VIRTUAL WORKSHOP | FEB 10, 2022

9:30am-12:30pm PT / 12:30pm-3:30pm ET

MAXIMIZING THE USE OF RECYCLED AGGREGATES FOR ROAD CONSTRUCTION IN CANADA

CIRCULAR ECONOMY LEADERSHIP CANADA

CIRCULAR INNOVATION COUNCIL

Welcome!

MAXIMIZING THE USE OF RECYCLED AGGREGATES FOR ROAD CONSTRUCTION IN CANADA

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Workshop Objectives

1. Examine the **economic and environmental benefits** of using recycled aggregates in road construction.
2. Gain insights into the **existing standards, specifications, and guidelines** for the use of recycled aggregates in road construction and **opportunities to harmonize** standards of practice in Canada.
3. Engage in conversations to **identify barriers / challenges to increasing the use** of recycled aggregates in road construction.
4. Share **case studies and examples from across Canada** to understand where and in what applications recycled aggregates are successful.
5. Explore how **public procurement can be an enabler** to support greater uptake of recycled aggregates to drive desired outcomes.

12:30-12:35pm EDT	Welcome & Introductions
12:35-12:45pm EDT	Setting the Context
12:45-2:15pm EDT	Presentations: • **Leandro Sanchez**, Dept. of Civil Engineering, University of Ottawa • **Juan Hiedra Cobo, Omran Maadani** & **Mohammad Shafiee**, National Research Council Canada (NRC) • **BREAK (10 minutes)** • **Jo-Anne St. Godard**, Circular Innovation Council • **Robert Klimas**, Engineering & Construction Services, City of Toronto
2:15-3:15pm EDT	**Breakout Group Discussions**
3:15-3:30pm EDT	Key Takeaways & Next Steps
3:30pm EDT	Meeting Adjourned

Setting the Context

CIRCULAR ECONOMY LEADERSHIP CANADA

Paul Shorthouse

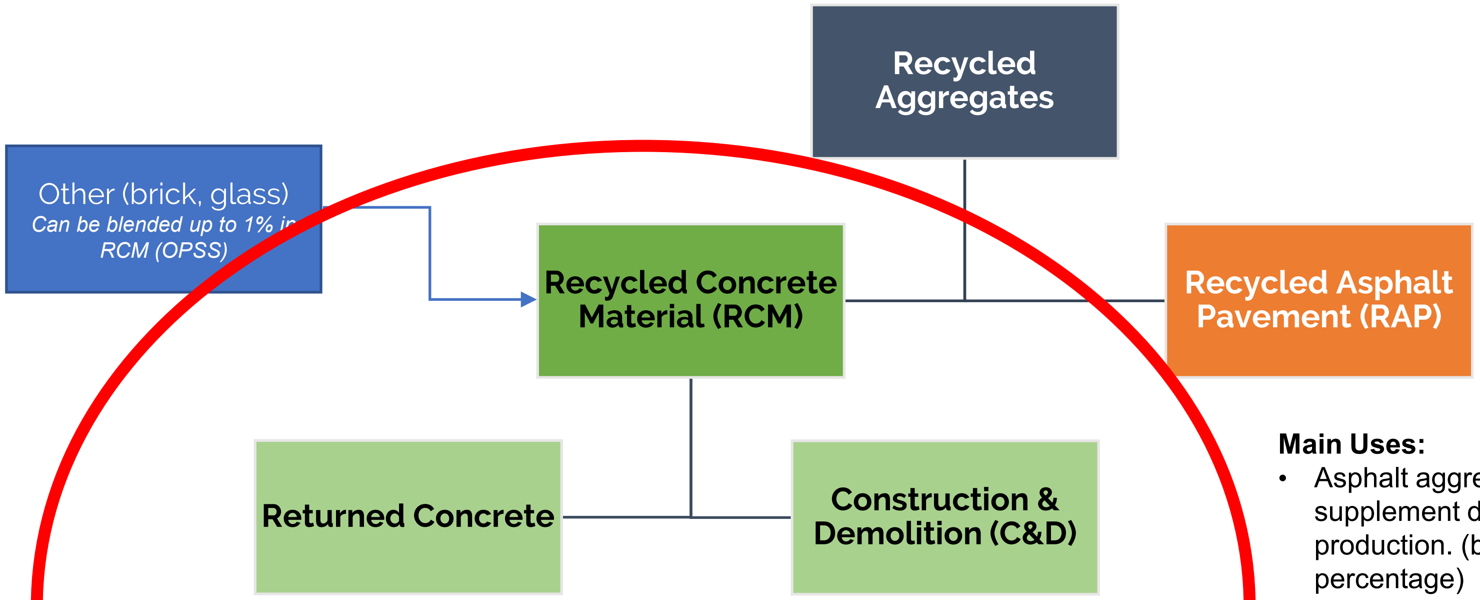
Managing Director

Current Snapshot

- A total of about 184 million tonnes of aggregate are used annually in the province.
- Virgin aggregates make up most of this demand…less than 7% come from recycled sources.[1]
- Municipalities are the largest consumers of aggregate in the province, using between 60 and 70 million tonnes a year.[1]
- There is a range of usage of recycled aggregates in road construction across Canada – some are adopting provincial standards, while others have their own standards and specifications.
- Some prohibit or severely limit the use of recycled aggregates altogether.

[1] Environmental Commissioner of Ontario, Good Choices, Bad Choices, 2017 Environmental Protection Report

Overview of Recycled Aggregates



Can not be used in concrete ready-mix applications due to oils in the asphalt

Main Uses: Road base, backfill
Limited use: In concrete mix

Products: Recycled Granular A, B1, B3 or blended into replace virgin material at quarry

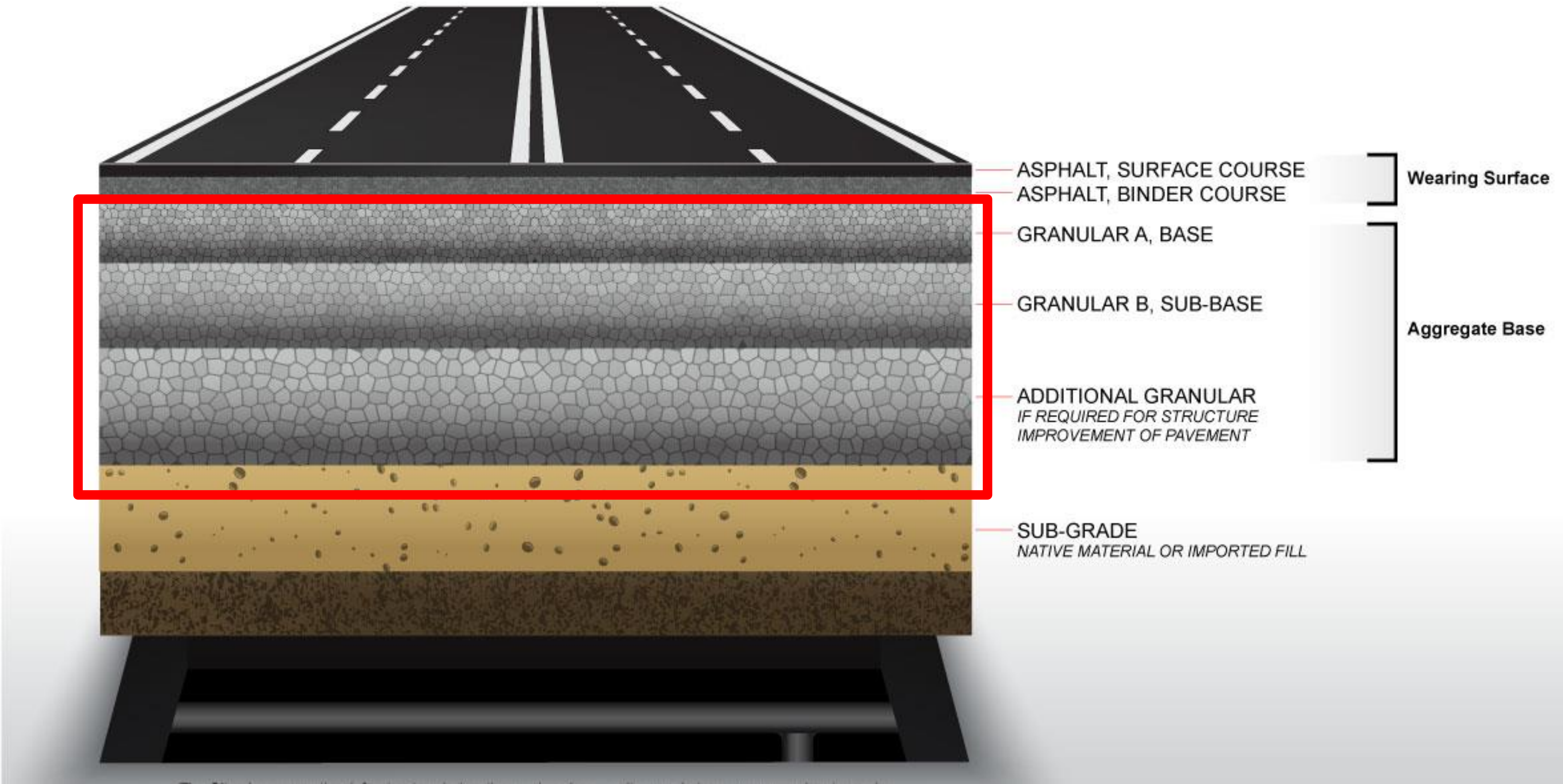
Main Uses: Road base, backfill
Limited use: In concrete mix

Products: Granular A, B, or blended into replace virgin material at quarry

Main Uses:
- Asphalt aggregate and/or supplement during hot-mix production. (blended at limited percentage)
- Granular base (or sub-base) aggregate (blended with virgin aggregates)
- Stabilized base aggregate
- Cold-mix asphalt.
- Private parking lots and driveways

Products: Max 30% RAP blending in Gran A, B1, B3 and M

Road Construction Layers



Benefits of RCM

1. **Availability:**

- Can be readily available based on C&D activities – with growing demand for recycling and recovering resources over landfilling

2. **Cost:**

- Potential to access recycled at a lower cost than virgin (varies by distance travelled, available supply, application, etc.)

3. **Environmental:**

- Preserving scarce natural aggregate resources and minimizing impacts from extraction
- Reducing materials to landfill
- Potential for reducing GHG emissions and wear and tear on roads from transport

Challenges & Risks

1. Quality and Consistency Issues
2. Performance Issues
3. Availability and Cost
4. Prescriptive Standards
5. Lack of Consistent Approaches
6. Perceived Risks and/or Business as Usual

Presentation

Dr. Leandro Sanchez
Associate Professor, Department of Civil Engineering

Université d'Ottawa | University of Ottawa

CIRCULAR ECONOMY LEADERSHIP CANADA

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Expanding the Use of Recycled Aggregates in Roads: Opportunities and key considerations

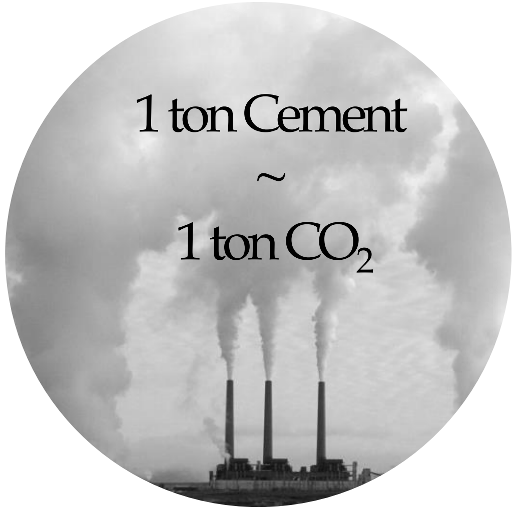
Leandro F. M. Sanchez, PhD, P.Eng
Associate Professor – Department of Civil Engineering
February 10th, 2022

Faculté de génie | Faculty of Engineering
genie.uOttawa.ca | engineering.uOttawa.ca

µStructure

uOttawa

Introduction



Net zero emissions by 2050 !

