



TOWN +GOWN

**Pushing the Recycling Envelope:
Construction and Demolition Waste.2**
ACS Manhattan Room
@150 William Street, 19th Floor
October 30, 2018, 8:30 a.m. to Noon

AGENDA

8:45 a.m. – 9:40 a.m. Academic Framing Presentations

- Introduction and Overview of Event: Terri Matthews, Director of Town+Gown
- Material Loops—Concrete as Case Study: Matthew Adams, Assistant Professor, Department of Civil and Environmental Engineering, New Jersey Institute of Technology
- Where’s the Data?: David Nadler, Assistant Professor, New York Institute of Technology
- Construction Logistics 101: Ronald Pennella, Adjunct Professor, NYU/Tandon School of Engineering, and Edward Lydon, Pavarini McGovern

9:40 a.m. – 9:50 a.m. Break

9:50 a.m. – 10:50 a.m. Knowledge Co-Creation—Simultaneous breakout working group table sessions by material

- Concrete
- Gypsum wallboard and ceiling tile
- Glass
- Carpet
- Soil

10:50 a.m. – 11:00 a.m. Break

11:00 a.m. – 11:30 a.m. Reconvening: Reporting Back and Closing Remarks

CDW.1 Background. Last year’s symposium event, *Pushing the Recycling Envelope: Construction and Demolition Waste* (see https://www1.nyc.gov/assets/ddc/downloads/town-and-gown/Precis_Final.pdf) (CDW.1) was intended as an initial exploration of issues associated with the expansion of construction and demolition waste (CDW) recycling in the city. Presentations on academic research related to concrete recycling were intended to create a knowledge base to understand the absence of specific references to CDW’s presence in the City’s waste stream and its contribution to the circular economy¹ in *New York City’s Roadmap to 80 x 50*, the City’s most recent articulated long-term sustainability plan required by the Charter.² In contrast to organic waste, concrete waste does not decompose or contribute to GHG, but the creation of concrete,³ the transportation of the raw materials to create concrete, and the transportation of concrete CDW for processing, recycling and disposal do contribute to GHG emissions, pointing to recycling concrete as a way to reduce concrete’s contribution to GHGs in the circular economy. Academic presentations of life cycle cost-benefit modeling were intended to serve as one tool that could help provide government, as regulator, with sufficient information to help determine options for potential intervention to increase recycling of CDW.

Concrete’s GHG profile, unfortunately, does not align well with the City’s span of regulatory control, which directly impacts the nature of available data. CDW is not part of the solid waste stream over which the City exerts significant regulatory control because New York State exerts significant regulatory control over CDW, which not only directly impacts the nature of available data but also impacts the market for recycled CDW.⁴



The precis document for CDW.1 summarized DDC’s 2003 *Construction and Demolition Waste Manual*, which was intended to be served as “an introduction and resource handbook for construction and demolition (C&D) waste reduction, reuse and recycling on New York City Projects,”⁵ and the final regulations, released by New York State Department of Environmental Conservation (DEC), effective on November 4, 2017, that significantly revised the State’s Solid Waste Management Regulations. At CDW.1, we learned that the city’s adoption of LEED standards for public buildings substituted for the 2003 guidelines and further that the last time the city explicitly focused on CDW was in its 1989-90 Waste

¹ *Ibid.*, pp. 99-100.
² City Charter, Section 20; see also Local Law 66/2014 with respect to the 80 x 50 requirement.
³ Most of those emissions are caused by the production of portland cement (an ingredient of concrete). This is caused mostly by decomposition of limestone in kiln (CaCo3->CaO+CO2), and also

by combustion of the fuel used for heating the kiln in cement plants. Producing a metric ton (1,000 kg) of cement can result in the release of around 800 kg of CO2 in the US. European plants are a bit more efficient, as some of them avoid using coal.
⁴ DDC, *op. cit.*, p. 8.
⁵ DDC, *op. cit.*, inside front cover

Composition Study, which together with the data issues related to regulatory control, suggested that a follow-up event to identify research gaps—what we don't know and need to know to advance CDW recycling—that academics within Gown can help us address was the most appropriate way to follow-up from CDW.1.

Over the summer and fall, Town+Gown collected feedback from agency practitioners within of Town, which is summarized in Appendix A.

