. Within a circular-economy framework, composting is positioned as a recycling or soil-enhancement strategy rather than an energy-recovery pathway, aiming to return organic carbon and nutrients to the soil system (Abdolmaleki et al., 2025). Research summarized in the review shows that wood-derived fines from construction and demolition waste can be incorporated into soil blends to improve plant growth, carbon assimilation, and nutrient retention when properly sized and proportioned. In this context, recycled lumber compost is not intended as a primary structural reuse but as a means of diverting low-grade wood waste from landfills while contributing to landscaping, soil amendment, and ecological restoration applications.

b) Successful composting of recycled lumber requires extensive preprocessing to ensure biological compatibility and environmental safety. The literature emphasizes that wood waste must be carefully sorted to isolate untreated wood from preservative-treated, painted, or engineered products, which contain resins or chemicals unsuitable for composting (Abdolmaleki et al., 2025). Size reduction through crushing or grinding is typically required to produce small particles that can biodegrade effectively and integrate uniformly with soil media. Experimental studies reviewed by Abdolmaleki et al. indicate that particle size plays a critical role, with mid-range wood fines demonstrating the most favorable effects on plant growth when blended with clay loam soils. Without adequate screening and particle control, composting performance declines and environmental risks increase.

c) The primary benefits of composting recycled lumber include landfill diversion, modest carbon sequestration in soils, and improved soil structure and fertility for non-agricultural applications. Composting also represents a relatively low-technology and locally deployable option compared to advanced recycling or energy-recovery systems (Abdolmaleki et al., 2025).

d) But there are a lot of restrictions. Only untreated wood is appropriate; markets for wood-based compost are frequently small and isolated, and contamination hazards are considerable in mixed demolition streams. As long as the material satisfies clean-wood requirements and is processed at an authorized composting facility in accordance with applicable solid-waste and organics regulations, composting clean, untreated dimensional lumber is permitted as a predetermined Beneficial Use Determination (BUD) under NYSDEC Part 360. This preset beneficial-use pathway specifically excludes lumber that has been painted, coated with preservatives, or is chemically tainted. This emphasizes the necessity of thorough sorting and testing prior to composting being deemed a suitable reuse approach in New York State.

3.3. Wooden Bricks

a) This beneficial use pathway involves making lightweight wooden bricks composed of wood waste fibers. Currently, available data are limited to wooden bricks made of 70.15% raw poplar fibers by volume (Shuai Zhang, 2019). These wooden bricks demonstrated promising compressive strength, with an average value of 160 psi (1.11 MPa), while maintaining a very low density of 0.035 pounds per cubic foot (Shuai Zhang, 2019). These results may be extendable to other types of wood and wood waste; however, further testing and research are required to confirm feasibility across different species.

b) In preprocessing, dimensional lumber must be inspected and cleaned of any fasteners, paint, or other contaminants, as the material must be processed into sawdust and then pulverized into fibers. In experimental poplar wooden bricks, the fibers were mixed with calcium hydroxide, which served as an adhesive, using a mixture ratio of 14.91% poplar fibers and 85.09% $Ca(OH)_2$ by mass (Shuai Zhang, 2019). The mixture was then placed into a squeeze die, molded using a cold press machine, and finished by drying in an air-drying house (Shuai Zhang, 2019). Because wood waste would be used instead of poplar, the composition of the mixture would likely depend on the species of lumber used.

c) The key benefit of these wooden bricks is that they do not require the dimensional lumber to meet specific grade, strength, or size requirements. As a result, dimensional lumber waste that cannot be reused in higher-value applications such as CLTs or GLTs can be processed into these lightweight wooden bricks. Additionally, durability testing of these wooden bricks in a non-load-bearing wall showed no observed fissures for more than one year (Shuai Zhang, 2019), indicating promising durability and longevity. Additional benefits include lower environmental impact, reduced demand for fresh lumber products, and an overall ecofriendly alternative to conventional dimensional lumber.

d) However, several drawbacks remain. Research and development on wooden bricks made from wood species other than poplar are limited, meaning the feasibility of using mixed wood waste fibers has yet to be fully explored. Furthermore, technical standards specific to wooden bricks made from reclaimed lumber have not been established. While a market for wooden bricks exists, the market for wooden bricks produced from reclaimed dimensional lumber remains limited.