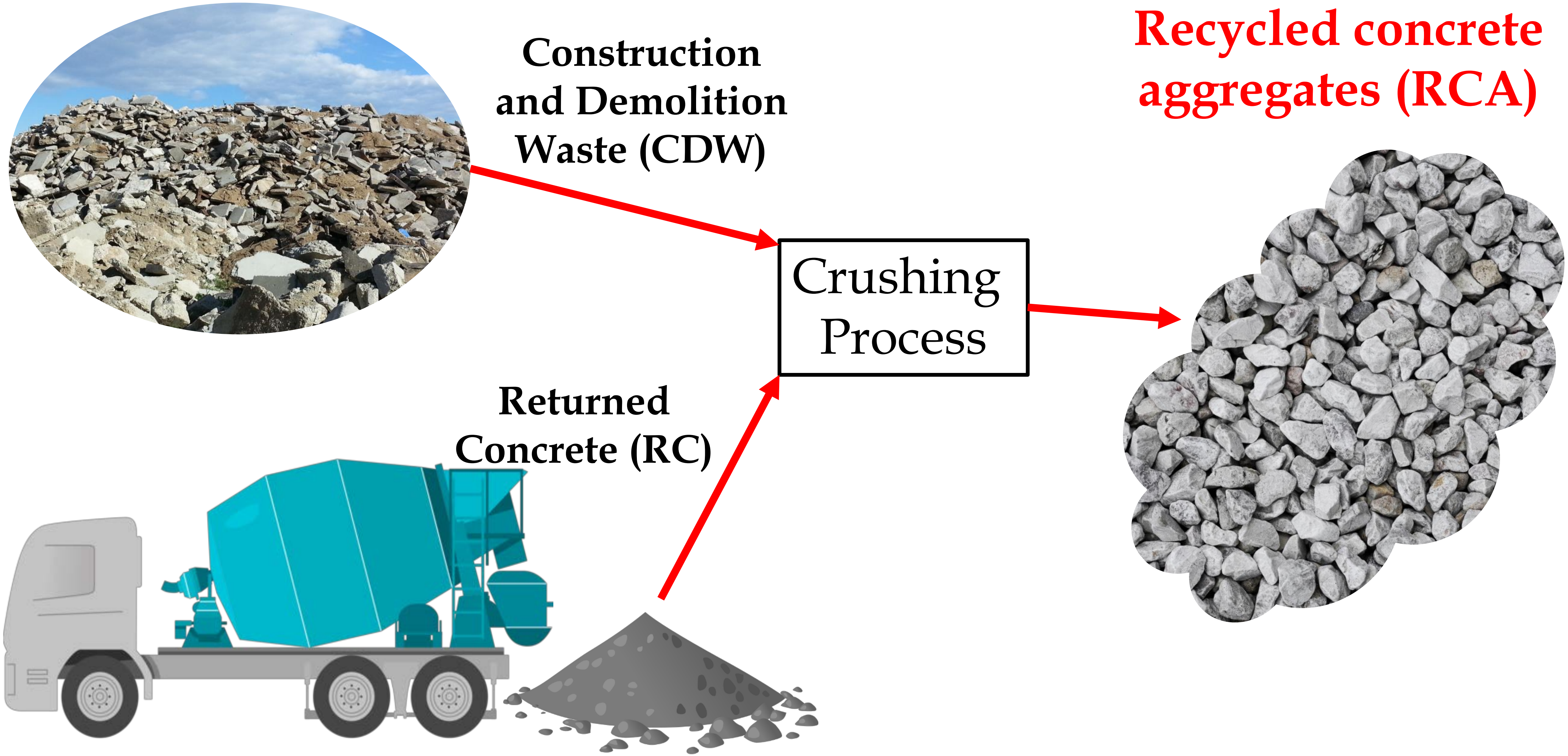
More sustainable use of aggregates !

Strategies: sustainable use of aggregates

Reduce the use of virgin aggregate	• Increase the use of recycled aggregate • Improve aggregate durability
Reduce the impact of virgin aggregate acquisition and processing	• Review environmental impact and remediation plans of different **Recycled concrete aggregates (RCA)** …rushing operations to …hape needed … should be decreased to avoid environmental and social impacts
Reduce the impact of aggregate transportation	• Avoid long-distance transport of aggregates • Increase use of local aggregates • Maximize the use of marine/barge and rail transport and minimize truck transport • Facilitate permitting of new aggregate sources and processing sites near major use areas • Use advanced aggregate acquisition and processing technologies

Islam, & Tarefder, R. A. (2020). *Pavement Design : Materials, Analysis, and Highways* (First edition.). McGraw-Hill Education.

Types of RCA


Construction
and Demolition
Waste (CDW)
Returned
Concrete (RC)
Crushing
Process
Recycled concrete
aggregates (RCA)

Types of RCA

Construction and Demolition Waste (CDW)

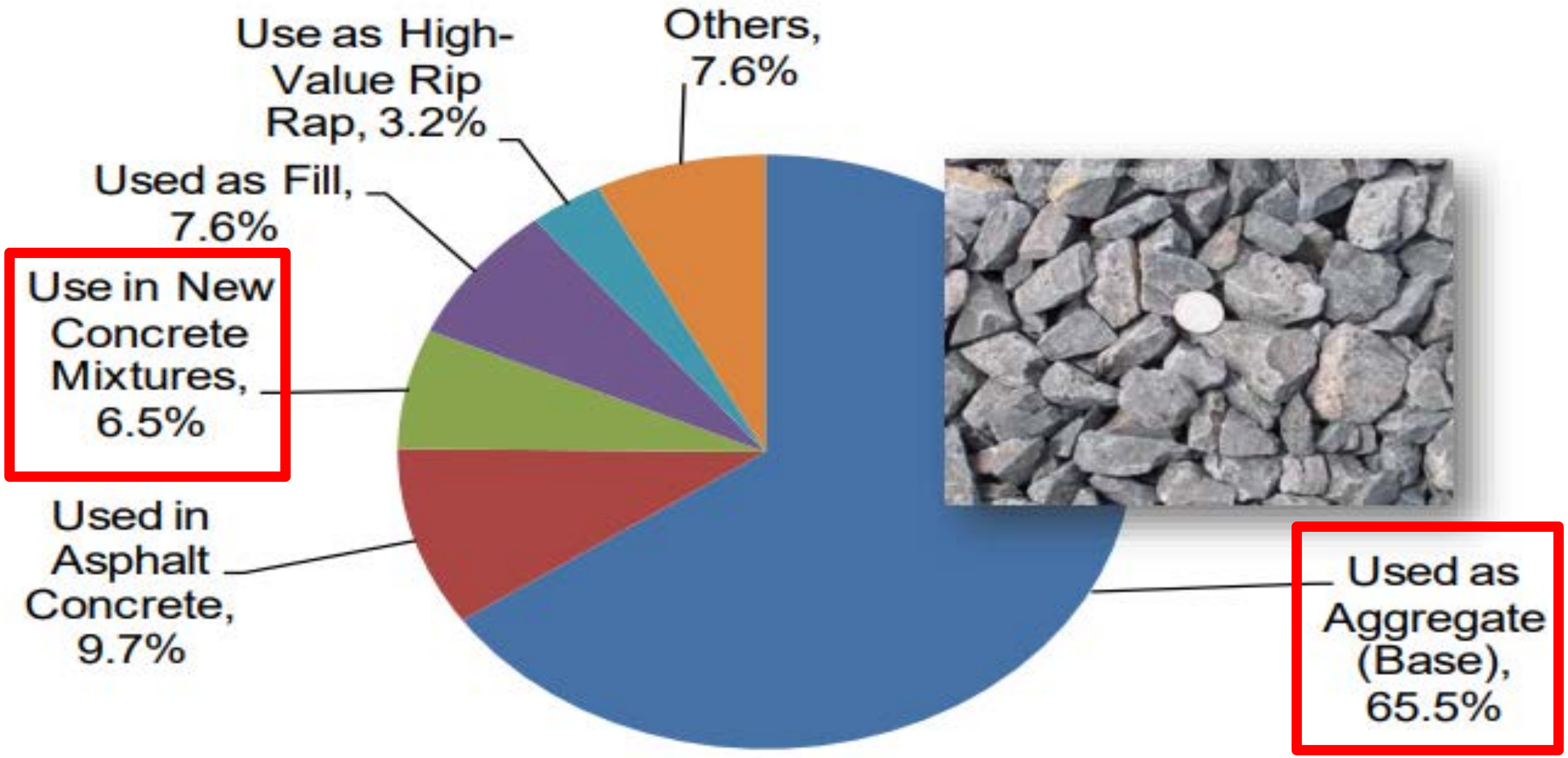
https://ec.europa.eu/environment/topics/waste-and-recycling/construction-and-demolition-waste_lv

≠

Returned Concrete (RC)

https://gcpat.com/en/solutions/products/clarena-rc-returned-concrete-management-solutions

Use of RCA in roads: USA



Van Dam et al, 2016, after Wilburn and Goonan 1998 and USGS 2000

Canadian perspective

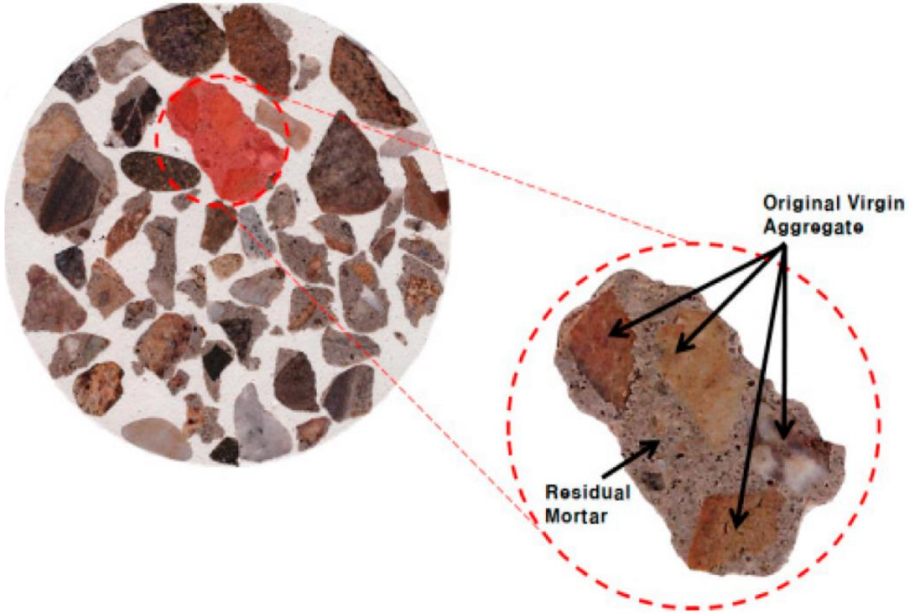
According to "*Reuse and Recycling of Road Construction and Maintenance Materials*" by the Federation of Canadian Municipalities and National Research Council (NRC):

- Concrete road works: RCA used in sidewalks, concrete pavement, curbs, etc., as base or new non-structural concrete;
- 30 to 50% asphalt debris allowed in the new base material, as long as the material provides adequate strength;
- CDW: debris must be considered and potentially rejected;
- Potential improvements in performance attributed to its **unique microstructure** (i.e., adhered mortar/cement paste incorporating unhydrated cement).

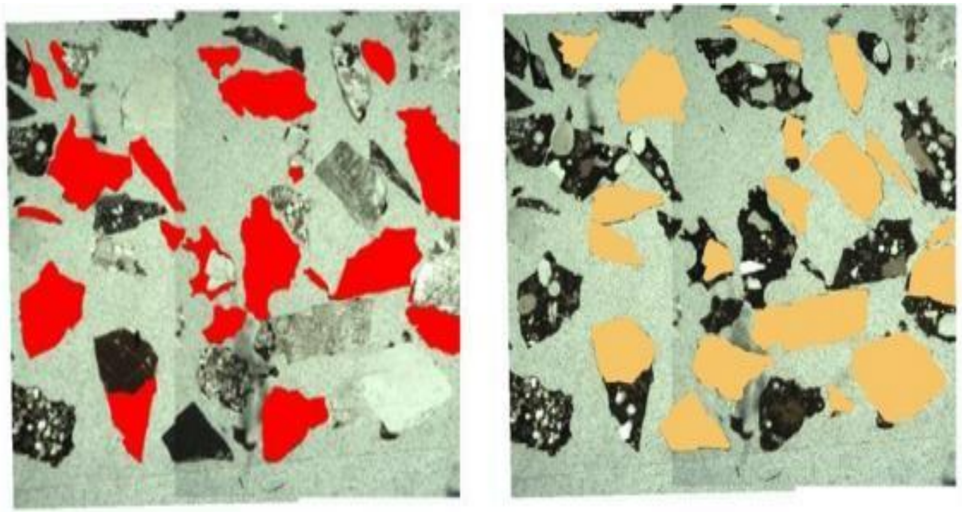
RCA microstructure

- RCA: multiphase material → ≠ microstructure!
- RCA in civil industry → non-structural applications (inferior quality);
- Concerns → high water absorption, high porosity – ↓ short and long-term performance;
- ***Residual mortar content (RMC) accounted*** → similar properties: RCA and CC mixes;

Use in concrete !