New Background Information for CDW.2. During the planning for this event, we learned of planned changes to LEED, which covers sustainable design and construction practices for buildings. See <https://www.usgbc.org/node/4717858?return=/pilots/credits/New-Construction/v4> [LEED v4: CHANGES ARE COMING TO CONSTRUCTION & DEMOLITION RECYCLING – RCI – Recycling Certification Institute, Recycling Facility Certification Program.](https://www.usgbc.org/node/4717858?return=/pilots/credits/New-Construction/v4)

We also learned about Envision, which covers sustainable design and construction practices for infrastructure. See https://research.gsd.harvard.edu/zofnass/files/2015/06/Envision-Manual_2015_red.pdf, in particular, RA1.3 to RA1.7.

Finally, we were reminded of recent local law changes (LL 152/2018) that will govern transfer stations located within the city. See [file:///C:/Users/matthewte/Downloads/Local%20Law%20152%20\(2\).pdf](file:///C:/Users/matthewte/Downloads/Local%20Law%20152%20(2).pdf).

Piloting Knowledge Co-Creation Sessions at CDW.2. With CDW.2, Town+Gown is piloting a new format for its symposium events aimed at “real time” co-creation of knowledge to identify what we know, what we don't know and need/want to know to make changes in practice and policy based on research so that Town+Gown can accelerate the action research cycle by:

- Moving Town+Gown research projects (see Appendix B for abstracts of completed projects) to

the “thought leader” stage and toward a more systemic form of decision-making, using Town+Gown projects and related symposium events as a point of departure

- Increasing academic synthesis and translation of current work in various areas as research resources

By identifying research gaps that the Gown community knows are important to the city, Town+Gown can work with Gown to focus future targeted research to address those gaps, which constitutes “action” within Town+Gown’s action research paradigm. It is also possible, however, that this knowledge co-creation can identify insights to support “action” without additional research.

Soon after CDW.2 concludes, Town+Gown will synthesize the work from the working groups as an addendum to the event precis and make it available to those who participated, post it to the Town+Gown website Archives, and create follow-up events, all with a view to developing future targeted identified research projects.

Protocol for Working Group/Table Sessions.

General Group Objectives:

- Practitioners and Academics share knowledge of what they are doing/would like to do/where known data is (*what we know*)
- Practitioners share knowledge of impediments (city-wide process/organizational issues and regulatory issues) (*what we need to know*)
- Identification of targeted research ideas in the presence of participating academics for future research projects/events in T+G to support practitioners and for researchers to use back at their schools to show areas that need work
- Also, identification of insights to support “action” without additional research
- All keeping in mind:
 - Role of city/city agencies as owner
 - Role of city/city agencies as regulator within its jurisdiction of its own

buildings/infrastructure, privately-owned buildings, industry participants, and markets

- Role of designers (architects and engineers) and builders
- Role of communities

Protocol:

Those attending CDW.2 will break into groups by material loop:

- Concrete
- Gypsum wallboard, ceiling tile and wallboard
- Glass
- Carpet
- Soil

Each material loop group will outline a proto CDW Management Plan, as a prompt, that could be a collection of the layered diagrams as described below. A simple graphic prepared for event will work for the whole process in abstract but is really a collection of many layers for each product and material that is used in buildings and infrastructure. These layers sometimes can also cross materials, say from glass (as a curtain wall) to aggregate in concrete.

Construction and Demolition Waste Management



Each group can use the graphic to ask some questions about each material. Using concrete as an example, we already have a lot of questions at many stages of

the process for concrete, which could be used by other material loop groups:

- At the raw material stage regarding a possible shortage of aggregates
- At the collection stage, site sorting etc.
- At the reuse stage, how do we use the material? Strength characteristics, etc.
- At the end stage, is alternate daily cover a beneficial use that would otherwise not be available (if we divert too much concrete?)
- We also have data gaps all around to begin to tackle the magnitude of the problems (and frame the solutions.)
- Market conditions and generation issues.

Each working group's end-product is a proto CDW Management Plan to illustrate puzzle elements we need to find and/or create through research to expand the market for the material loop.

With the materials made available at each table, the working group will explore ideas in the topic area in some capturable form and present them at the end of the session, with suggestions for next steps for Town+Gown and the working groups.

