

# Ceramic Tiles and Waste Reduction

Amy Chen, Janine Choy, Lia Levine  
Professor Hejintao Huang at the Cooper Union

## Introduction

Ceramic tiles is a widely utilized resource in NYC and can be found in:

- Homes (tiling in bathrooms and kitchens)
- Subways (wall tiling)
- Various industrial and technical products
  - Chemical and petrochemical processing (pipes, pumps, and valves)
  - Electronics (electrical capacitors, resistors, and protective casings for smartphones and computers)
  - Medical field (dental implants, synthetic bones, and surgical tools)

Ceramic tile waste and discard also holds high reuse, recycling, and repurposing value:

- Structural concrete (strengthening & cost reduction)
- Sound barriers (useful for high noise pollution areas like NYC)
- Soil incorporation (stabilization)
- Fire mitigation (high heat resistance and durability)
- Alkali-activated mortars (reduces waste while maintaining strength)

## Rules and Regulations

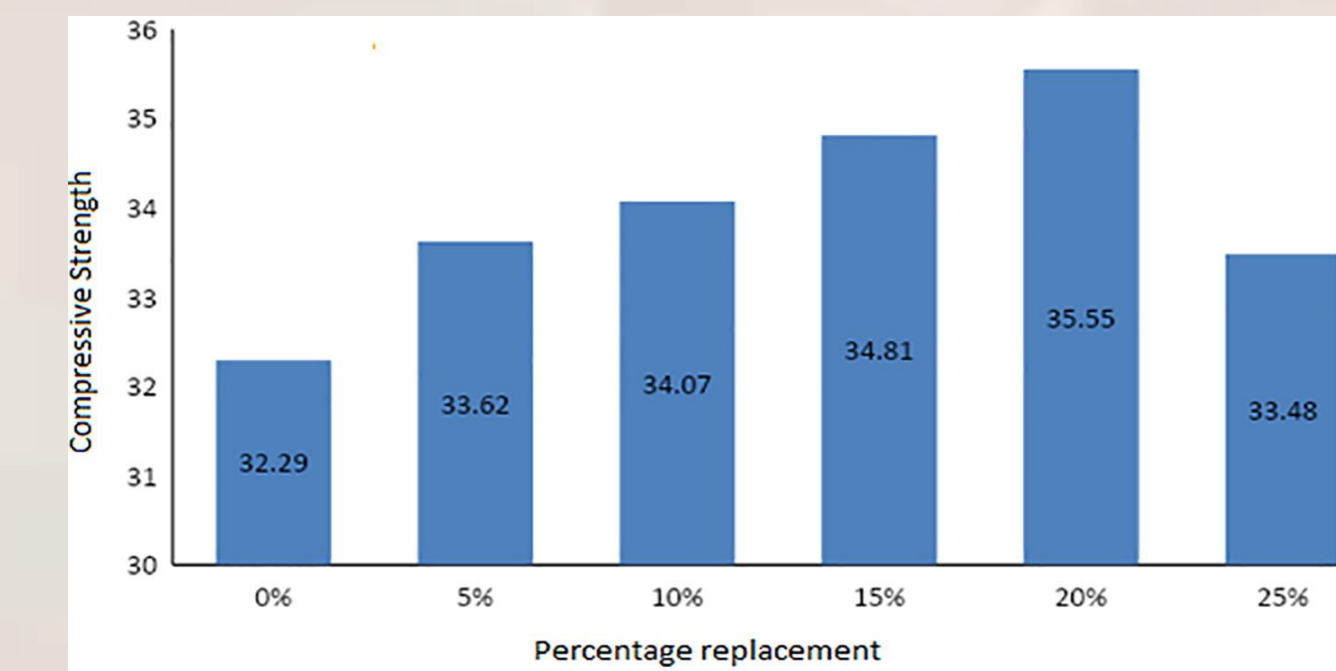
**Beneficial Use Determination (BUD):** Allows waste material to be put to another purpose