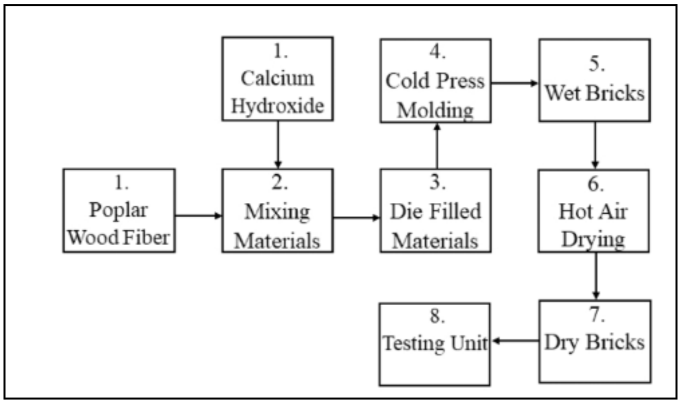


Figure 10. *Wooden brick production process. Wood waste can be converted into lightweight masonry units through fiber processing, mineral binding, and cold pressing. This pathway enables reuse of low-grade dimensional lumber that cannot be structurally reused.*
Source: *Abdolmaleki et al. (2025)*

3.4 Biofuel Use for Low-Grade Lumber

a) Biofuel production is a primary recovery pathway for low-grade recycled lumber and construction and demolition wood waste (CDWW) that cannot be feasibly reused or recycled into higher-value products. Within a circular-economy framework, energy recovery represents the “recover” tier of the 4R hierarchy, capturing residual value from untreated or minimally processed wood waste before disposal (Abdolmaleki et al., 2025). Life-cycle analyses of urban wood utilization show that such material is commonly diverted to biomass boilers, cogeneration systems, or industrial heat applications, including kiln drying at sawmills, where it substitutes directly for fossil fuels (Alanya-Rosenbaum et al., 2022). This pathway is particularly relevant for heterogeneous waste streams dominated by short lengths, damaged members, or mixed residues that are structurally unsuitable but retain significant calorific value.

b) Before low-grade recycled lumber can be used as biofuel, extensive preprocessing is required to ensure fuel quality, regulatory compliance, and combustion efficiency. Both studies emphasize the importance of sorting wood waste streams to isolate untreated wood from preservative-treated, painted, or composite products, which pose emissions and ash-handling concerns (Alanya-Rosenbaum et al., 2022; Abdolmaleki et al., 2025). Typical preprocessing steps include removal of metal fasteners, grinding or chipping to achieve uniform particle size, and screening to reduce contamination. These operations require additional energy inputs—diesel and electricity for grinding and handling—which must be included in life-cycle assessments when evaluating net environmental benefits (Alanya-Rosenbaum et al., 2022). As a result, fuel preparation is both a technical and environmental constraint on large-scale deployment.

c) The principal benefit of converting low-grade recycled lumber into biofuel is its ability to displace fossil fuel use while diverting wood waste from landfills. Scenario-based life-cycle modeling demonstrates that substituting natural gas with urban wood biofuel can substantially reduce fossil-derived greenhouse gas emissions, particularly in industrial heat applications (Alanya-Rosenbaum et al., 2022). Within the circular-economy literature, energy recovery is also recognized as a necessary outlet for residual wood fractions that cannot be economically reused or recycled, thereby improving overall system efficiency (Abdolmaleki et al., 2025). However, limitations remain significant. Combustion releases biogenic carbon immediately rather than storing it long-term; fuel quality is inconsistent across waste streams, and markets for biomass energy depend heavily on local infrastructure, regulatory incentives, and fuel pricing. These factors often make biofuel a lower-priority option compared to material reuse or recycling when cleaner pathways are available.