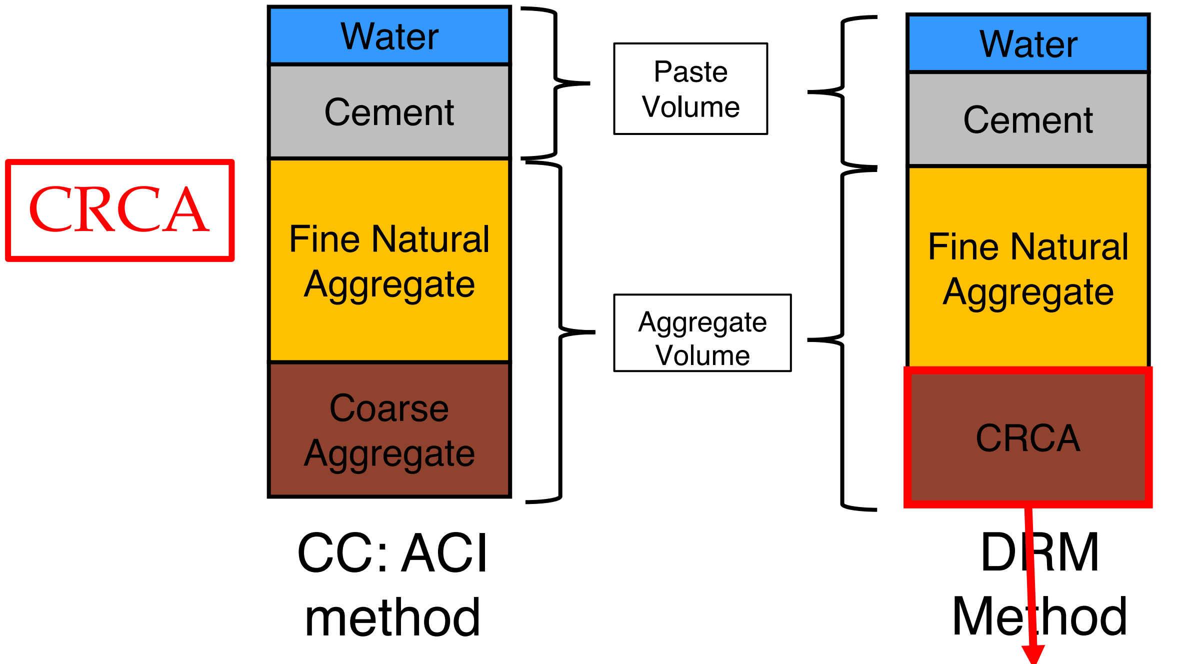


Beauchemin & Fournier, 2012

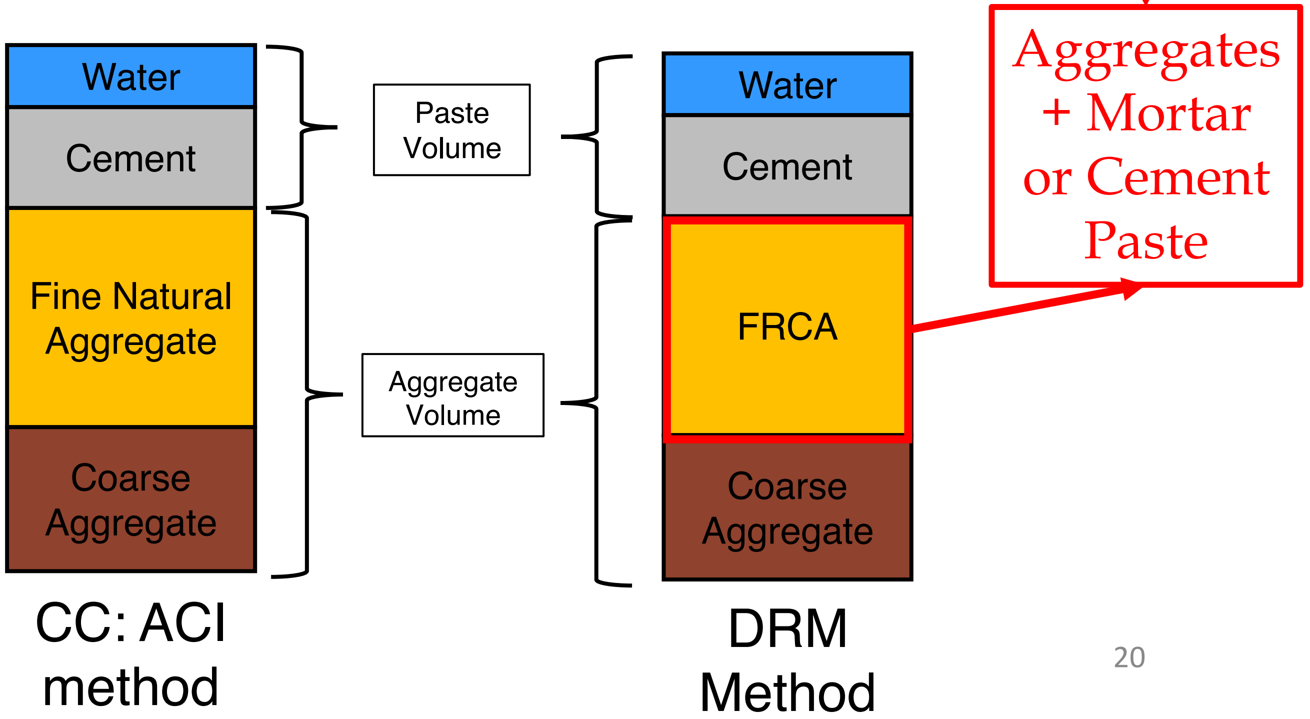


Mix- Design (DRM)

- DRM → RCA is used as NA;
- RMC → is not accounted for in the mix;
- **DRM techniques:**
  - Volume or Mass;
  - Based on ACI mix-design method;
  - FRCA = Natural aggregate.
  - CRCA = Natural aggregate;

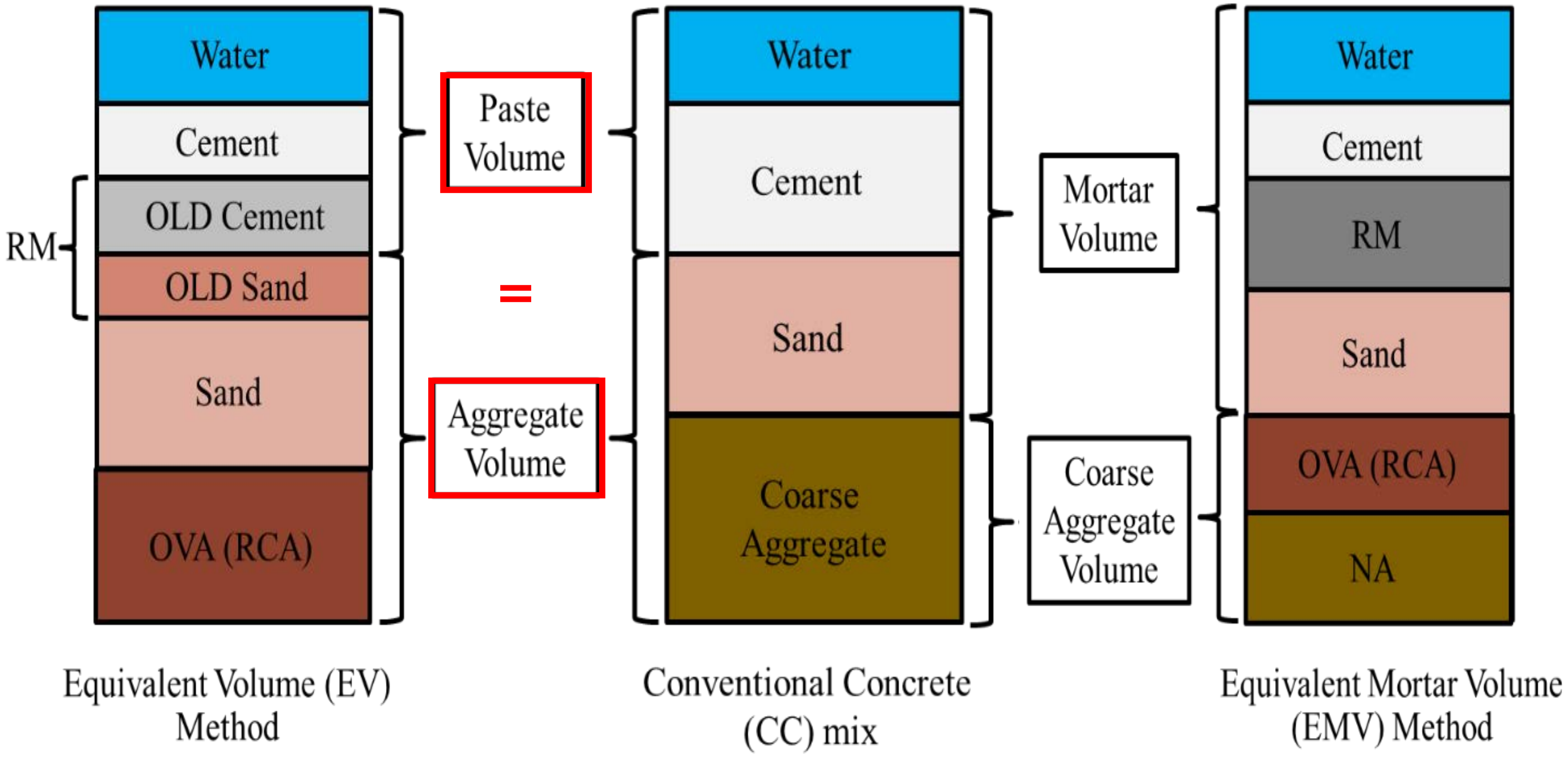


FRCA



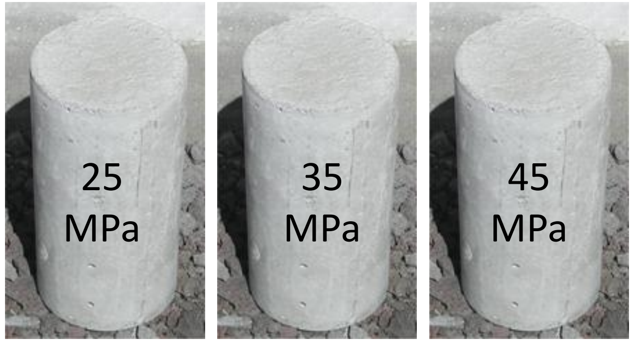
Lower performance than companion conventional concrete !

Mix- Design (EV): coarse and fine RCA

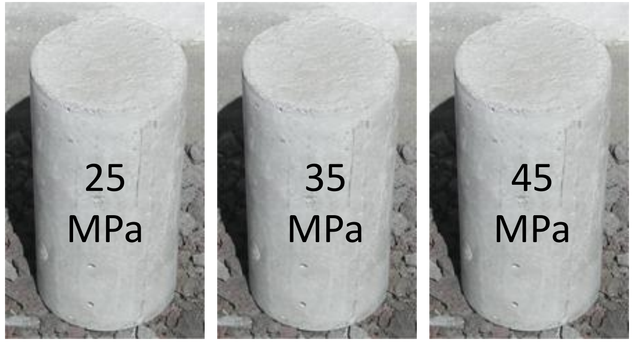


Interesting results

- Study of the CRCA source/quality



Quartzite gravel (S)

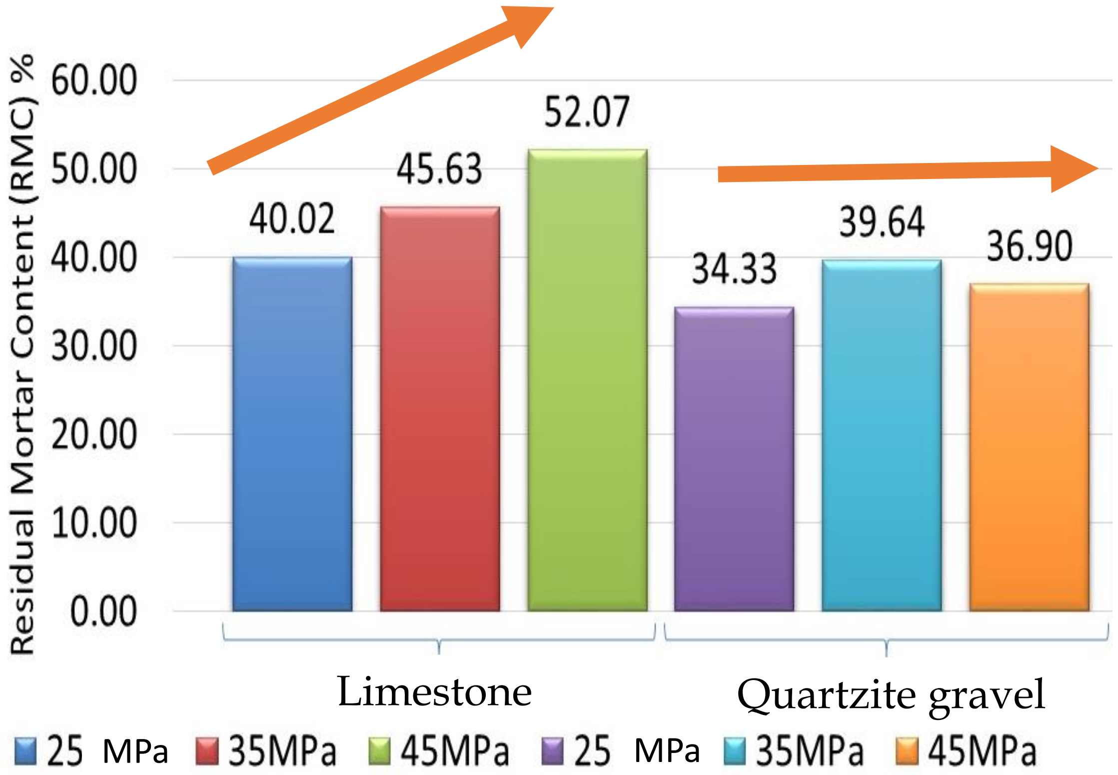


Limestone (NS)