Each working group can use whatever process they feel will work for it, but should consider assigning members to the following roles:

- sticky note maker + placer on white paper (familiar to those who have been through VE/VA engagements)
- picture taker
- summarizer and/or presenter to reconvened group

Practitioner Comments after CDW.1: Prelude to What We Need to Know

DSNY	<p>Products to explore:</p> <ul style="list-style-type: none"> • ceiling tile • gypsum wallboard • recycled glass aggregate <p>Policies to explore:</p> <ul style="list-style-type: none"> • Requiring a recycling plan and deposit be made before initiation of a construction project • Requiring a recycling rate for C&D • Allowing time for deconstruction prior to demolition • Extended Producer Responsibility for C&D products
DDC	<p>Given the logistical complexity of reusing demo'd material as aggregate on site, I wondered if it was worth thinking about a banking or credits system? Did also wonder about identification of appropriate product fabrication w/reused aggregate: e.g., Jersey barriers, parking stops etc., for which qualitative control might not be so critical (or at least articulating this, though it didn't seem to resonate too well with the general sense of the meeting).</p>
DEP	<p>Creating policy drivers to incentivize the recycling market Review of the DEC Pat 360 regulations an applicability to City infrastructure Discussion on recycling rates of waste transfer stations.</p>
DEP	<p>Calculating the true recycling rate for mixed construction demolition waste, not all recycling facilities in NYC recycle 100% of the material they receive. How can we specify specific recycling locations in the specs and contracts without sole-sourcing Creating a platform to coordinate for soil transfer from active construction sites across different agency projects.</p>
DDC	<p>We can see if we can gather information on how this can be used to help us achieve better sustainable goals, and credits with the Envision Rating System.</p>
DDC	<p>Using recycled concrete aggregate (RCA) in asphalt without additional research poses risks such as</p> <ul style="list-style-type: none"> • RCA will have a higher void ratio (Gsb vs Gsm) due to the entrained air in the cement paste, which will drive up the asphaltic cement demand. <ul style="list-style-type: none"> ○ Is the carbon savings by recycling aggregate greater than the carbon sink from using more petroleum in the asphalt mix? ○ The higher asphalt levels will possibly lead to more rutting, and this is solved by modifying the aggregate gradation, which makes the concern in 1.c below even worse. • RCA will have a lower friction resistance capacity – concrete gets the friction capacity due to the aggregate at the surface, but the RCA will have a mix of aggregate and cement paste at the surface. The wearing of the cement paste will lead to the surface possibly polishing and becoming too smooth, and allowing the surface aggregates to pop and start raveling of the asphalt surface. • Asphalt is generally mixed using a bunch of well graded piles of material (a stockpile of 3/8", 1/2", 5/8", etc.) that are blended to make a very precise gradation – much more scientific than how concrete aggregates are graded. If most RCA is just a low-effort mill and crush that might make a well-graded C33 mix, would it require additional processing and handling to be ready for incorporation into asphalt? This additional processing would need to be taken into account for any value calculations. • Products where RCA might be used: Parking stops seem like a good idea, but, in that context, it is necessary to consider a jersey barrier as <i>structural</i>.

Abstracts of Completed Town+Gown Projects

2017-2018

Analyzing Construction and Demolition Waste Flows within New York City

Town: NYC EDC

Gown: Carnegie/Heinz

Researchers: Christian Bergland, Taimur Ahmed Farooq, Alvaro Gonzalez, Jafar Haider, Yui Xu

Objective. The research team was tasked with developing a framework to permit greater value capture, within the construction and demolition sector, of low-value recyclable construction and demolition waste, which includes gypsum wallboard, carpet and ceiling tiles generated in building construction.

Methodology. Using gypsum as the case study material, the research team intended to identify the market value and materials flows of gypsum waste generated by construction sector activities within the city by conducting a stock and flow analysis of gypsum, in the broader conceptual context of a “cradle-to-cradle” version of the circular economy model. As part of the stock and flow analysis of gypsum, the research team also reviewed the city’s current reporting system for construction and demolition waste (CDW) generally and the LEED system program with respect to CDW, and conducted case study analysis of gypsum recycling outside the U.S.

Findings. The team, however, encountered significant data issues that impeded the ability to conduct a stock and flow analysis at the city-level. A database with elements necessary for a stock and flow analysis covered the mid-Atlantic states that aggregated New York City data with data from other localities in the New York State. A New York State-wide database, however, was found to be highly aggregated. In view of the lack of New York City-specific systems data, the team developed a two-pronged approach one of which involved actions that NYC EDC could undertake on its own, such as creating an informational campaign to raise awareness and promote CDW recycling at job sites, and the other of which focused on systemic actions to provide incentives for recycling as a route to creation/expansion of markets for recycling and to improve stakeholder data production capacity as a foundation for future efforts.