d) In New York State, the use of recycled lumber as biofuel is not approved as a predetermined BUD under NYSDEC Part 360. Only when the feedstock is made entirely of clean, untreated, and uncontaminated wood is energy recovery from recycled timber allowed on a case-by-case, permit-dependent basis. Preservative-treated or painted lumber is not allowed in energy recovery paths under Part 360 standards because of the risks to ash management and air quality. This distinction is further supported by Abdolmaleki et al. (2025), who identified untreated wood waste as appropriate for recovery paths, whereas treated wood need alternate disposal or more stringent regulatory regulations. Therefore, rather than a general or preset BUD pathway, biofuel production from reclaimed timber in New York is a conditional reuse method that necessitates facility-specific authorization and adherence to Part 360 licensing regulations.

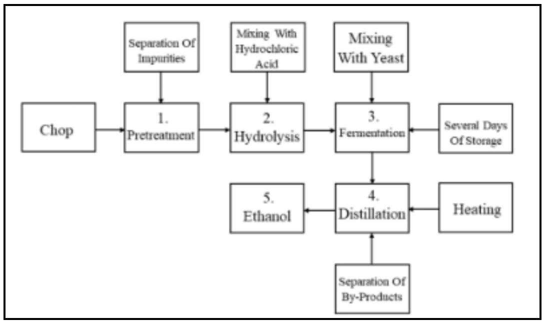


Figure 11. *Bioethanol and biomass energy recovery pathway. Low-grade recycled lumber can be converted into energy, displacing fossil fuels. Energy recovery provides an outlet for wood waste that cannot be reused materially.*
Source: *Abdolmaleki et al. (2025).*

