NAC Executive Insights

Reducing Waste in Construction Projects

Key Points

- Construction waste reduction begins at project conception, not inception; the construction waste management plan should be developed at an early stage.
- Construction waste can be viewed as consisting of solid, liquid, and gaseous wastes.
- Effective scope control is an essential first step in construction waste minimization.
- Construction waste minimization continues into the supply chain.
- Waste minimization during the construction phase has as much to do with efficient productive construction execution as it does with control measures.
- Poor quality construction in the first instance, out of sequence construction, and poor scope control all result in higher rework levels and with it growth in construction waste streams.
- Construction waste minimization requires the causes of added waste generation through poor management oversight and practices be addressed.

Introduction

This Executive Insight focuses on waste reduction in construction projects. Increasing emphasis on environmental, social, and governance (ESG) goals, including those incorporated in the United Nations Sustainable Development Goals (SDG), has elevated attention on waste reduction throughout all sectors and activities. Construction projects represent a growing area of focus with opportunities being identified in:

- Energy usage and source
- Materials selections, including reuse
- Waste elimination through design
- Construction management and work processes
- Owner-centric processes

The decisions made or failed to be made, the timeliness of those decisions, and the completeness of decision frameworks have much to do with the industry's ability to reduce construction waste.

In 2018, 600 million tons of construction and demolition waste were generated in the United States, more than twice the amount of generated municipal solid waste. The vast majority of this waste was from demolition waste. This suggests further opportunities for the 25 percent not currently targeted for reuse[1] of these materials. These opportunities begin by eliminating potential waste streams, reducing the 25-30 percent of construction materials arriving at a site, which often end up in the waste stream.

Begin at the Beginning

Construction waste reduction begins at project conception, not inception. It is at this stage where the owner can make key decisions that will impact overall environmental, social, and governance (ESG) performance—with construction waste reduction being one element of this broader focus.

For the owner, reducing waste must begin with a strong and clear commitment to both the organization's and the project's life-cycle performance from an ESG perspective. This commitment should be embodied in the owner's strategic business objectives and translated to desired outcomes both during the design and construction phases as well as during the much longer operations phase.[2]

During the project conception phase, the owner's project requirements must include clear ESG requirements to guide development of the engineer's basis of design. Alignment and comprehensive commitment to the desired strategic objectives and outcomes must be a whole of the owner's organizational commitment. Procurement and contracting strategies should incentivize achievement and out performance in waste reduction in both the construction and operating phases. This Executive Insight will not further consider operating phase waste reduction except to say that it really begins at this conception stage.

What are the Types of Construction Waste Encountered?

Construction waste consists of solid, liquid, and gaseous wastes. The wasted labor associated with low productivity is arguably another form of construction waste. This Insight, however, will only consider its impacts in generation of added construction waste.

The various waste steams can be characterized by their hazard levels. This drives a consideration of other factors related to initial material choices and how to capture, treat, and dispose of any hazardous residuals. Hazard levels are not further considered in this Executive Insight but are important design, procurement, and construction considerations.

Table 1 summarizes some of the types of construction waste encountered.

[1] The principal reuse of demolition materials is as aggregate.
[2] Executive Insight, Business Basis of Design https://www.naocon.org/wp-content/uploads/Business-Basis-of-Design.pdf

Table 1 Types of Construction Waste[3]		
Solid Waste	**Liquid Waste**	**Gaseous Waste**
Concrete	General site runoff (silt and/or potentially contaminated)	Diesel generator exhausts
Bricks	Fuel and chemical plumes from construction operations[4]	Purging and other vented gas
Ceramics and tile	Dredge disposal (potentially contaminated) runoff	Industrial gas, especially greenhouse gas (GHG), released during construction operations
Wood		Vehicle emissions from onsite construction equipment
Insulation materials		Vehicle emissions associated with work force vehicles to, from, and onsite
Glass		Logistics chain emissions from handling and transport of the materials of construction
Plastic		
Ferrous metals		
Non-ferrous metals		
Stone and clay		
Dredge waste		
Vegetation		
Rocks		
Asphalt		
Miscellaneous packaging not otherwise included above		

Minimizing Construction Waste

Design phase. Construction waste minimization begins in earnest at the design stage, with a focus on related design considerations including:

- Focusing on facility needs, not wants. Effective scope control[5] is an essential first step in construction waste minimization
- Adaptive reuse of any existing site facilities

[3] Human wastes from the construction work force are not considered here.
[4] Pre-existing hazardous plumes would be part of any planned site mitigation measures.
[5] Executive Insight, Know What You Are Trying to Accomplish: The Primacy of the Scope Baseline https://www.naocon.org/wp-content/uploads/Know-What-You-Are-Trying-to-Accomplish-The-Primacy-of-the-Scope-Baseline.pdf