35 MPa mixes → ≠ RCA sources

Interesting results

- Study of the CRCA source/quality

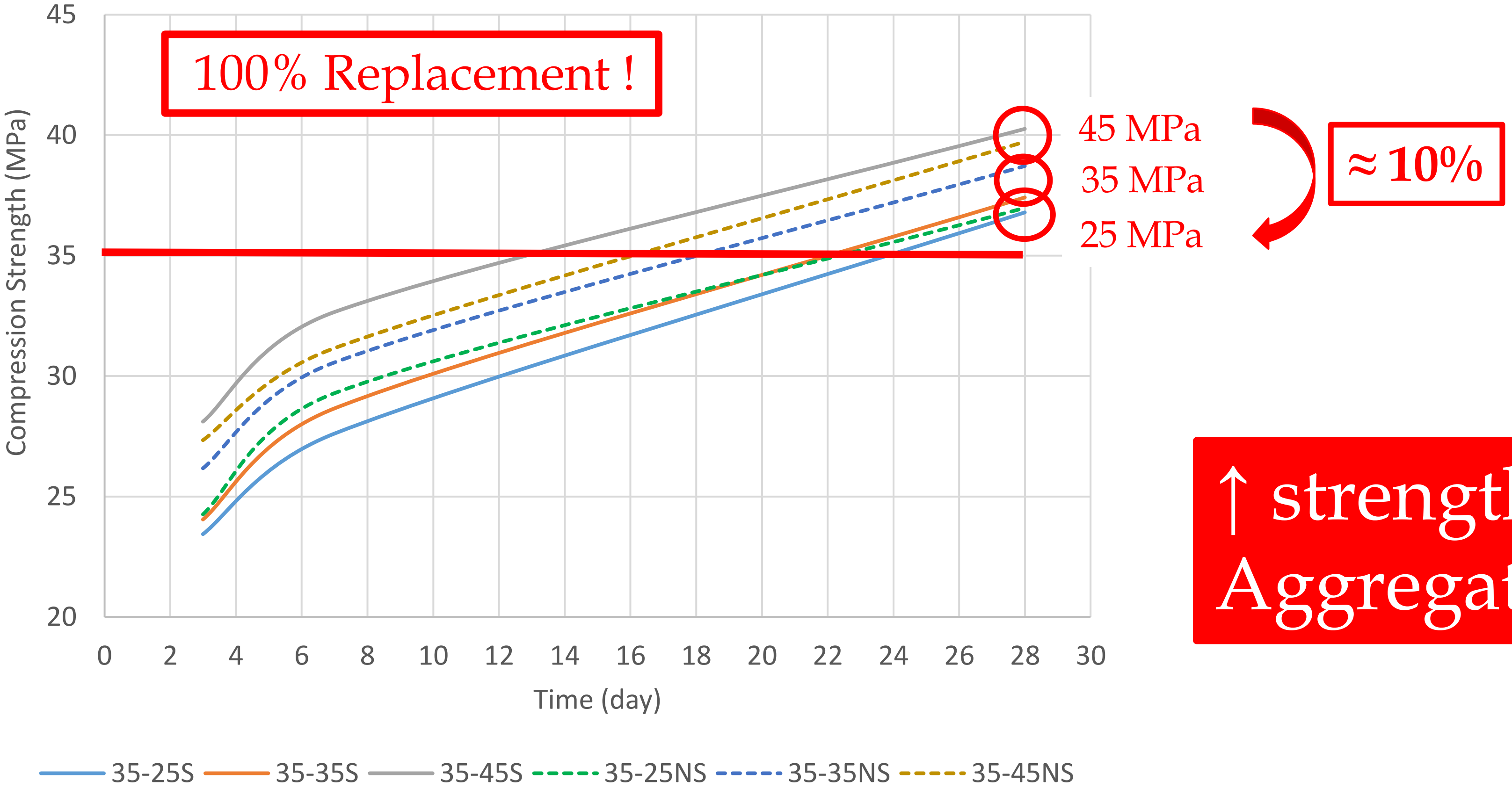


↑ strength - ↑ RM ;
↑ bonding - ↑ RM .

RM anging from 34 to 52% !

Interesting results

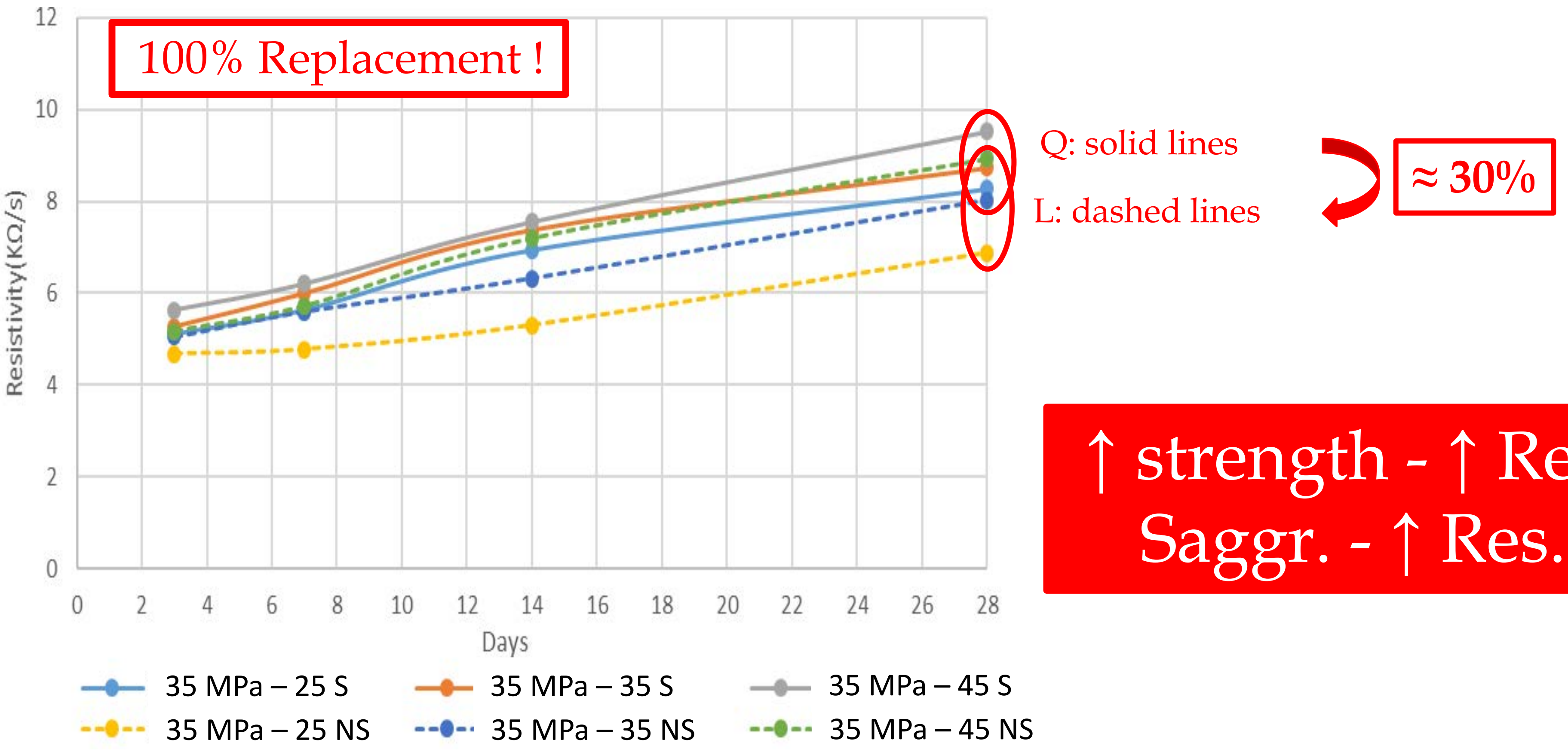
- Study of the RCA source/quality
- 35 MPa mixes with ≠ sources: **Compressive strength**



↑ strength - ↑ fc ;
Aggregate type – ?

Interesting results

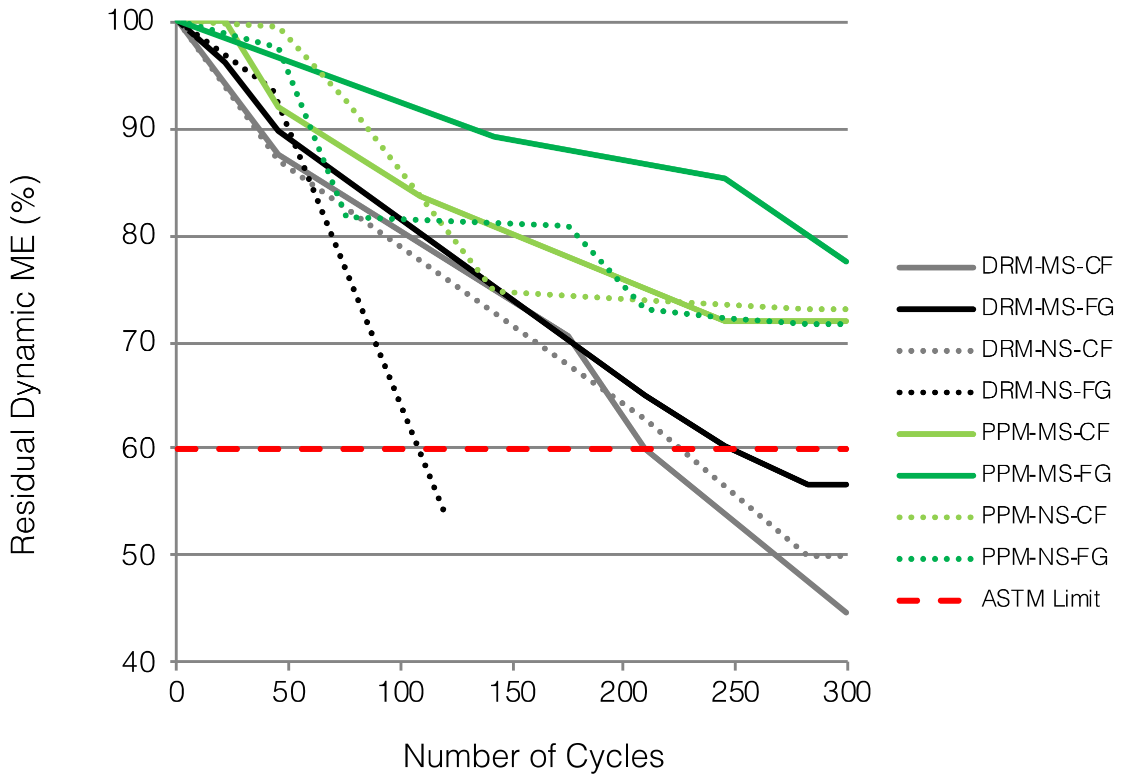
- Study of the RCA source/quality
- 35 MPa mixes with ≠ sources: **Electrical resistivity (durability index)**