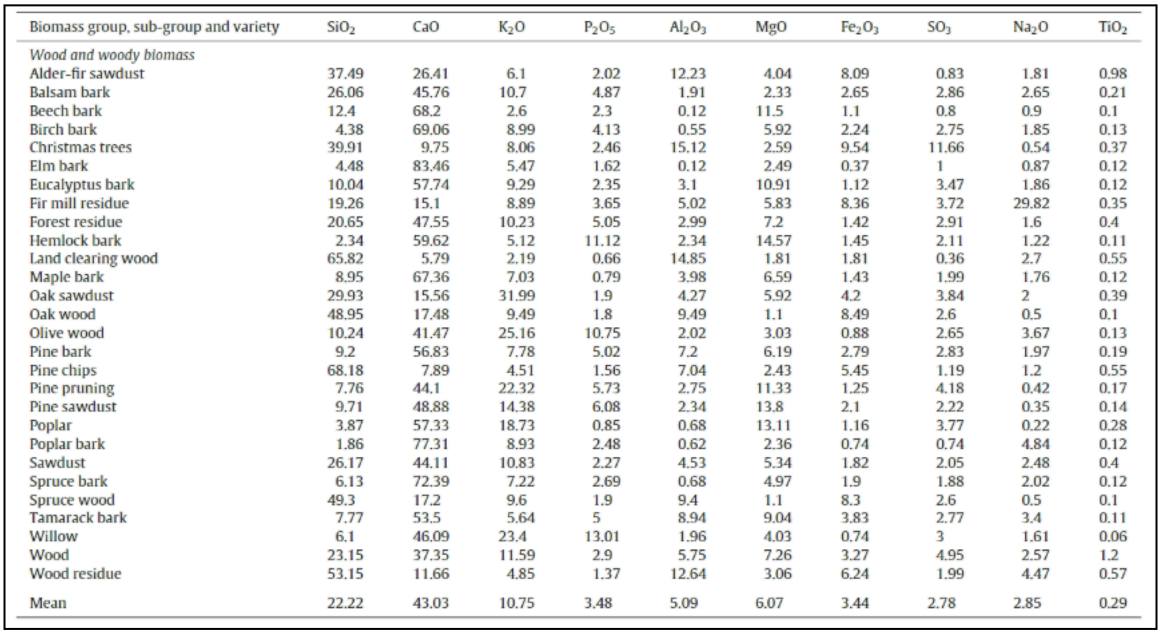
3.5. Wood Waste Ash

a) Cement production has a significant carbon footprint; over 400 kg of carbon dioxide are generated for every 600 kg of cement produced (Cheah Chee Ban, 2011). Alternative supplemental materials are becoming more and more necessary in the manufacturing of concrete as the world's need for cement keeps rising (Cheah Chee Ban, 2011). Biomass wood ash, which is defined here as the ash generated by burning clean, unprocessed wood, is one such substitute. Waste from burning recovered dimensional lumber may be used as an additional cementitious material in the manufacturing of structural concrete, in conjunction with the previously mentioned usage of dimensional timber as biomass fuel (Cheah Chee Ban, 2011). It is important to distinguish this material from coal fly ash, as biomass wood ash differs significantly in chemical composition, physical properties, and regulatory treatment.

b) The characteristics of biomass wood ash are significantly influenced by the temperature at which combustion occurs. Cheah and Ramli (2011) found that when combustion temperatures rose from 538 °C to 1,093 °C, the ash production decreased by 45% and the carbonate content decreased. Therefore, recovered dimensional lumber should be burned at temperatures below 500 °C for the most ash production. The resulting biomass wood ash is naturally different since reclaimed dimensional lumber comes from a variety of wood species. Because of this, the ash needs to be described and possibly classified according to unit weight, specific gravity, fineness, and chemical composition, especially the amounts of silica (SiO_2), alumina (AlO_3), iron oxide (FeO_3), and quicklime (CaO) (Cheah Chee Ban, 2011). These physical and chemical properties strongly influence the quality and performance of concrete produced using biomass wood ash as a cement replacement.

c) According to studies, substituting around 10% biomass wood ash for cement can increase the development of calcium silicate hydrate (CSH) gel, decrease the amount of non-hydrated cement and portlandite, and decrease the porosity of cured mortar. Additionally, this substitution increases corrosion resistance, lessens drying shrinkage, and improves the cement–aggregate interfacial transition zone, all of which increase the strength and durability of concrete (Cheah Chee Ban, 2011). In addition to improving performance, using biomass wood ash lessens reliance on cement manufacturing, hence reducing carbon emissions and the negative environmental effects of limestone extraction. Furthermore, compared to imported supplemental materials, biomass wood ash can be obtained locally from nearby combustion facilities, lowering emissions associated with transportation.

d) But there are still restrictions. It has been demonstrated that replacement levels more than roughly 10% lower mechanical strength, adversely influence workability, and increase water demand in concrete mixtures (Cheah Chee Ban, 2011). In contrast to coal fly ash, which is regulated by ASTM C618, there is currently no widely accepted standard for biomass wood ash as an additional cementitious ingredient. Therefore, project-specific acceptance criteria, such as chemical composition limits, fineness requirements, loss-on-ignition thresholds, and performance-based testing to prove compliance with strength and durability requirements, would be necessary for the use of biomass wood ash in structural concrete. The use of biomass wood ash in concrete should be viewed as a controlled or pilot-scale application rather than a standard, generally used technique until such standards are developed.