Next Steps. Since the researchers had identified the absence of system-level data as a foundational roadblock to increasing CDW diversion, the team suggested that efforts to solve the data issue would be necessary for the city to begin to act on many of the other recommendations, especially those based on the international case studies.

2015-2016

Replacing Natural Aggregates with Recycled Aggregates for Concrete Making in NYC—An Environmental Impact Assessment Study

Town: See note below*

Gown: CUNY/CCNY-Grove

Researcher: Meryl Lagouin

Objective. In the course of an internship project with CUNY/CCNY faculty, Meryl Lagouin performed a partial comparative life cycle assessment (LCA) to compare the environmental impacts of two concrete product systems—concrete with coarse natural aggregate and concrete with coarse recycled aggregate—focusing specifically on the effects of cement content, transportation distances and landfill avoidance in New York City. Since among the mostly inert construction and demolition waste materials (CDW) generated by the construction sector, concrete is a

significant component, use of recycled CDW aggregate (RCA) as a replacement for natural (virgin) aggregate (NA) in concrete for new uses can increase reduction of this component of CDW in landfills, with associated transportation effects, and preserving natural resources associated with concrete production.

Methodology. This partial comparative LCA focused on the New York City area and considered two categories of processes—the extraction and production of raw materials and the transportation of the raw materials to concrete plants—and excluded processes assumed to be the same for both product systems, such as producing concrete in a ready-mix plant, service and demolition phases. The LCA used private aggregated data sources for lifecycle elements of the concrete production function and used data collected from the New York City Department of Sanitation (DSNY) with respect to transfer stations, which recycle CDW, located within the City limits which DSNY regulates, to calculate the average distance between job sites and landfills and associated transportation effects, including avoided transportation due to recycling RCA. Among the LCA assumptions was an assumed 8 percent additional cement for recycled cement production; an assumption that infrastructure itself was the only parameter responsible for the beneficial environmental impact (i.e., if x% of CDW is recycled in RCA usable for new concrete, then only x% of the beneficial impacts of landfill avoidance would be allocated to the recycled concrete in the LCA); an assumption that landfilling CDW was a negative environmental impact; and, an assumption that the collected recycled products go to the nearest transfer station within New York City. The results of interim data processing permitted a further assumption that 43 percent of transfer stations located within the City are turned into RCA, which was combined with an additional assumption such as that only CDW that can be turned into RCA are sent to transfer stations, which, in turn, led to landfill avoidance metrics. The researcher used SimaPro software and ecoinvent life cycle inventory (LCI) datasets to model elements of the LCA in order to transform market and production system activities for the two waste scenarios.

Findings. The LCA tool permits quantification of all material flows with their associated potential environmental impacts and characterizing the effects of the different processes. The comparative LCA noted the predominance of cement production as a negative environmental impact in the concrete production function, and found that, in absolute terms, the production of RCA and NA had similar environmental impacts. When transportation and landfill avoidance were added to the LCA model, however, a lower negative environmental impact for concrete production resulted, and, regardless of landfilling, the use of RCA in new concrete has a lower negative environmental impact than the use of NA for concrete production.

Next Steps. These comparative findings suggest that, with additional research, it is possible to reduce the overall negative environmental impacts of concrete production by increasing the use of RCA in new concrete within a geographic area. Project-specific LCA studies need to be performed to determine in what types of construction projects the use of recycled CDW in concrete (or other applications) has the highest environmental benefit. In addition, consequential LCA studies needs to be conducted to investigate the recycling consequences other than avoided landfilling for the environmental burden of construction.