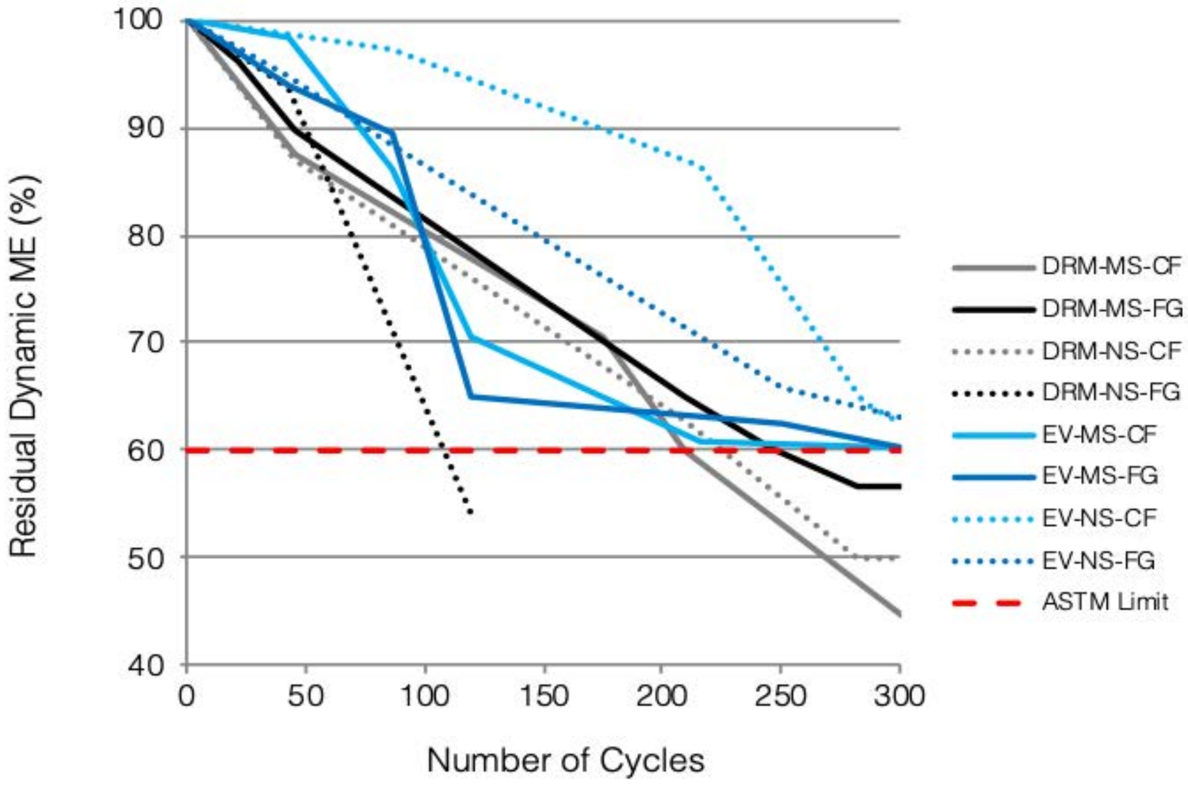


↑ strength - ↑ Res. ;
Saggr. - ↑ Res. ;

Interesting results

- Study of the FRCA/mix-proportioning
- 35 MPa mixes with ≠ sources: **Freeze-thaw resistance (NRC)**





Frost resistant = less than 40% reduction over 300 cycles !

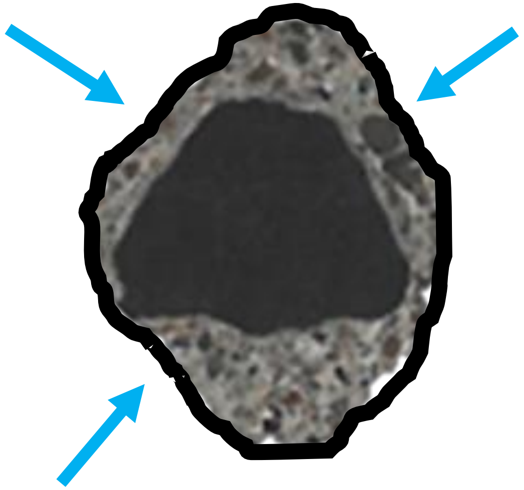
Swiss perspective

According to "SIA 2030: Concrete with recycled aggregates":

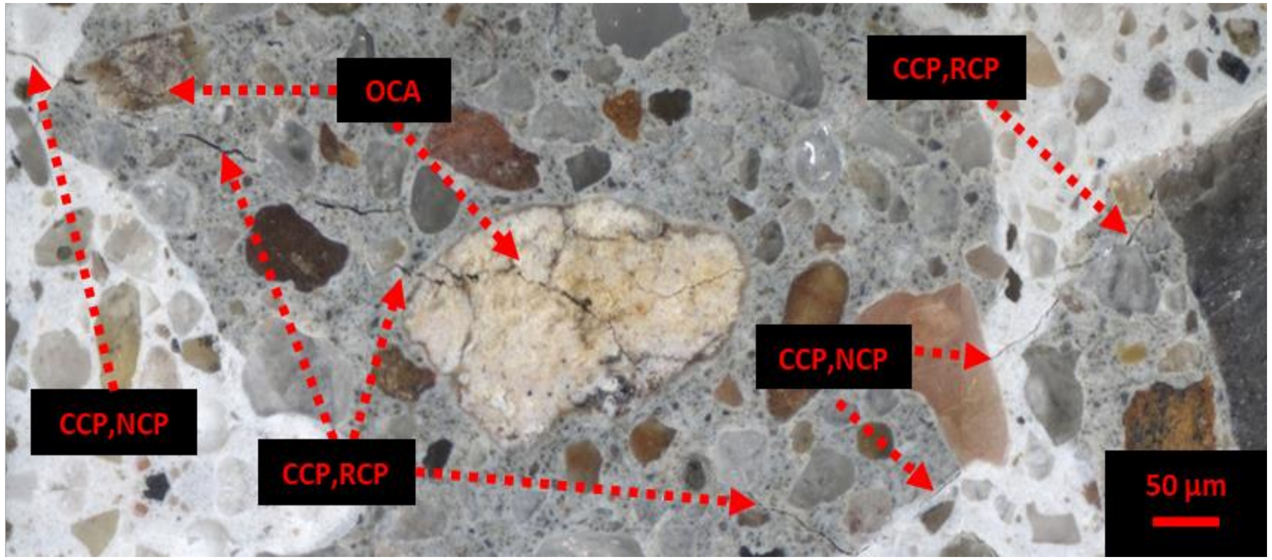
- Concrete: 25% RCA still considered "conventional concrete";
- Recycled concrete (RC-C):
  - RC 25: 25-50% by mass of RCA (returned or processed concrete);
  - RC 50: 50-100% by mass of RCA (returned or processed concrete);
- Recycled concrete (RC-M)
  - RC 10: 10-40% by mass of RCA (construction and demolition waste);
  - RC 40: 40-100% by mass of RCA (construction and demolition waste);
- **Recycled concrete: treated as an especial product (incentive or obligation for use);**

Research possibilities?

What is ASR?
Alkalis in pore solution of cement paste
+
reactive minerals in aggregates
+
humidity

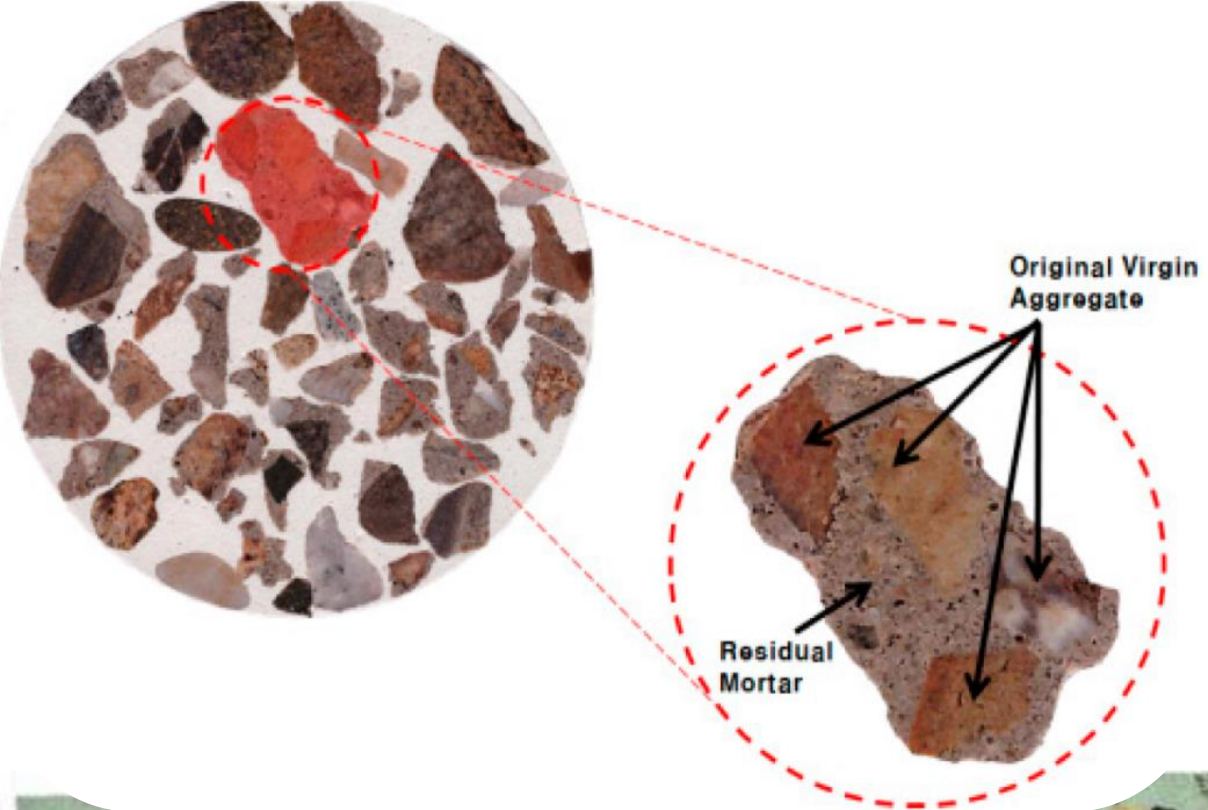


In concrete, we continue to see "secondary damage"…



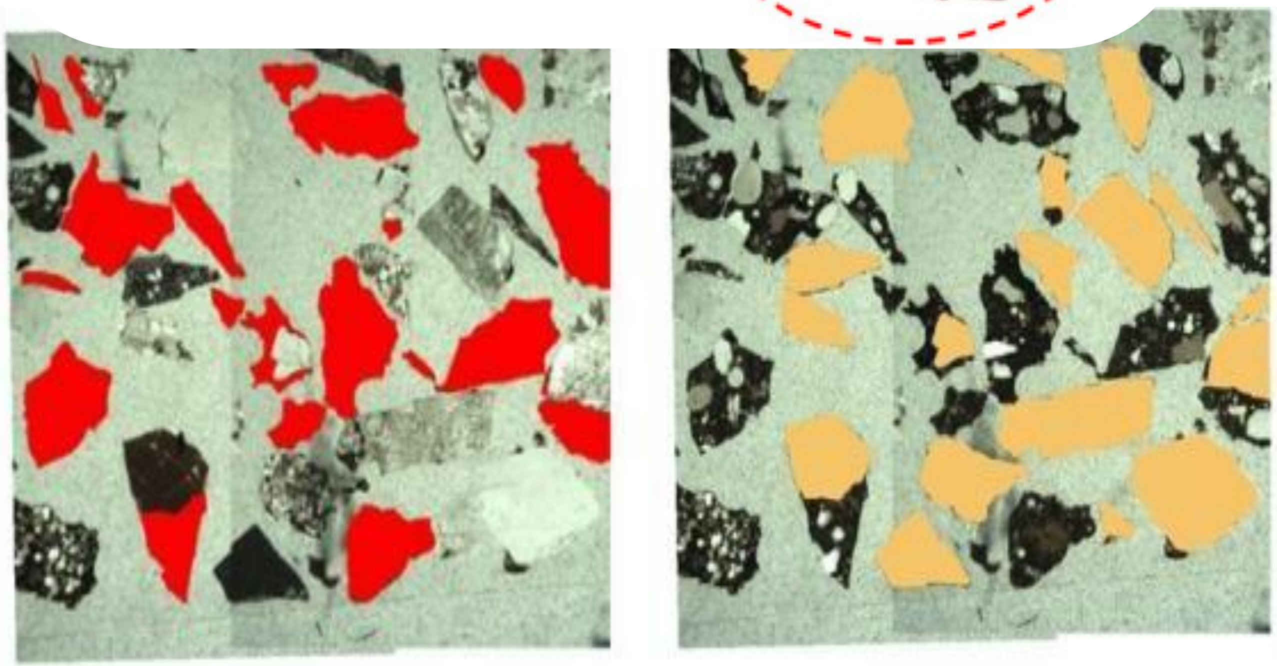
Mukhopadhyay et al. (2010): ASR-affected RCA in Hot-Mix-Asphalt (HMA) - acted as a barrier against further ASR however….

Another interesting application of RCA was in **pervious concrete pavement**, increase in hydraulic properties was observed while using 100% RCA (Strieder et al. 2021)



Thank you!