Biomass group, sub-group and variety	SiO_2	CaO	K_2O	P_2O_5	Al_2O_3	MgO	Fe_2O_3	SO_3	Na_2O	TiO_2
Wood and woody biomass										
Alder-fir sawdust	37.49	26.41	6.1	2.02	12.23	4.04	8.09	0.83	1.81	0.98
Balsam bark	26.06	45.76	10.7	4.87	1.91	2.33	2.65	2.86	2.65	0.21
Beech bark	12.4	68.2	2.6	2.3	0.12	11.5	1.1	0.8	0.9	0.1
Birch bark	4.38	69.06	8.99	4.13	0.55	5.92	2.24	2.75	1.85	0.13
Christmas trees	39.91	9.75	8.06	2.46	15.12	2.59	9.54	11.66	0.54	0.37
Elm bark	4.48	83.46	5.47	1.62	0.12	2.49	0.37	1	0.87	0.12
Eucalyptus bark	10.04	57.74	9.29	2.35	3.1	10.91	1.12	3.47	1.86	0.12
Fir mill residue	19.26	15.1	8.89	3.65	5.02	5.83	8.36	3.72	29.82	0.35
Forest residue	20.65	47.55	10.23	5.05	2.99	7.2	1.42	2.91	1.6	0.4
Hemlock bark	2.34	59.62	5.12	11.12	2.34	14.57	1.45	2.11	1.22	0.11
Land clearing wood	65.82	5.79	2.19	0.66	14.85	1.81	1.81	0.36	2.7	0.55
Maple bark	8.95	67.36	7.03	0.79	3.98	6.59	1.43	1.99	1.76	0.12
Oak sawdust	29.93	15.56	31.99	1.9	4.27	5.92	4.2	3.84	2	0.39
Oak wood	48.95	17.48	9.49	1.8	9.49	1.1	8.49	2.6	0.5	0.1
Olive wood	10.24	41.47	25.16	10.75	2.02	3.03	0.88	2.65	3.67	0.13
Pine bark	9.2	56.83	7.78	5.02	7.2	6.19	2.79	2.83	1.97	0.19
Pine chips	68.18	7.89	4.51	1.56	7.04	2.43	5.45	1.19	1.2	0.55
Pine pruning	7.76	44.1	22.32	5.73	2.75	11.33	1.25	4.18	0.42	0.17
Pine sawdust	9.71	48.88	14.38	6.08	2.34	13.8	2.1	2.22	0.35	0.14
Poplar	3.87	57.33	18.73	0.85	0.68	13.11	1.16	3.77	0.22	0.28
Poplar bark	1.86	77.31	8.93	2.48	0.62	2.36	0.74	0.74	4.84	0.12
Sawdust	26.17	44.11	10.83	2.27	4.53	5.34	1.82	2.05	2.48	0.4
Spruce bark	6.13	72.39	7.22	2.69	0.68	4.97	1.9	1.88	2.02	0.12
Spruce wood	49.3	17.2	9.6	1.9	9.4	1.1	8.3	2.6	0.5	0.1
Tamarack bark	7.77	53.5	5.64	5	8.94	9.04	3.83	2.77	3.4	0.11
Willow	6.1	46.09	23.4	13.01	1.96	4.03	0.74	3	1.61	0.06
Wood	23.15	37.35	11.59	2.9	5.75	7.26	3.27	4.95	2.57	1.2
Wood residue	53.15	11.66	4.85	1.37	12.64	3.06	6.24	1.99	4.47	0.57
Mean	22.22	43.03	10.75	3.48	5.09	6.07	3.44	2.78	2.85	0.29

Figure 12. *Chemical composition of biomass wood ash. Biomass wood ash exhibits significant chemical variability depending on wood source and combustion conditions. Variability necessitates testing and limits immediate standardization for concrete use.* ***Source:*** *Cheah Chee Ban (2011).*

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4. NYC Specific Context

4.1 Role of dimensional lumber

Dimensional lumber is a standardized wood product, commonly made of softwood, produced in uniform sizes and used in construction. In NYC, it is used most in low- to mid-rise buildings under Type III, IV, and V construction. In practice, dimensional lumber framing remains common in NYC's new one- and two-family homes. According to NYC DOB, the majority of these structures use wood or cold-formed steel framing systems. However, dimensional lumber plays a more limited role in new mid- and high-rise development. Most mid- and high-rise projects require key building elements to be noncombustible. Additionally, NYC code mandates Type IA construction for buildings 420 feet or taller. The NYC Building Code, Chapter 23, permits dimensional lumber for conventional light-frame construction with specific limitations, including maximum floor-to-floor heights not exceeding 11 feet 7 inches and exterior bearing wall heights not exceeding a stud height of 10 feet (NYC Department of Building, 2022). Wood framing is permitted for interior fit-outs, partitions, and structural applications where it meets fire-resistance requirements specified in the (NYC Department of Building, 2022). As a result, wood waste enters the construction and demolition stream through renovations and full building deconstruction processes (Department of Design and Construction, 2003). This makes reclaiming dimensional lumber important under NYC law, as it is designated as a recyclable material pursuant to §16-306 of the Administrative Code (Department of Sanitation, 2025).