- **Masonry products are designated to BUD and may be used as aggregate when they:**
  - Are uncontaminated and recognizable
  - Are separated from other material prior to processing
  - Contain negligible amounts of soil or wood
- **Concrete with excavated masonry filler may be used:**
  - Under foundations and pavements above seasonal highwater table
  - For embankments or subgrade:
    - In transportation corridors
    - On sites where existing material is more contaminated than fill
- **A sample of excavated masonry material must be analyzed before use unless:**
  - Quantity of excavated material does not exceed 10 cubic yards from one site
  - Does not exhibit historical evidence of contamination based on site use, reported spill events, or visual and other indicators
  - No visual indication of chemical or physical contamination is discovered during excavation

## Reuse, Recycling and Repurposing Strategies

### Ceramic Waste as Concrete Coarse Aggregate

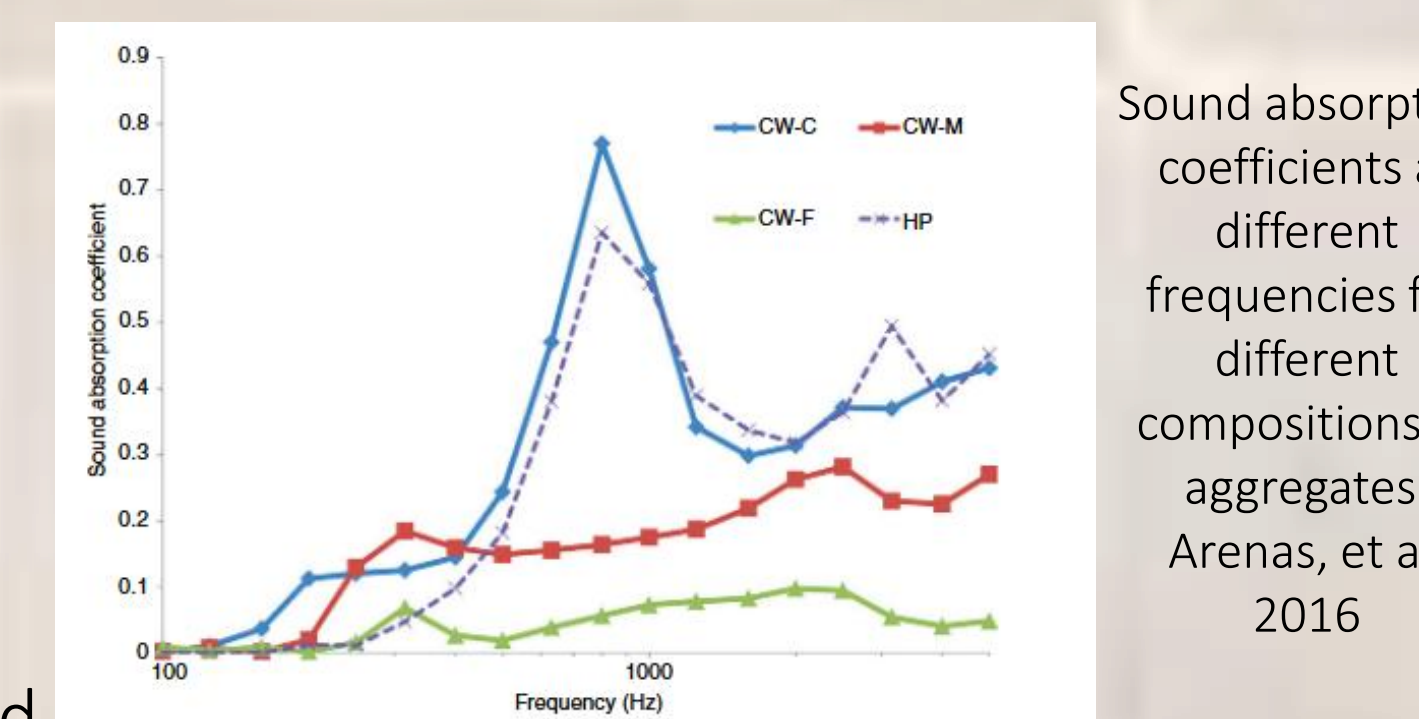
- Ceramic tile waste is abundant, ecologically conscious, and provides structural benefits
  - Thermal protection/reduced heat conduction due to porous nature
  - Replacement for depleting crushed concrete reserves
  - Durable, hard, resistant to degradation forces
- Key Benefits
  - Linear increase in abrasion resistance
  - Reduction in thermal conductivity coefficient
  - More cohesive/workable than crushed stone aggregate
- Key Limitations
  - Decrease in compressive, split tensile, and flexural strength after 20% replacement