Questions?



Presentation

Dr. Juan Hiedra Cobo
Research Officer, Transit & Transportation Infrastructure

Dr. Omran Maadani
Research Officer, Road Projects

Dr. Mohammad Shafiee
Research Officer, Road & Pavement Engineer

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Toward Sustainable Construction Industry

STAKEHOLDER WORKSHOP: MAXIMIZING THE USE OF RECYCLED AGGREGATES FOR ROAD CONSTRUCTION IN CANADA

Omran Maadani, PhD.
Mohammad Shafiee, PhD., P.Eng.
Juan C. Hiedra Cobo, PhD., P.Eng.

Integrated Urban Solutions
Sustainable Resilient Infrastructures and Communities (SRIC)
Construction Research Center
National Research Council Canada | Conseil national de recherches Canada

Recycled Aggregate

Background

- ❑ Shortage of aggregate: Consumption 4 billion T/25 years;

  6 lane expressway= 52 T/km (APAO, 2004)
- ❑ Concrete Waste: 150 million T/year in USA – (Salem 2003)
- ❑ Increased sustainability:

  Growing shortage of natural aggregate required using RCA
- ❑ Barriers to RCA use
  - High cost of concrete crushers
  - Lack of understanding the characteristics and durability performance of RCA
- ❑ Cost: natural quality aggregate Vs RCA

Recycled Aggregate

Primary Sources

- ❑ Recycled aggregate: produced by crushing concrete and asphalt

- ▪Reclaimed Concrete Aggregate (RCA)
- ▪Reclaimed Asphalt Pavement (RAP)

Fine RAP

Coarse RAP

Typical Applications of RCA in Road Construction

Ontario usage – 3% (Miller, 2005; Gilbert, 2004; CAC, 2004)

- ❑ Used as road base and subbase - 68 %
- ❑ Hot Mix Asphalt – 9 %
- ❑ High value RipRap – 3 %
- ❑ New concrete – 7%
- ❑ General fill – 7 %
- ❑ Other – 6%

Standards in different jurisdictions

Recycled Aggregates in Canada: OPSS-1001 Gap Analysis (GA) and Research work is required

- Properties of RCA: Shape, texture, gradation; fines; specific gravity; Absorption; F/T and Abrasion Resistance

RCA Concrete: OPSS-1002; CSA-A23.2; ACI code, ACPA-1993 GA and Research work is required

- Fresh properties: Slump; Air content; unit weight; slump loss; initial and final set time
- Hardened properties: Compressive strength; Flexural strength; Bond strength; Modulus of Elasticity; Dry Shrinkage; water absorption; Freeze and thaw

RCA Pavement: Hot Mix Asphalt (OPSS-1003) and Unbound materials (OPSS-1010)

❑ Hot Mix Asphalt - HMA (OPSS-1003) GA and Research work is required

- Marshal Vs Superpave

❑ Unbound materials (OPSS-1010) GA and Research work is required

- Compaction effort (Moisture density relationship); Resilient modulus; Absorption test; and F/T; Abrasion test

Standards in different jurisdictions

Optimization of concrete mixture design: (Gap analysis and research work is required)

- ❑ Canadian Standards Association (CSA-=A23.1)
  - RCA concrete mixture
  - Unshrinkable backfill
- ❑ American Concrete Pavement Association (ACPA-1993)

Concrete fresh and hardened properties

- ❑ Canadian Standards Association (CSA-=A23.2)

Specification and Limitations in different jurisdictions

- **Concrete: Must meet CSA A23.1**
  - Structural
  - Non-structural (Lab and field work is required)
- **Material Specification for Aggregates – Base, Subbase, Select Subgrade, and Backfill Material**
  - OPSS 1010 and The Best Practices Guide for Recycling Aggregate (Toronto Area Road Builders Association (TARBA)
    - Pipes bedding:100% RCA and 30% RAP
    - G-A; G-B-I; G-B-III and G-S: 100% RCA and 30% RAP
    - Possibly G-O and G-B-II: 100% RCA?
  - OPSS 1001 (aggregate General); 1002 (Aggregates – Concrete); 1003 (Aggregates-HMA): MTO Laboratory Testing Manual
    - Gradation
    - Freezing and Thawing
    - Petrographic analysis
    - Abrasion: Los Angles (LA) abrasion test (Increase the limitation)
    - Asphalt content on aggregate

Recycled Aggregate Guidelines

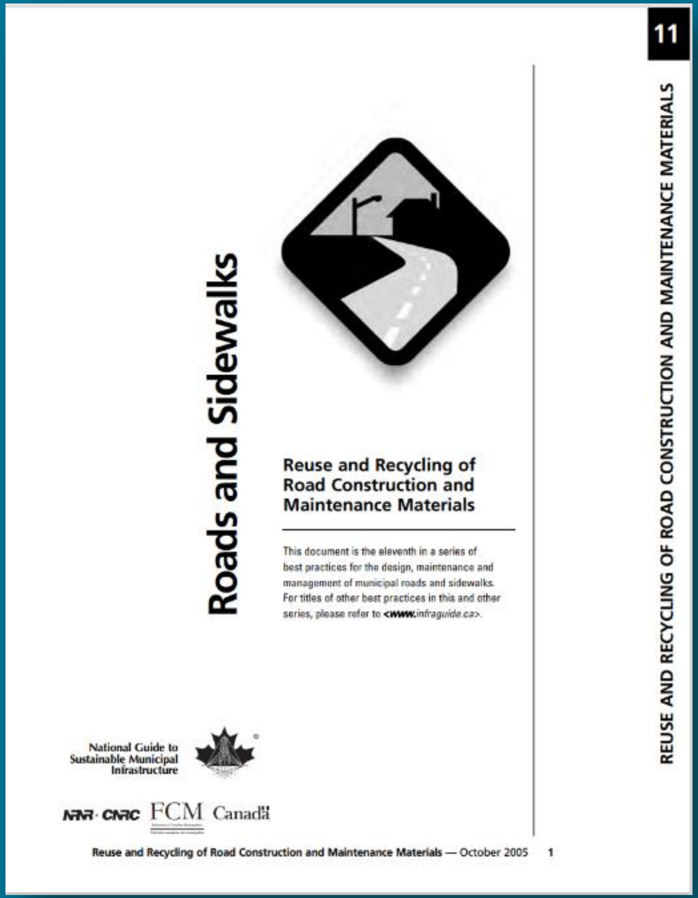
Roads; Sidewalk bases and Trench backfill

- The Best Practices Guide for Recycling Aggregate (TARBA)
  - Specification: OPSS 1010
  - Quality control
  - Production
  - Environmental compliance
  - Safety
- **Ontario Good Roads Association: Reclaimed asphalt best practices guide to be unveiled in spring 2022**
  - Stockpiling quality assurance specifications
  - Examination of good management
  - Processing operations

NEEDS FOR FUTURE RESEARCH

Use of RAP & RCM in Granular Base/Subbase

- Use of RAP as granular base or subbase reduces the amount of new granular material required.
- Value of the RAP asphalt cement as a binder and the energy invested to produce it.
- Particular benefits of using processed RCM in subbase in urban areas due to cost saving in supply and transportation.


11

REUSE AND RECYCLING OF ROAD CONSTRUCTION AND MAINTENANCE MATERIALS

Roads and Sidewalks

Reuse and Recycling of Road Construction and Maintenance Materials

This document is the eleventh in a series of best practices for the design, maintenance and management of municipal roads and sidewalks. For titles of other best practices in this and other series, please refer to <www.infraguide.ca>.

National Guide to Sustainable Municipal Infrastructure

NRC · CNRC FCM Canada

Reuse and Recycling of Road Construction and Maintenance Materials — October 2005 1

Recycled Aggregates in Unbound Layers

- Limited research on performance of recycled aggregates in unbound layer
- Constructability concerns and the validity of the standard tests:
  - Properties of aged asphalt binders
  - Contaminants (soil, mud, etc.) that are not found in virgin aggregates
  - Long exposure of RAP and RCM to the elements
- Using Accelerated Pavement Testing (APT) and In-Service Test Pavements to evaluate potential construction materials, pavement designs, and other pavement-related features

Accelerated Pavement Testing (APT)

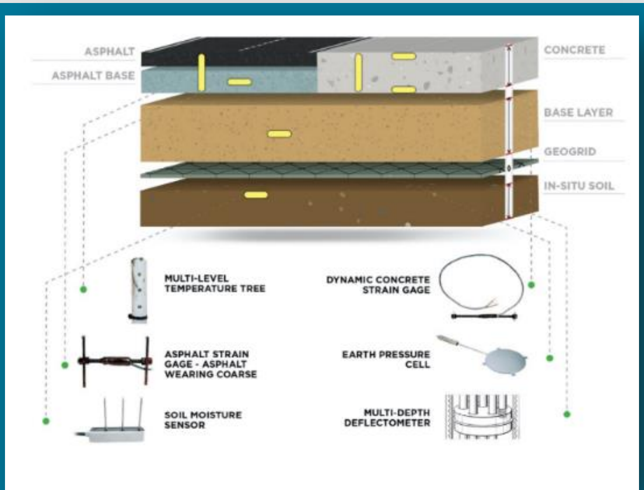
- Evaluation of flexible and rigid pavement sections built with unbound recycled aggregate layers
- Assessing the effects of single or multiple factors such as various aggregate properties on the performance of unbound pavement layers
- Long-term impacts of freeze/thaw, strength loss, etc. may not be fully investigated

Circular Test Track IFSTTAR - FRANCE

FAA’s Heavy Vehicle Simulator (HVS)-Dynatest

In-Service Test Pavements

- Evaluating actual practice via pavement projects representing a range in truck traffic level and different climate regions.
- Incorporating recycled aggregates using different construction procedures
- Installing pavement instrumentation to measure response and evaluate performance



Pavement Instrumentation (Photo Courtesy of BDI Test)

Controlled Vehicle testing- University of Alberta

Conclusions

- RCA is a sustainable product that has proven a high performance material for an increasing number of applications
- Commitment to increasing the use of RCA and RAP
  - Continuously reviewing policies,
  - Benchmarking with other municipalities and
  - Conducting research to identify best practices.
- State of the art literature review:
  - Identifying gaps
- Promote performance based guidelines and standards based on
  - Laboratory Testing, and
  - Field Investigation
- Support ongoing works on revising policies

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NRC.CANADA.CA

Thank you

Omran Maadani, PhD.
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Juan C. Hiedra Cobo, PhD., P.Eng.

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Presentation

CIRCULAR INNOVATION COUNCIL

CircularProcurement.ca

Advancing the circular economy through purchasing power

Jo-Anne St. Godard

Executive Director

PUBLIC PROCUREMENT TO MAXIMIZE USE OF RECYCLED AGGREGATE

Jo-Anne St. Godard
Executive Director
Circular Innovation Council
10 Feb 2022

PUTTING CIRCULAR
ECONOMY CONCEPTS
INTO ACTION

BACKGROUND

- Established in 1978 as Recycling Council of Ontario
- Mandate: support market transitions and government policy frameworks that redefine discards as resources and facilitate their re-integration into production cycles
- Instrumental in facilitating partnership between government and municipalities to create the Blue Box program
- Unique membership: spans entire value and supply chains
- Interests: Policy and Advocacy | Resources and Services | Programs and Pilots

Recycling Council of Ontario

WASTE REDUCTION WEEK IN CANADA

PLASTIC ACTION CENTRE

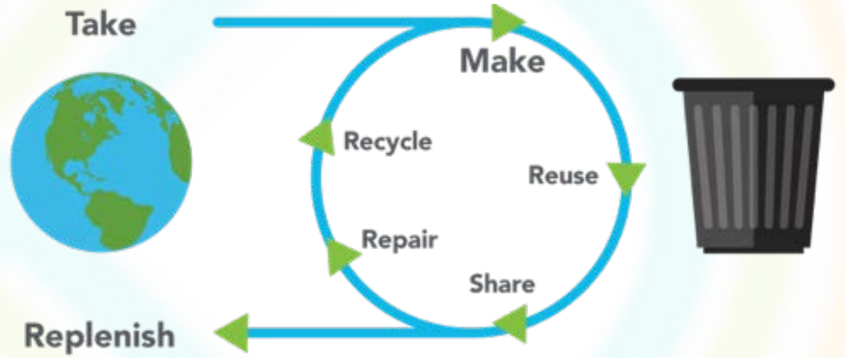
CIRCULARPROCUREMENT.CA

MODELS OF CONSUMPTION

LINEAR ECONOMY

Sustainability is improved by focusing efficiency within "take-make-waste"-model i.e. **maximizing economic value with a minimized environmental impact.**

CIRCULAR ECONOMY



Restorative and **regenerative** by design, and aims to keep products, components, and materials at their **highest utility and value** at all times.