4.2 NYC regulatory and policy landscape affecting reclaiming lumber wood

Most construction projects in NYC rely on private charters rather than residential curbside collection. Under NYC's sanitation framework established by Local Law 87 of 1992 and DSNY commercial recycling rules (Department of Sanitation, 2025), generators of private carter collected waste are required to source separate designated recyclable materials and arrange lawful collection and processing pathways (Department of Sanitation, 2025). The rules define designated recyclable materials to include metal, glass, plastic, cartons, paper, cardboard, textiles, and yard waste, among other materials (Department of Sanitation, 2025). For reclaimed lumber, the practical implication is that recovery success depends on jobsite practices that prevent contamination (DDC, 2003). This includes keeping wood separate from mixed debris, gypsum dust, adhesives, wet waste, and fine residues. Private carters are required to collect designated recyclable materials only when they have been sourced separated by the generator and must maintain records of collection and delivery to a recycling processor. When wood is kept clean and segregated in clearly labeled, suitable receptacles, it is more likely to be directed into reuse markets rather than downcycled, such as into mulch, or disposed as solid waste (DDC, 2003).

4.3 Local Law 97 and Embodied Carbon Alignment

Local Law 97 of 2019 primarily regulates operational greenhouse gas emissions from buildings over 25,000 square feet, requiring them to meet emissions limits beginning in 2024, with stricter limits in 2030 (NYC Department of Buildings, 2019)The law aims to reduce emissions from the city's largest buildings by 40% by 2030 and to net zero by 2050 (NYC Department of Buildings, 2019). While LL97 focuses on operational emissions rather than embodied carbon, it has shifted decision making toward whole building carbon performance, electrification, and material strategies that reduce lifecycle impacts. This is particularly significant given that buildings and construction account for nearly 40% of global energy-related carbon dioxide emissions, with construction material sources as one of the major contributors (Bergsagel, 2019). Although reclaimed lumber does not directly reduce operational emissions, it can support broader climate strategies by reducing embodied impacts associated with virgin material production and disposal or export. By reusing salvaged wood, the city can reduce landfill waste, store embodied carbon, and reduce future deforestation (Bergsagel, 2019). In practice, LL97 can function as an indirect policy driver that encourages owners and design teams to adopt material reuse where feasible, especially when combined with procurement policies or client sustainability targets aligned with the law's net zero goals (NYC Department of Buildings, 2019).

4.4 NYCEDC Circular Design and Construction Guidelines

NYCEDC's circular design guidance provides a policy-oriented rationale for designing buildings and renovations to enable material recovery (EDC NYC, 2024). This includes design for disassembly, take-back planning, and procurement specifications for salvage. For reclaimed lumber, these guidelines support specific interventions such as selective deconstruction instead of mechanical demolition, salvage friendly detailing, and contracting language that prioritizes reuse outcomes (EDC NYC, 2024). Although guidance is not coded, it strengthens the usage for reclaimed lumber pilots in NYC and helps translate reuse intent into implementable project requirements. The guidelines aim to divert 75% of construction and demolition materials from landfill and ensure that 25% of all building materials are low carbon (EDC NYC, 2024).

4.5 Known NYC Implementation Pathways and Pilot-Oriented Strategies

Reclaimed dimensional lumber is most implementable in NYC when paired with project delivery methods that explicitly plan for salvage and verification. The NYC Department of Design and Construction's Construction and Demolition Waste Manual emphasizes that waste management is a cooperative effort requiring coordination among administrators, architects, construction managers, and contractors (EDC NYC, 2024). This is particularly significant given that C&D waste accounts for more than 60 percent of the solid waste stream in NYC, considerably higher than the national average of 25 to 45 percent (EDC NYC, 2024). As of 2024, the city produces on average 7,500 tons of construction and demolition waste per day (EDC NYC, 2024). Key strategies include selective deconstruction, and sorting plans that sequence removal to preserve lumber length and limit damage through proper denailing and avoiding excessive breakage. On-site segregation and protection measures, such as covered storage, moisture control, and clear labeling, are essential to maintain quality throughout the salvage process (Department of Design and Construction, 2003). The manual's waste reduction and recycling hierarchy prioritizes waste reduction first, followed by material reuse, then recycling, and finally disposal of remaining waste (Department of Design and Construction, 2003). Third-party grading or specification limits can restrict reclaimed lumber to non-structural uses unless grading documentation is available, reducing compliance uncertainty (EDC NYC, 2024). Procurement language should establish minimum reclaimed content targets for approved applications, such as blocking, non-structural partitions, and millwork backing, rather than blanket structural requirements. These approaches align with NYC's constraints, including limited staging space, tight schedules, and high labor costs, with tipping fees ranging from the mid $60s to $80 per ton and expected to continue rising (EDC NYC, 2024). They also reduce uncertainty for code compliance and risk allocation, making reclaimed lumber more feasible within the city's construction environment.