- Reducing the site footprint, thus limiting the site area disturbed or required to be graded. Footprint reduction reduces attendant facility infrastructure with fewer miles of roads, utilities (power, water, communication), and fencing, each with its associated waste percentages.
- Reducing material quantities and associated waste by reducing design margins.
- Detailed design simplification at the system, structure, and component levels.
- Reduction in the need for temporary works through incorporation of access during construction provisions as part of the project's design.
- Incorporation of bracing steel required for transport of major equipment, prefabricated assemblies, and modules as part of the final structural design, eliminating their removal and insertion into the project's waste stream.
- Alternative framing techniques
- Reducing the number of items of supply (SKU) to minimize overordering of parts and components.
- Increasing prefabrication and modularization to capture manufacturing efficiencies in materials management.
- Selection of environmentally friendly materials with improved waste performance properties. Examples of material selection choices to consider include:
    - Self-healing concrete
    - More carbon-friendly laminated timber
    - Natural bamboo when scaffolding is required
    - Unfired wool bricks
    - Bio-char by-product for insulation
- Use of recycled building materials.
- Development of ESG-aware specifications (see examples in the following supply chain and construction sections).
- Leveraging the power and features of building information modeling (BIM) to support and enforce the above strategies.
- Leveraging artificial intelligence (AI) enabled optimizations on many of the specific items above.

Supply chain. Construction waste minimization continues into the supply chain.[6] All aspects of the supply chain should be examined for opportunities to achieve ESG objectives and to reduce construction waste. Supply chain activities supporting waste reduction include:

- Accurate material takeoffs and equipment specifications
- Purchased equipment and supplies ESG requirements, including those associated with construction waste minimization (often overlooked), incorporated into specifications and purchase orders. Procurement agreements can prevent excess materials and packaging from arriving at the site.

[6] Executive Insight, Procurement Management in Large Complex Programs https://www.naocon.org/wp-content/uploads/Procurement-Management-in-Large-Complex-Programs.pdf

- Sub-tier (second and third level) supplier ESG flow-down requirements, including those related to construction waste minimization
- Supplier commitment to low waste measures, including take back schemes
- Low carbon footprint cements[7]
- Embedded carbon tracking and minimization associated with procured equipment and materials
- Limits on uses of emitted greenhouse gases associated with manufacturing processes and cleaning activities.
- Elimination of temporary bracing to be removed and disposed of at site.
- Use of single type packaging materials (versus multiple material types) to promote efficient segregation and recycling at site. Packaging materials would include either all cellulose (wood, cardboard, paper), recyclable plastic, or metal.
- Procurement of items of supply using reusable packaging.
- Minimize loosely supplied materials.
- SKU reduction to limit over-ordered quantities and future waste streams. Just-in-time and small quantity material contracts eliminate excess materials at the site that could enter the waste stream.
- Increased levels of prefabrication (including full modularization[8]) in a manufacturing environment, thus limiting field assembly activities and associated waste. Increased prefabrication can include spooling of associated home run power and instrumentation cabling and installation of otherwise field-installed piping and instruments.
- Sourcing of pre-cut or precast materials.
- Logistical[9] chain consolidation of shipments to reduce packaging and bracing to be removed and disposed of at site; reduce idling time associated with last mile and site congestion.
- Protection of items of supply during transport and storage.

Construction phase. During the construction phase, earlier design and procurement activities in which construction has actively participated are built upon. Construction's involvement extends back to the inclusion of a construction basis of design before design commences.[10] The construction waste management plan also should be developed at an early stage.

Waste minimization during the construction phase has as much to do with efficient productive construction execution as it does with some of the control measures outlined below. Low productivity results in extended project schedules and with it extension of construction waste streams associated with extended general conditions periods.

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[7] CO_2 curing can also be used after concrete has been cast, creating solid carbonates that also improve the strength of concrete, thus requiring less cement. CarbonCure™ and Solidia™ have developed technologies to use these processes for poured concrete at the site, precast concrete, and cinder blocks.
[8] Executive Insight, Modularization
[9] Executive Insight, Logistics https://www.naocon.org/wp-content/uploads/Logistics.pdf
[10] Executive Insight, Constructability Review before Design Commences https://www.naocon.org/wp-content/uploads/Constructability-Review-Before-Design-Commences.pdf

Poor quality construction in the first instance, out of sequence construction, and poor scope control all result in higher rework[11] levels and with it growth in construction waste streams.

