

*Construction and Demolition Waste Used as
Recycled Aggregates in Concrete:*

*Solutions for Increasing the Marketability of
Recycled Aggregate Concrete*

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Building Materials Reclamation

Introduction



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UNC Charlotte Building Materials Reclamation Program Overview

- Grant from the US Department of Energy
- Purpose:
 - Develop innovative and cost-effective ways of diverting construction and demolition (C&D) waste from landfills through recycling and reuse
 - Possibly develop strategies that create small business opportunities
- Ongoing research as part of this grant:
 - Reclamation and reuse of structural steel members
 - Use of gypsum wallboard as a soil amendment
 - Use of concrete and masonry rubble as recycled aggregate in concrete materials



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Introduction

- Most RA used in ready-mixed concrete applications consists of crushed returned concrete.
- Some components of C&D waste, particularly concrete slabs, beams, columns, and masonry walls can be crushed and graded into RA material.
- Use of C&D waste as RA in concrete has been successfully demonstrated
- Acceptance and use have not become widespread, particularly in Charlotte and Mecklenburg County, North Carolina



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Goal of this Study:

From a local/regional perspective, show that use of RA, produced from C&D waste, in concrete is

- Technically feasible
- Economically viable
- Investigate the feasibility of developing a substantial supply of concrete-grade RA from C&D waste
- Identify a range of potential concrete products that could potentially incorporate the RA from C&D waste
- Synthesize feedback from those involved in the industry regarding
 - impediments to more widespread use of RA from C&D waste in concrete applications
 - incentives that could promote acceptance and use

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Current endpoint for RA comprised of C&D waste

- Worldwide:
 - Europe has excelled at reusing high proportions of C&D Waste in new construction
 - RILEM and BRE have made strides towards a standard for recycled aggregate use in Portland Cement Concrete
- In Mecklenburg County, North Carolina:
 - Low-grade uses
 - Fill material
 - Surfacing material for temporary roads
 - Some roadbed material
 - Temporary roads at the Landfill

RA in Mecklenburg County, North Carolina

- 2005 statistics:
 - Concrete and other hardscape rubble comprised 8% of the C&D waste produced
 - Approximately 28,000 tonnes
- Current economic conditions have resulted in a reduced intake of rubble materials (and overall C&D waste volume)
- Currently, the C&D landfill has more internal demand for RA produced from C&D waste (for haul roads) than that which is being provided



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Case Study – Idlewild Elementary School

- Demolished portion of school was built in 1953.
 - Concrete slab-on-grade
 - Reinforced and unreinforced masonry walls
 - Steel framed roof, some prestressed concrete double-tees



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Case Study – Idlewild Elementary School



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On-Site Testing Prior to Demolition

- Concrete slab-on-grade
 - Documented location of portion of slab to be crushed, graded, and returned to laboratory
 - Cores removed
 - Rebound hammer testing
- Masonry walls
 - Documented location of walls to be crushed, graded, and returned to laboratory
 - Whole brick and whole clay tile samples removed



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Top-Down Demolition Strategy

- From demolition contractor's standpoint, advantageous for several reasons:
 - Concrete slab-on-grade remains in place until remainder of building is cleared from site
 - Ensures that equipment has a sound surface to traverse
 - Concrete slab is used as a sorting pad for other materials



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Top-Down Demolition Sequence

1. Removal of hazardous materials such as asbestos
2. Removal of valuable metals (copper, non-critical steel structures)
3. Demolition of non-masonry partition walls, drop ceilings, and fenestration
4. Collection and disposal of materials listed in #3
5. Demolition and removal of roof framing, decking and covering
6. Demolition and removal of masonry partition and exterior walls
7. Demolition and removal of concrete slab



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Crushing Operations

- Portions of concrete slab and masonry walls were transported (separately) to demolition contractor's crushing operations.
- Crushed and graded
 - Minimal additional work was required to ensure that the material stayed “clean.”
 - No additional equipment was added and no operational changes made prior to crushing and grading of the material.