Reduction in compressive strength after 20% replacement with ceramic aggregate. Bommisetty, et al. 2019.

### Concrete Aggregates in Sound Barriers:

- Conventional noise barriers reflect noise
  - Higher sound energy absorption due to its porous properties
  - Absorbs up to 800 Hz frequencies
- Key Benefits:
  - Absorbs frequencies that are the most difficult to remove (under 1000 Hz)
- Key Limitations:
  - Would need other aggregates to maximize the number of frequencies absorbed



Sound absorption coefficients at different frequencies for different compositions of aggregates. Arenas, et al. 2016

### Reuse of Ceramic Waste in Soil Matrices:

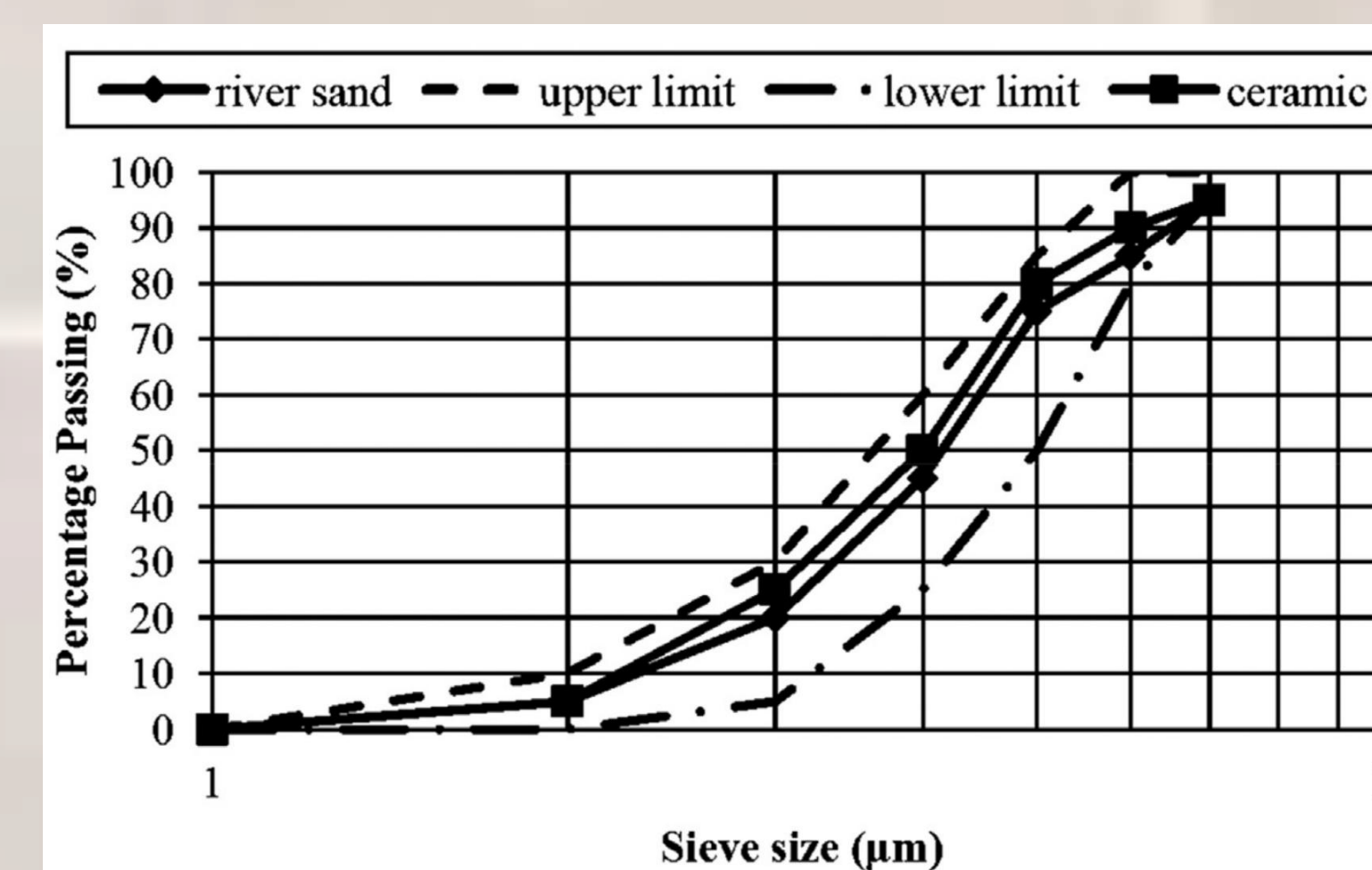
- Improves soil matrices and stabilization
  - By increasing strength and reducing swelling
  - Best used for expansive soils
  - Most improved with the addition of lime with the ceramic waste
- Key benefits:
  - Longer foundation and structure life spans
- Key limitations:
  - High water absorption, could weaken soil structure in humid climates