Specific construction waste minimization efforts to consider include:

- Selection of appropriate energy sources
    - Select sites may support use of solar power for site-based sensors, lighting, or integration with grid supplied power. This has proved beneficial in remote sites and reduces the need for hydrocarbon-based fuels.
    - Purchased power may include a requirement for green power to be supplied.
    - Hydrogen/ammonia for onsite power generation (emerging technology).
    - Onsite fleet utilizing electric vehicles and natural gas buses (larger sites).
- Optimization of onsite use of power
    - Cognizance of optimal diesel generator operating load factors.
    - Utilization of microgrids to minimize diesel generator idling and stand-by loads through optimized dispatch of onsite diesels (larger sites).
- Cut and fill balancing to eliminate need for offsite disposal of surplus soil.
- Maximization of the use of environmentally friendly materials such as those identified in the design stage (self-healing concrete, more carbon-friendly laminated timber, natural bamboo when scaffolding is required, unfired wool bricks, and bio-char by-product) for contractor designed facilities and specified materials.
- Use of carbon absorbing concrete.
- Reuse of construction waste materials
    - Chippings of scrap wood on site can provide mulch or groundcover.
    - Gypsum (de-papered) can be used in limited quantities as a soil amendment.
    - Leftover paints can be remixed and used as primer coat.
    - Concrete, masonry, and brick waste (perhaps from onsite demolition) can be recycled onsite as fill or subbase material.
        - Crushed concrete aggregate can replace new aggregate in new concrete. This substitution is a popular option because of the global sand shortage.
    - Glass (from demolition of existing site facilities) may be crushed and used as aggregate in concrete.
    - Stone/clay may be pulverized into gravel and used in specialized products like thermal insulating concrete or become filler beneath roadbeds or driveways.
- Segregated packaging materials can be returned to suppliers for reuse.
- Recycling of segregated waste streams
    - Cellulose materials, including wood, can be recycled for new engineered wood products and mulch
    - Cardboard packaging
    - Asphalt
    - Metals

[11] Executive Insight, Rework in Engineering and Construction Projects

    - Glass
    - Plastics (non-contaminated; segregated)
- Capture of site runoff and treatment to minimize liquid waste discharges and potential environmental problems; reuse of site runoff for dust control.
- Leverage means and methods and focused general conditions to support waste minimization.
    - Eliminate double-handling of materials (wasted energy; increased risk of damage)
    - Install onsite material shredders and compactors (promotes onsite recycling and reduced waste volumes)
    - Provide bins for waste collection for each subcontractor (facilitates enforcement of subcontractor waste minimization commitments; support segregation of waste for recycling)
    - Establishing temporary bins in each building work zone and collecting waste by trade
    - Prevent waste mixing with soil except where planned (as soil amendment)
    - Maintain a clean site to limit inadvertent inclusion of materials into the waste stream (also supports site safety)
    - Conduct cutting operations in central areas supporting segregated waste collection and reuse of lumber, rebar, and piping
    - Establish recycling targets at each construction phase (monitor and track)
    - Frequently collect waste at the site to support waste segregation and recycling

Construction waste minimization also requires that the causes of added waste generation through poor management oversight and practices be addressed. These often result in extended schedules and include:

- Poor management oversight and supervision
    - Absence of a construction waste reduction plan
    - Poor project management
    - Inadequate communication and coordination
- Inadequate subcontractor selection process and oversight
- Inadequate project control practices (construction planning; inaccurate estimates and schedules; poor schedule control, resulting in delays)
    - Inaccurate quantity takeoffs
- Poor scope control or design quality
    - Incomplete design at time of procurement or contracting notice to proceed (NTP)
    - Delayed design preparation or approvals
    - Poor quality design (high requests for information/RFIs; errors and omissions)
    - Frequent changes in scope or design
- Poor quality construction[12]
    - Inadequate materials testing
    - Poor or inconsistent means and methods

[12] Executive Insight, Redefining Quality https://www.naocon.org/wp-content/uploads/Redefining-Quality.pdf

    - Poor workmanship
    - Rework due to above or out of sequence construction[13]
- Inadequate materials and equipment
    - Shortage of materials
    - Late delivery of materials and equipment
    - Equipment availability and poor maintenance resulting in failures
    - Poor inventory control
- Extended schedules associated with lower than planned labor productivity
    - Labor shortages (unskilled)
    - Lack of appropriate experience (skilled)
    - Low labor productivity[14]
    - Delays in decision making
    - Slow information flows
    - High absenteeism

Summary

Construction waste reduction represents a significant opportunity to support efficient design, procurement, and construction while reducing project costs and supporting project environmental, social, and governance (ESG) goals. It begins at project conception— with owner commitment and clearly defined outcomes. The defined owner's requirements are then included in an expanded basis of design that is developed before design begins.

Construction waste can be viewed as consisting of solid, liquid, and gaseous wastes. Effective scope control is an essential first step in their minimization. Efforts begun in the design stage then continue throughout the procurement and construction phases, guided by the construction waste management plan developed at an early stage.

Waste minimization during the construction phase has as much to do with efficient productive construction execution as it does with the various control measures outlined in this Executive Insight. Poor quality construction in the first instance, out of sequence construction, and poor scope control all result in higher rework levels and with it growth in construction waste streams.

Finally, construction waste minimization requires that the causes of added waste generation through poor management oversight and practices be addressed.

[13] Executive Insight, Out of Sequence Construction
[14] Executive Insight, Barriers to Productivity

About the Author

Bob Prieto was elected to the National Academy of Construction in 2011. He is a senior executive who is effective in shaping and executing business strategy and a recognized leader within the infrastructure, engineering, and construction industries.