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Characteristics of RA

Gradation of RA and Recycled Brick Masonry Aggregates Produced from Idlewild Elementary School Demolition Rubble

Sieve Opening [mm]	% Finer	
	Recycled Concrete Aggregate	Recycled Brick Masonry Aggregate
19	100	100
13	100	99.8
9.5	85.0	85.1
4.75	14.0	19.5
2.36	3.0	0.8
Pan	0.0	0.0



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Characteristics of RA

Characteristics of RA and Recycled Brick Masonry Aggregates Produced from Idlewild Elementary School Demolition Rubble

Characteristic	Recycled Concrete Aggregate	Recycled Brick Masonry Aggregate
Bulk Density (kg/m ³)	1,281	975.5 (ASTM C29 shoveling procedure)
Absorption (%)	7.6	12.2
Abrasion Resistance (% lost)	TBD	43.1

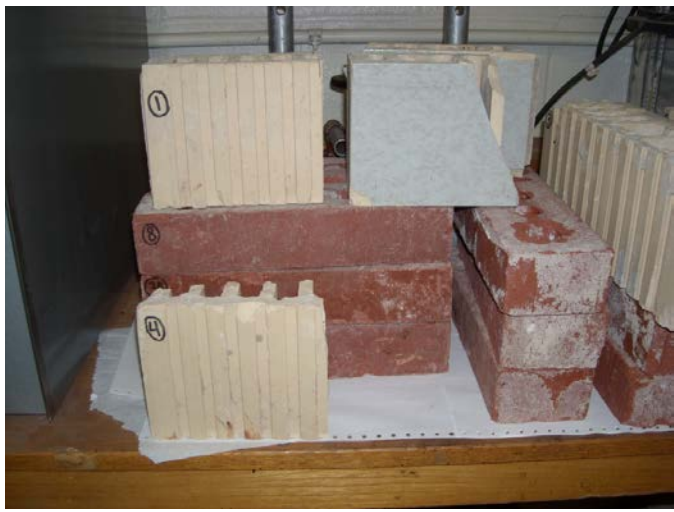


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Characteristics of RBMA

Composition of Recycled Brick Masonry Aggregate

Material	% by weight	% by volume
Clay brick	64.5	63.9
Clay tile	2.1	1.9
Mortar	30.1	31.6
Other (rock, porcelain, lightweight debris)	3.3	2.6



Development of Concrete Applications

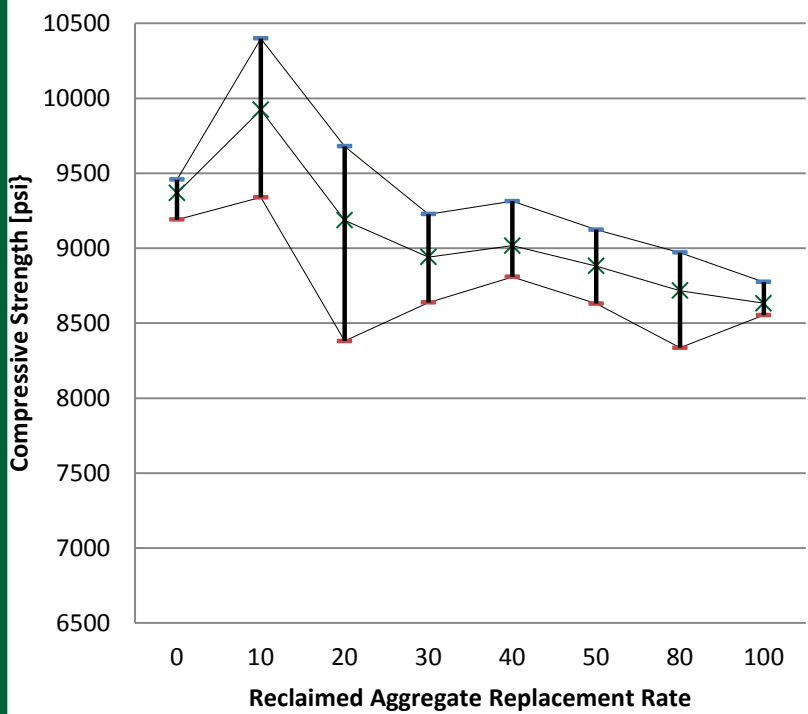
- Ongoing research – findings in future presentations
- Portland Cement Concrete
 - Recycled concrete aggregate (slab-on-grade)
 - Recycled brick masonry aggregate (brick masonry walls)
 - Development of concrete mixture designs, mechanical properties
- Geopolymer Concrete
 - Recycled concrete aggregate (slab-on-grade)
- Overall:
 - Careful source separation of reasonable quality C&D waste materials has resulted in production of a relatively consistent RA.
 - Concrete incorporating RA (up to 100% replacement) produced from C&D waste obtained at the case study site has exhibited acceptable fresh properties and mechanical properties.