### Ceramic Tiles in Infrastructure Improvement:

- Ceramic tiles are sustainable, highly resistant and resilient materials
  - Inert material (remains chemically unchanged when heated)
  - Fired at extremely high temperatures
- Thermal and mechanical tests at ambient and fire conditions
  - ASTM E84 - flame spread of combustible materials
  - ASTM E16 - non-combustibility of materials
- Key benefits:
  - Non-combustible, inert, and non-thermally conductive
- Key Limitations:
  - Lack of expertise, standardized testing methods, equipment, and complexities

### Ceramic Tile Waste in Alkali-activated Mortars

- CTW replaces fine aggregate and fly ash
- Sustainable and eco-friendly
  - Reduces use of natural aggregates and waste of CTW
  - Maintains similar or greater strength to original materials
- Material characterization tests
  - Particle size tests & sieve analysis
  - ASTM C33 - grading requirements of fine and coarse aggregate in concrete
- Engineering tests
  - Compressive strength, drying shrinkage, water absorption
- Key benefits:
  - Environmental sustainability
- Key limitations
  - Processing required to meet ASTM C33 requirements



Sieve analysis of sand and CTW aggregates within the upper and lower limits of ASTM C33 standard

Altheeb, et al. 2023

## Material Properties

### Acids

- Can protect against acidic solutions
- Weak to basic solutions

### Freeze thaw

- Porous nature allows for water within concrete to expand, minimizing freeze thaw effects

### Sound proofing

- Absorbs frequencies under 800 Hz when mixed into cement

### Thermal Properties

- High heat resistance and thermal stability due to firing at extremely high temperatures (1200-1250°C)
- Thermally insulated, with low heat transfer
- Fire resistant
  - Non-combustible and does not propagate flames

### Chemically inert and nonreactive

- Will not with other chemicals
- Will not rust, corrode, or break down chemically
- Stable when exposed to heat, moisture, or environmental pollutants

## References

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## Acknowledgements

Amazing hejintao huang