FIVE CIRCULAR BUSINESS MODELS

Circular Supplies	Product As Service	Product Life Extension	Sharing Platform	Resource Recovery
Renewable, recoverable, or biodegradable sources serve as inputs in design and production	Purchase service or result rather than product or asset	Prolong lifespan, utilization, and value through repair, remanufacture, resale	Fully utilize assets by maximizing usage and value amongst several users	Acquire additional use and value from existing resources by avoiding disposal and impacts from new extraction

CIRCULAR PROCUREMENT

Goods and services are purchased systemically and purposefully to incorporate closed-energy and material loops within value and supply chains to reduce waste and other environmental impacts.

HOW IS IT DIFFERENT?

Focuses on outcomes rather than specifications.

WHY PUBLIC PROCUREMENT?

- Procurement: Circular demand creates circular supplies and suppliers
- Public procurement in Canada represents on average 15% of Canada's GDP

CURRENT VALUE: ~ $200 BILLION

- Advances environmental and social public policy agendas: **Carbon Emission and Waste Reductions; Local Business and Economic Growth**
- Direct and Indirect Influences:
  - Direct spending on goods and services.
  - Enable market transition - Stimulus to the economy.
  - Funding to other organizations.
  - Advancing Best Practice ; Developing market standards, training and employment.

ROLE OF MUNICIPALITIES

Represents 80% of all public procurement

$160 billon annually

- 500+ municipalities declared a climate emergency.
  - Some with circular economic ambitions.
- Directly manage the damage created by a linear economy: weather events, waste, pollution.
- Hub of Canadian economy.
- Strong Incubators of innovation / catalysts for change.
- Direct relationships with industries, businesses.
- Nimble policymakers.

Transition to the circular economy requires a systems change.

Cities and communities are in and of themselves ... systems

CITY OF TORONTO (2018)

TOP SPEND CATEGORY	CATEGORY SPEND ($M)	TOTAL SPEND
Construction & Infrastructure	111.6	54%
Information Technology	74.9	4%
Transportation & Fleet Management	51.9	3%
Facilities Management	35.5	2%
Furniture & Office Supplies	37.7	2%
Textiles	10.4	1%
Food & Catering	18.7	1%

BENEFITS

Environmental

- Reduced reliance on limited natural materials
- Better efficiency of existing resources
- Create market demand increased for recycled materials and content
- GHG / waste / water usage reduction

Economic

- Reduced costs
- Local employment opportunities
- Innovation is stimulated
- Improved fiscal responsibility and economic growth

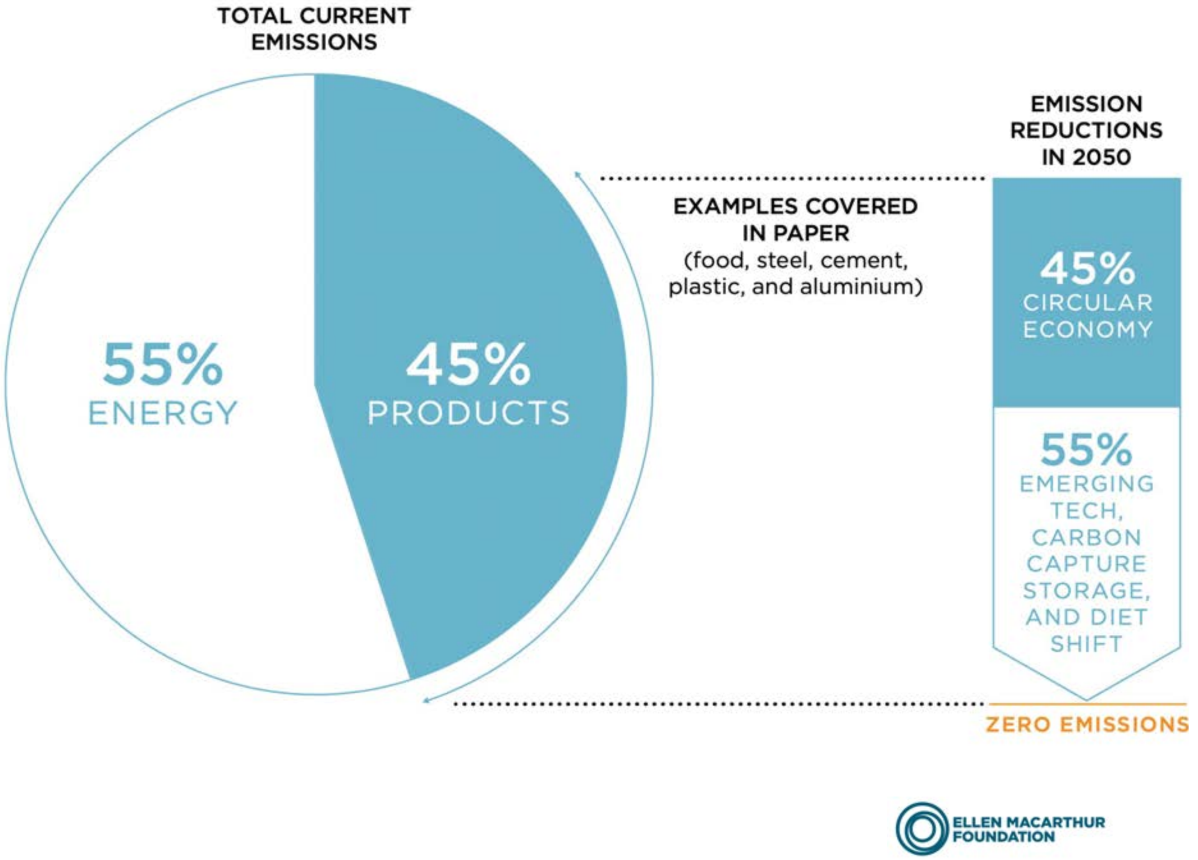
Social

- Local employment opportunities
- Fosters unique public and private partnerships

CATEGORIES OF EMISSIONS THAT RECYCLED AGGREGATES ADDRESS

Categories of Scope 3 Emissions

- Purchased goods and services.
- Capital goods.
- Fuel- and energy-related activities.
- Transportation and distribution.
- Waste generated in operations.
- Business travel.
- Employee commuting.
- Leased assets.



WHAT IS THE VALUE OF OUTCOMES-BASED STANDARD ADDRESS?

1. Minimize risks
2. Mitigate issues of quality control
3. Level the playing field for procurers and suppliers alike
4. Standardize testing
5. Reduce barriers
6. Improve compliance and increase usage
7. Ensures consistent application
8. Easily adopted/embedded in procurement documents
9. Specifications based on outcomes allows market to best respond to needs

LEVERAGING PROCUREMENT

1. What role would national standards on recycled aggregates have on maximizing the public procurement opportunity?

2. How can we support procurement functions to implement such a standard?

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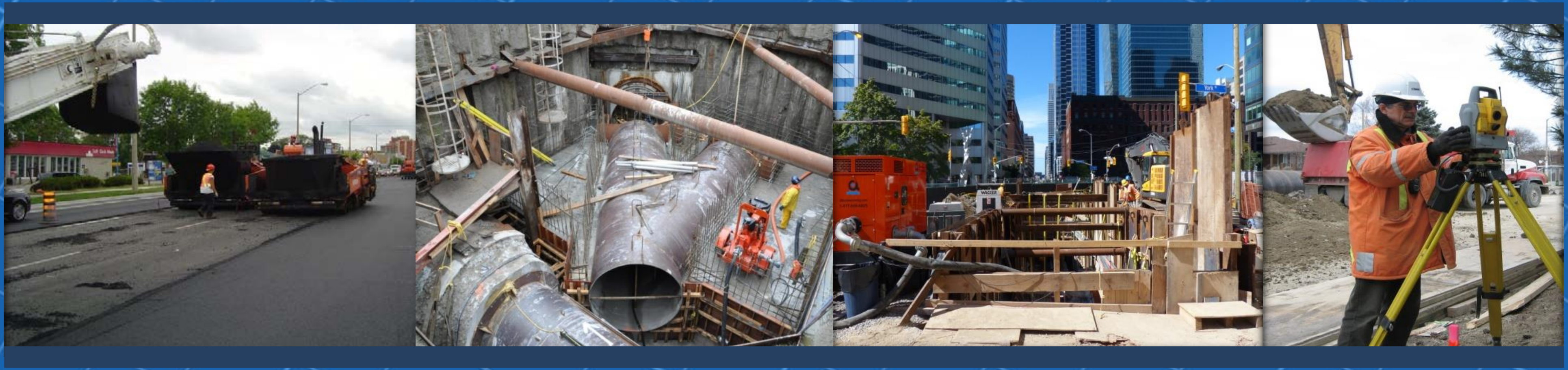
/company/CircularInnovation /CircularInnovationCouncil /CircularInnovationCouncil @CircularOnline

Presentation

Robert Klimas

Senior Engineer, Engineering & Construction Services

Use of Crushed Concrete by the City of Toronto Inspection, Testing and Design



Robert Klimas
Engineering & Construction Services

TORONTO

February 10, 2022

Introduction to the Project

- Concerns raised in 2013 about observed performance
  - May not be equivalent to natural sand and gravel sources
  - Lower apparent strength
  - Spongy appearance when used in wet conditions
  - Premature failure (heaving) noted
    - Both roadway and sewer use
  - Aggregate breakdown during handling
  - Low permeability
  - Consultants not comfortable designing and specifying these materials

Introduction to the Project

Evaluate the performance issues in three phases

1. Desktop study of the current state-of-the-practice and city issues
2. Sampling and testing of typical RCM in City Projects
3. Update of City’s field inspection and design guides

Provide training to City staff on the updates

Desktop Study – Phase 1

- Recent City of Toronto experience with RCM
- Specifications review and recommendations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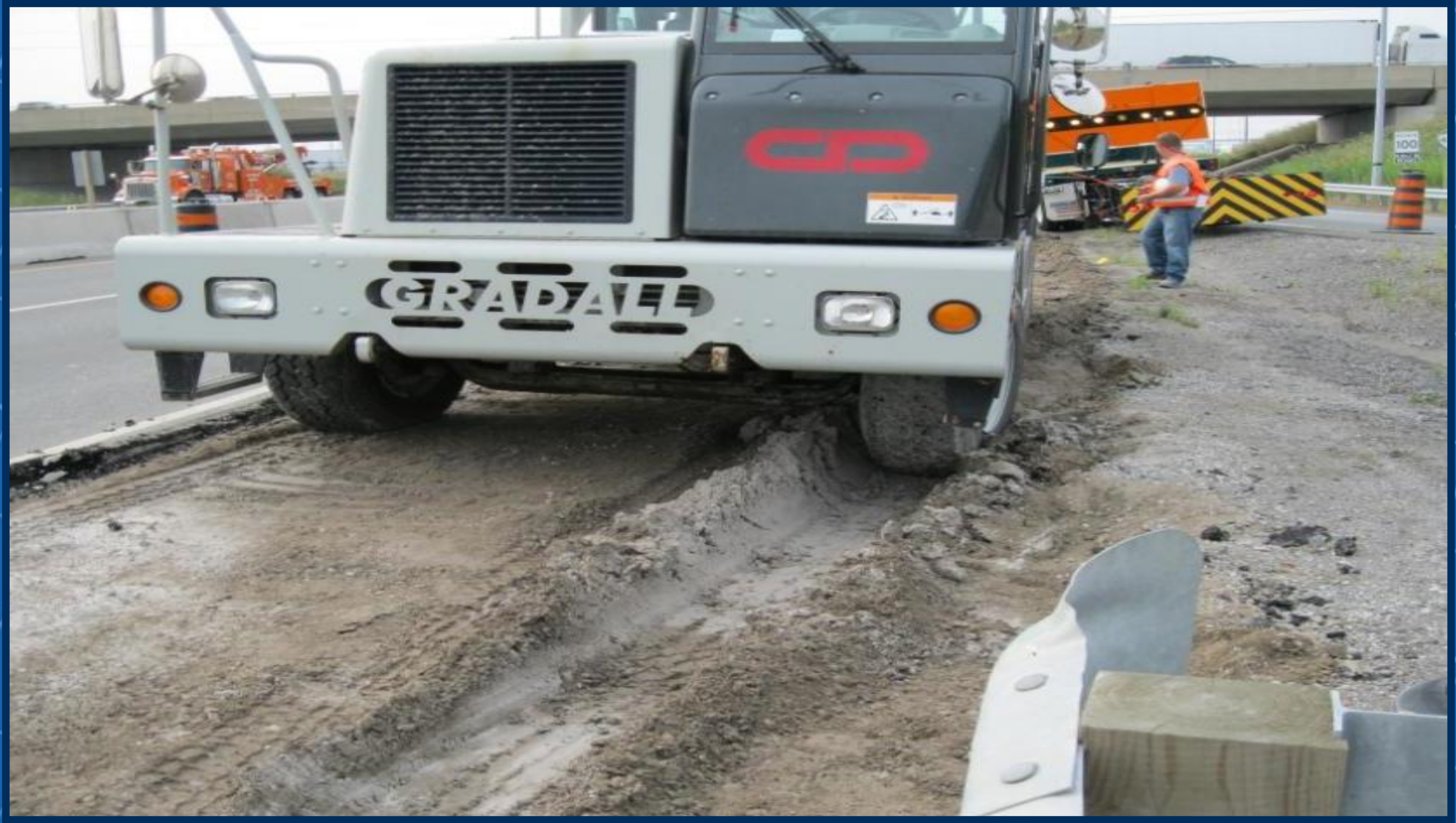
CITY OF TORONTO
Engineering & Construction Services