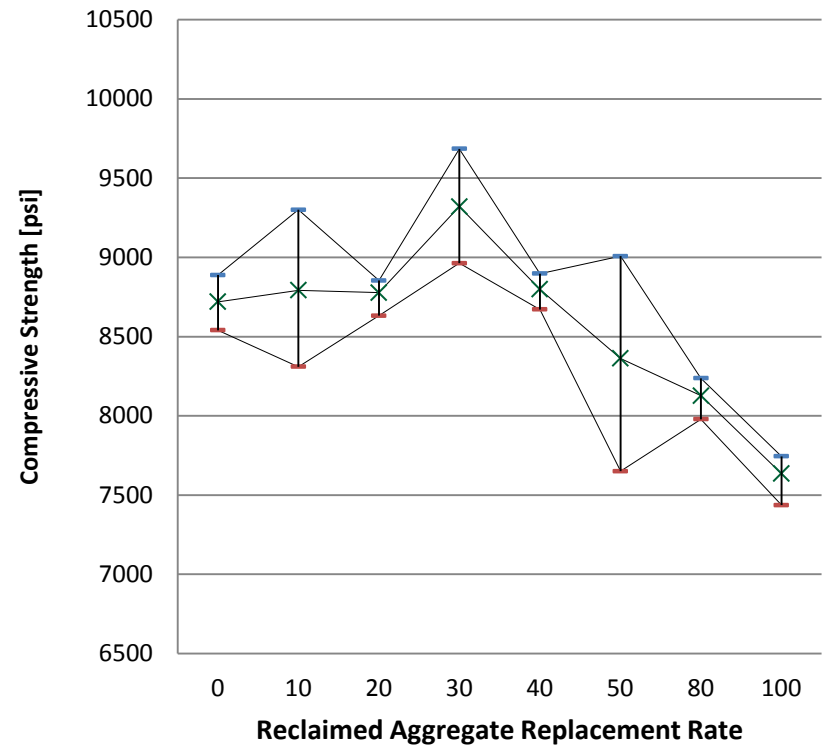
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Reclaimed Aggregates within Portland Cement Concrete

Mixed Demolition RCA – 28 Day Compression



Source Separated (Idlewild Elementary School) RCA - 28 Day Compression



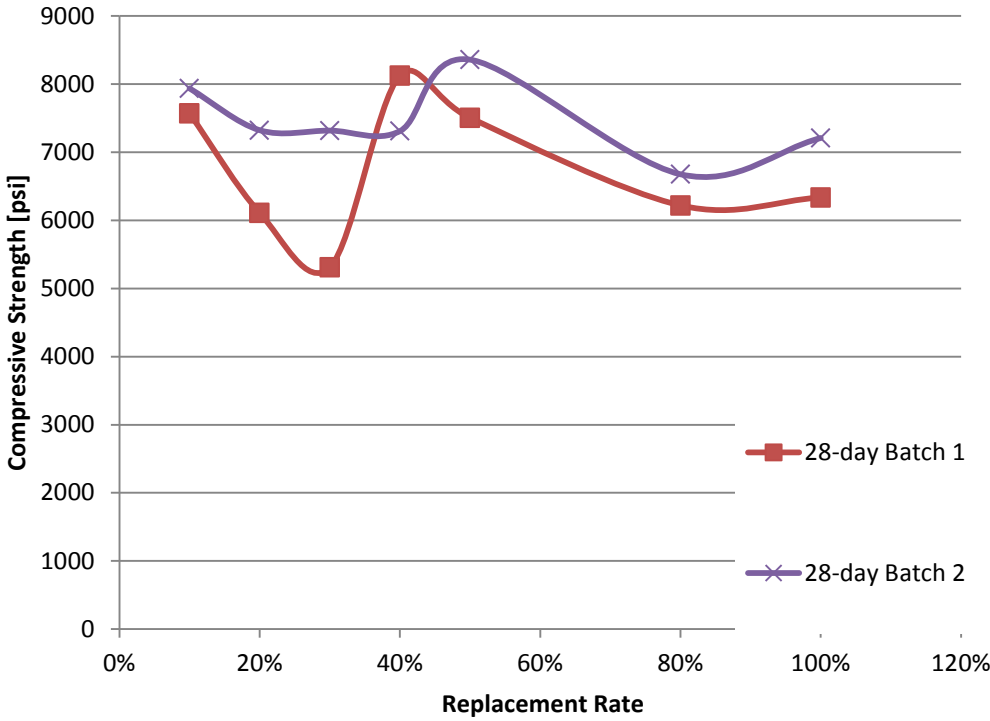
Aggregates provided by D.H.Griffin Wrecking Co.