4.6 Infrastructure, Storage, and Permitting Constraints in NYC

NYC's urban form creates practical barriers that are often more decisive than material science. Space limitations present a primary challenge, as constrained staging areas reduce the ability to store and protect salvaged lumber on site (DDC, 2003). Under NYS regulations, construction and demolition debris handling and recovery facilities must meet specific registration or permit requirements to legally process C&D materials. Exemptions exist for on-site storage or at contractor storage yards up to certain volume limits, but only for specific types of C&D debris such as recognizable and uncontaminated concrete, concrete products, brick, rock, asphalt pavement or asphalt millings. Moisture and contamination risk is heightened when exposed storage increases moisture uptake and biological degradation, while contact with dust and adhesives reduces reuse value. Hauling logistics further complicates the process, as reuse requires routing to salvage yards or processors that can handle sorting, denailing, and regrading. However, routing options may be limited by facility capacity and allowable operating conditions. For wood to be accepted at registered CDDHRFs under 6 NYCRR 361-5.2, it must be unadulterated wood that cannot include painted, treated, or coated wood, or glued wood such as plywood or fiberboard products. All C&D debris shipments must include a tracking document that identifies the source, transporter, and intended destination. Time and cost pressures add additional constraints, as demolition is often scheduled for speed while deconstruction requires more labor hours and coordination, which must be justified by disposal savings or salvage value (DDC, 2003). These constraints should be explicitly acknowledged because they determine whether reclaimed lumber is feasible on a scale or only viable for targeted applications.

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5. Conclusion

From the beneficial use cases reviewed, the most viable strategies are using ash-derived supplementary cementitious material (SCM) in structural-grade concrete and using clean, untreated wood fines as feedstock for controlled organics processing (composting).For concrete, it is important to distinguish between conventional fly ash and wood-waste ash. NYC concrete provisions explicitly recognize fly ash and other pozzolans conforming to ASTM C618, including allowances to increase fly ash content under specified conditions. NYC public-work specifications commonly reference ASTM C618 fly ash requirements. However, the straightforward pathway is not that wood fly ash is already commonly used. Rather, the regulatory and specification framework for ASTM C618 pozzolans already exists, and wood-waste ash would need to be qualified to those same performance-based expectations. This includes meeting requirements for strength contribution, durability, and consistency, and gaining acceptance by project specifications and local practice before it can be treated as a routine SCM. The next steps are to demonstrate that wood-waste ash can consistently meet relevant acceptance criteria, including durability controls such as loss-on-ignition and variability management. Performance must also be documented through mix qualification testing suitable for structural applications.

For composting, this pathway provides a biologically appropriate reuse option for low-grade recycled lumber only when the material stream is clean and untreated. Painted, treated, coated, or glued wood must be excluded from "unadulterated wood" pathways under New York State environmental definitions that govern acceptance at regulated facilities. Additionally, NYC project specifications can be restrictive about acceptable compost products for engineered soils. For example, NYCDEP green infrastructure specifications identify leaf compost as the approved admixture for meeting engineered-soil organic content requirements. Compost derived from wood fines may therefore require separate approval and clear end-use specifications. Ultimately, material properties and condition determine whether recycled lumber can qualify for composting or for processing into fly ash as beneficial reuse rather than requiring alternative recovery pathways. Key factors include chemical composition, degree of degradation, and contamination.

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