Use of Crushed Concrete by the City of Toronto
Phase 1: Review of Current State-of-Practice

Construction Materials Engineering Report



Hwy 427 north of Finch Ave

TORONTO


100
HOGAN
100

Phase 1 – Typical Sources

Class I

(a) Crushed concrete from runways, aprons and roadways
(b) Rejected precast elements (Pipes)
(c) Crushed concrete from bridge & dam structures

Class II

- Crushed concrete from non-structural structures (Sidewalks, curbs & gutters, footings)

Class III

- Crushed concrete from washout/cleanout

(f) Construction & Demolition waste (Mainly buildings)
(g) Consumer waste (Brick, Cinder block, Masonry, Tiles)

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Phase 1 – Staff Surveys

- Historically main issues were with excessive RAP and soil (silt and clay)
- More recently some projects noted excessively fine (sandy) RCM that met specs but had low bearing strength (construction vehicles) and poor drainage
- Post construction heaving
- Differential heaving
- Damage of Gaskets

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Phase 1 – Specification Review

- Reviewed TS 1010 (2004)
- New Special Provision GN124S03 Developed
  “Reclaimed Concrete Material and Reclaimed Asphalt Pavement”
- Added requirements for Granular A RCM, Granular A RAP and 50 mm crushed aggregate

Reclaimed Concrete Material and Reclaimed Asphalt Pavement

Special Provision No. GN124S01 May 2013

Amendment to OPSS 1010 (Apr 2004) – Material Specification for Aggregates – Base, Subbase, Select Subgrade, and Backfill Material

OPSS 1010.03 DEFINITIONS

Section 1010.03 of OPSS 1010 is amended by the addition of the following:

Granular A RCM means a set of requirements for dense graded recycled material intended for use as granular base within the pavement structure.

Granular A RAP means a set of requirements for dense graded recycled material intended for use as granular base within the pavement structure.

50 mm Crushed Aggregate means a set of requirements for dense graded recycled material intended for use as granular base within the pavement structure.

OPSS 1010.04 SUBMISSION AND DESIGN REQUIREMENTS

OPSS 1010.04.01 Submission of Test Data

Subsection 1010.04.01 of OPSS 1010 is amended by deleting the first paragraph in its entirety and replacing it with the following:

The Contractor shall have test results available for the aggregates to be used in the work. The QC testing records shall be made available to Contract Administrator at least five Working Days before the delivery of the material. Test results shall be submitted by either the stockpile/pit-run method or control chart method. All test data forms shall be legible.

OPSS 1010.05 MATERIALS

OPSS 1010.05.02 Granular A, Granular M, and Granular S

Subsection 1010.05.02 of OPSS 1010 is amended by the addition of the following clause:

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Phase 1 – Specification Review

- May contain up to 100 Percent RCM and varying amounts of RAP
- No glass or ceramic material permitted
- Deleterious material (Max 0.5%) and added gypsum, gypsum plaster and wall board mix to list

Phase 1 – Recommendations

- Supplemental testing for water-soluble sulphate concentration and comparison to risk assessment criteria
- Contractors to provide quality control plan for RCM sources
- Contractors to demonstrate control of sources
- Contractors to guarantee that no construction and demolition waste building materials used

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Phase 2 – Inspection of Stockpiles

- Inspected and photographed the RCM source stockpiles
- Noted types of materials present and any deleterious materials
- Wide variability of material types
- Wide variability in source material sizes

Phase 2 – Inspection of Stockpiles

- Inspected and photographed the RCM product stockpiles
- Noted types of materials present and any deleterious materials (negligible)
- Metal appropriately separated during processing
- High angle of friction

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Phase 2 – Stockpile Samples

- Sampled in accordance with MTO LS-625
- Sampling pad is created by 3 bucket loads from a front end loader
- Thoroughly mixed and back bladed to make a pad 0.3 to 0.5 m thick
- Material is sampled from 3 separate locations from the pad using an approved spade

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Phase 2 – Laboratory Testing

- Road and stockpile samples were tested in accordance with TS 1010 (2014) in Lab
- Full physical suite of tests completed for compliance check
- Additional water soluble sulphate risk assessment criteria assessed by CAEAL certified third part lab
- Results compared against typical virgin aggregates

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Phase 2 – Laboratory Results

- Roadway and stockpile materials were found to pose a low risk of sulphate induced heave
- Results ranged from 720 – 1100 μg/g
- Once sample tested 4,400 μg/g – moderate risk
- Importance of demonstrating control of stockpile

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Phase 2 – RCM in Trenches

- Concerns raised regarding RCM use as pipe bedding and trench backfill
- PHCs and PAHs present in RAP could leach and damage rubber pipe gaskets
- Tufa precipitates could reduce the permeability or clog drains
- pH of leachate could affect some water resources and fish habitat

Phase 2 – RCM in Trenches

- RAP considered to be chemically stable
- Granular A RCM added to TS 1010
- Tufa not an issue in the City based on research to date
- pH still requires more research
    - Some research shows an initial spike in pH (first couple of hours) followed by a fairly rapid normalization
- Can be corrosive to some metals (galvanized and aluminum piping)

Phase 2 – Contractor/Supplier QC Plan

- Key Elements
  - Identify how the sources are controlled during delivery to ensure they are from a suitable source
  - Detailed description of process including how deleterious materials are identified and removed and how gypsum and plaster are kept out

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Phase 2 – Contractor/Supplier QC Plan

- Key Elements Continued
  - Provide documentation showing control of the physical properties testing including evaluation of water soluble sulphates during production
  - Provide a written certificate expressly stating that no construction or demolition waste building materials have been used in the production

Phase 2 – Conclusions

- RCM involved in case studies generally meets City specification requirements
- Similar to the properties of virgin materials
- Physical and mechanical properties were observed to vary, sometimes considerably between projects
- Confirms the need for contractor 'Quality Control' and City 'Quality Assurance'

Toronto

Phase 3 – City Standard Updates

- Focus on five main areas identified during first two phases
  - RCM without RAP used for pipe bedding and backfill
  - Aluminum and galvanized pipes and fittings not used in conjunction with RCM materials
  - Begin completing water soluble sulphate testing in new projects
  - Begin requesting contractor material testing data to confirm 'Quality Control'
  - Complete physical testing in accordance with TS 1010

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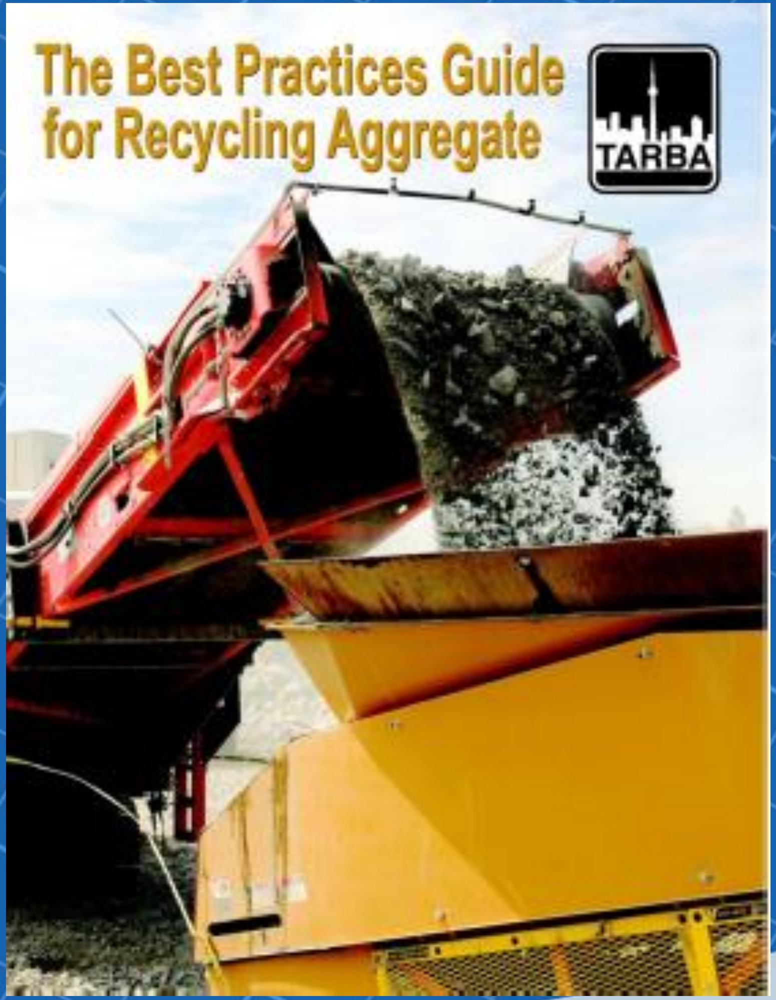
Design with RCM – TS 1010

- Start with selecting the most appropriate RCM material for the infrastructure being designed
  - **Granular A Native** – dense graded aggregates intended for use as granular base within the pavement structure, granular shouldering and backfill. Granular A is also intended for use as embedment material for flexible pipes, bedding and cover for rigid pipes and backfill material for all pipes
  - **Granular A RCM** – dense graded recycled concrete material intended for use as bedding, embedment material and trench backfill round underground infrastructure
  - **Granular A RAP** – dense graded recycled asphaltic material intended for use as granular base within the pavement structure and/or road allowance
  - **50 mm Crushed Aggregate** – dense graded recycled material intended for use as granular base within the pavement structure

RCM Production - ARO

- Aggregate Recycling Ontario created in order to set standard for producing quality aggregates for project use
- Indicate commitment to produce quality materials
- Maintain process control to achieve desired result
- Instill confidence in end user



RCM Production

- TS 1010 Supplemental Requirements
  - Contractors shall submit a detailed QC plan covering RCM production and placement
  - Contractor shall provide a written certificate to the CA expressly stating that no building demolition wastes have been used in the production of RCM
  - Contractor shall include water soluble sulphate testing and ensure concentrations less than 5000 µg/g
    - Testing frequency for sulphate testing is one every 1000 tonnes (same frequency as gradations) or until control is established, and then every 5000 tonnes thereafter

RCM Inspection and Testing

- TS 1010.07.02.01 – Production\General
  - All Contractors or suppliers producing RCM for City construction projects shall provide a detailed Quality Control plan covering RCM production and placement as part of their materials submissions.
  - The QC plan shall describe the Contractor's or suppliers processes for the control, acceptance and documentation of sources of old concrete and identify how the sources of old concrete are controlled during delivery to ensure they are from a suitable source.

RCM Inspection and Testing

- At project startup, visit the production facility
  - confirm it is following the control practices outlined in their document (recommend minimum annually)
  - Confirm that designated stockpile is being used
  - Ensure that trucks are properly loaded to reduce segregation issues

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TORONTO

Upcoming Events

March 29 & 31, 2022:

Stakeholder Workshop: A Circular Roadmap for the Built Environment in Canada

2-part virtual event and workshop, hosted by CELC and CSA Group on the sidelines of GLOBE Forum 2022. The event series will convene stakeholders to explore the potential for developing a circular economy roadmap for the built environment / construction sector in Canada.

For more info and to register, email:
pshorthouse@circulareconomyleaders.ca

Upcoming National Zero Waste Council Event

Accelerating the Use of Recycled Asphalt Pavement Across Canada: Stakeholder Workshop

Date / Time: **April 20th, 2022 / 10–11:30am PST**

Registration opening soon @ www.nzwc.ca

Why attend?

- Learn about the benefits & connect with peers on the barriers
- Insights from City of Richmond pilot project & Recycled Asphalt Pavement Toolkit
- Hear how to initiate recycled asphalt projects in your area and accelerate utilization
- Share your experience with recycled asphalt

zeroWASTE
NATIONAL ZERO WASTE COUNCIL
An Initiative of Metro Vancouver

Thank you!

CIRCULAR ECONOMY LEADERSHIP CANADA

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