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Reclaimed Aggregates within Geopolymer Cement Concrete

- Recycled aggregates were mixed into the geopolymer concrete by replacing 10, 20, 30, 40, 50, 80, and 100% of the virgin aggregate volume



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Geopolymer Concrete Beams with Recycled Aggregates



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Geopolymer Concrete Beams with Recycled Aggregates



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Local and Regional Market for RA – Input from Those Involved in the Industry

- Demolition Contractors
- Aggregate Producers
- Concrete Producers

- Impediments preventing widespread acceptance and use of RA in concrete
- Possible incentives that could be used to promote use of RA in concrete
 - Particularly RA from C&D waste



Impediments to Use of RA in Concrete – Perspective of Aggregate Producers

- Existence of on-site and low-grade uses for RA
- Potential for unsteady supply of source material
- No examples of large scale use
- Conflict with other cost centers within a company
- Equipment costs
- Limited awareness of crushing as a disposal option
- Availability of illicit dump sites
- Quarries have a political advantage in large projects

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Impediments to Use of RA in Concrete – Perspective of Concrete Producers

- Ready supply of virgin aggregates in the Mecklenburg County, NC area
- Preference for returned material
 - Known composition enhances comfort level
- Storage space and handling requirements
 - Space at a premium at many facilities
 - Cost to up-fit existing facilities with storage and conveying systems can be significant
- Lack of experience with recycled materials
 - Additional training and guidance, grounded in research and field study is needed

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Incentives and Tactics to Promote the Use of RA – Input from Aggregate Producers

- Waive tipping fees for higher quality rubble at crushing operations
 - Offset cost of hauling
- Provide income tax credits
 - Identified as perhaps the incentive of most interest
- Create demand from project owners
 - Tax credits for use or other incentives to encourage selection over virgin aggregates
- Create more stationary/permanent crushers
 - Capable of producing more consistently graded material



Incentives and Tactics to Promote the Use of RA – Input from Concrete Producers

- Explore potential products
 - Lower-strength uses such as footings
- Consolidate operations
 - If a single facility could receive and crush C&D waste, quarry virgin aggregates, and batch concrete, development of mixtures containing appropriate quantities of RA would be more feasible.
- Engineers submit their own quality control plan
 - For use on niche projects (such as buildings seeking LEED certification), specifications from engineer regarding source material handling, prequalification tests for mixtures, and additional testing requirements.



Conclusions

- In Mecklenburg County, North Carolina, RA produced from the existing stream of C&D waste is currently directed to non-concrete low-grade applications.
- Shortage of field experience with RAC in North Carolina has delayed interest in and acceptance of the material by engineers, contractors, and suppliers.
 - Much research and guidance on RAC has been centered on RA produced from returned concrete.
 - Additional research focusing on performance of RA from C&D waste sources needs to be performed.



Conclusions

- Apprehension regarding use of C&D waste as RA based upon:
 - Potential for contamination of source material with other debris
 - Inconsistent physical properties
- “Top-down” demolition approach has been shown to address these concerns
 - Already routinely utilized by many demolition contractors
 - Has been shown to produce relatively clean and uniform sources of RA with satisfactory characteristics for PCC applications.



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Conclusions

- Concrete incorporating up to 100% RA produced from the case study site has been shown to exhibit acceptable performance.
 - Findings to be presented in subsequent publications
- Concrete producers can realize cost savings with RA
 - If supply and consistency of C&D waste increases, improved market interest in RA should follow.
 - Remaining impediments include:
 - Equipment and operational cost barriers
 - Other economic issues such as tipping fees, hauling costs, and increased product development expenses

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Acknowledgements

- United States Department of Energy
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- Vulcan Materials
- Argos USA
- National Ready Mixed Concrete Association

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Questions?



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NCDOT Recycled Aggregate Usage

- Yes
 - Base Course
 - Projects with Special Permission to include Recycled Material
- No
 - Hot Mix Asphalt
 - Portland Cement Concrete
 - Miscellaneous