** Past volumes of Building Ideas have abstracted projects that originated outside Town+Gown, but nonetheless relate to the Built Environment or existing research questions. Since projects like this can provide the foundation for future research projects within Town+Gown, they are captured in Building Ideas.*

2013-2014

Life Cycle Cost Analysis and Green Infrastructure in New York City Life Cycle Cost Analysis and Green Infrastructure in New York City

Town: NYC DDC, NYC DOT, NYC DEP, NYC OMB

Gown: Columbia/SIPA

Researcher: Christopher Eshleman

Objective. Earlier Town+Gown projects attempting to develop feasible life cycle cost benefit models ran into impediments largely due to the unavailability of cost data at the time. The first project focused on modeling NYC

DOT's sustainable roadway design program, and the second project focused on modeling bioswales and permeable pavement gutters, two types of green infrastructure "add-ons" to standard roadway reconstruction projects. As both NYC DEP, with its 2010 Green Infrastructure Plan, and NYC DOT, with its sustainable roadway program, began to pilot and experiment with these "green infrastructure" elements, rudimentary cost and performance data began to become available, providing the necessary conditions to demonstrate the feasibility of developing *and using* a life cycle cost benefit analysis model during the City's capital budget planning and adoption processes.

Methodology. Eshleman designed the model in the Excel program to be both simple and accessible. He incorporated standard capital asset life cycle methodology and theory into the model in order to permit capital planners and budget analysts to conduct cost effectiveness analysis in a way that would capture discounted initial and life cycle costs and physical performance. The costs included operations and maintenance costs and replacement costs of various project options, while the physical performance metrics included water capture under several rainfall scenarios. Eshleman used data from NYC DDC, NYC DOT and NYC DEP where available and comparable data from elsewhere as proxies.

Findings. Eshleman demonstrated that the model permitted a cost effectiveness analysis, for a one inch rainfall event, of a bioswale project in Brooklyn and a permeable pavement project in Queens. The initial use of the model suggested that the permeable pavement installation may be more cost efficient over its useful life than the bioswale when it comes to capturing water during major storms. The point of this initial use of the model, however, was not to conclude that the City should shift its policies in any particular direction, but to establish the feasibility of developing and using such a model in the City's annual capital planning and budgeting processes.

Next Steps. This most recent life cycle cost benefit modeling project to which actual cost data was applied in an initial test run, points to the feasibility of City agencies using life cycle modeling in capital planning and budgeting, certainly for green infrastructure, but also for all the elements of the roadway. Eshleman's model was not able to include all the benefits accruing from these types of features nor was it possible to test the range of rain events that are likely to occur in the context of climate change. However, were City line and oversight agencies to collaborate and begin using this type of model for capital planning and budgeting purposes, they could adapt it to include other benefits and expand the range of rainfall volumes and speed of runoff.

2011-2012

Gypsum Recycling in PlaNYC 2030: Spaces for Government Intervention

Town: NYC DDC

Gown: Columbia/GSAPP

Researcher: Caroline Bauer

Objective. In the context of a master of urban planning thesis guided by the research question *How to Design Incentives for Sustainability Implementation?*, Caroline Bauer focused on gypsum recycling at two public owners in New York City, as a case study to assess how government, as regulator, can create incentives for desired behavior. While PlaNYC lists gypsum scrap recycling as a priority, it also notes the lack of gypsum recycling resources and infrastructure. This project specifically sought to identify the kinds of actions the City might take to incentivize gypsum recycling.

Methodology. Bauer conducted a literature survey related to both government regulation and gypsum production and recycling, in particular to document the lifecycle of gypsum wallboard from extraction to disposal. Bauer conducted two series of interviews, one of government officials to describe the culture in which decisions about recycling regulations and enforcement occur and another of supply chain participants to describe current practices related to gypsum use and recycling and the nature of the current market for gypsum recycling services. Bauer also analyzed standard contractual relationships on construction projects to identify the roles and responsibilities related to construction product inputs such as gypsum in order to conduct a proto cost benefit analysis of feasible incentives.

Research Findings. During the process of assessing the benefits and costs of the various incentive proposals identified, Bauer found that the original question of how the City should incentivize gypsum recycling shifted to whether the City should incentivize gypsum recycling. Gypsum is an abundant and cheap material to extract, recycled scrap is difficult to sell, and synthetic gypsum has emerged as a “greener” and cheaper alternative to recycled gypsum. The nature of the material and the market for its production, which is at the national level, suggested that local government was not the appropriate or optimum actor for gypsum recycling regulation or incentives to increase recycling compliance. Bauer concluded that the City should re-examine whether gypsum recycling should remain a policy priority.

Next Steps. Bauer included recommendations on how other stakeholders in the supply chain could handle the material given its incompatibility with the transfer station and landfill environment. The methodology Bauer followed also provides a basis to develop a model for use in analyzing future local recycling proposals.