MAXIMIZING THE USE OF RECYCLED AGGREGATES FOR ROAD CONSTRUCTION IN CANADA

STAKEHOLDER WORKSHOP

SUMMARY REPORT

February 2022

CIRCULAR ECONOMY SOLUTIONS SERIES

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Workshop Co-hosts

Acknowledgments

This report was prepared by Circular Economy Leadership Canada (CELC), in collaboration with Circular Innovation Council. The workshop co-hosts would like to thank the following organizations who supported the workshop by providing data and information, participating in pre-workshop interviews, with workshop promotion and facilitation, and/or with a financial contribution.

B.C. Ministry of Transportation
City of Guelph
City of Ottawa
City of Richmond
City of Toronto
CRH Canada Group Inc.
Lafarge Canada
Municipal Engineers Association of Ontario
Nelson Aggregate Co.
NRC-CNRC
Ontario Ministry of Transportation
RW Tomlinson Limited
Smart Prosperity Institute
The Delphi Group
University of Ottawa

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1. Background

Opportunities exist across Canada for the greater use of recycled aggregates in road construction and other major infrastructure projects which, in turn, can deliver economic and environmental benefits. However, the lack of national standardization and specifications between levels of government and between jurisdictions leads to inconsistent application and a wide variability in the usage of recycled aggregates on infrastructure projects. As a result, the ability of governments to integrate recycled aggregate through procurement is limited. Can a national, harmonized approach and set of standard specifications be developed to maximize the use of recycled aggregates for road construction?

On **February 10, 2022**, Circular Economy Leadership Canada (CELC) and the Circular Innovation Council (CIC) convened a group of stakeholders for a solutions-oriented, interactive, virtual workshop, exploring the potential for greater use of recycled aggregates in roads and major infrastructure projects in Canada through public procurement.

The workshop, part of the Circular Economy (CE) Solutions Series Built Environment work stream, featured expert insights into practical applications, as well as interactive breakout discussions that allowed participants to strategize together on how to scale ideas and overcome barriers for maximizing the use of recycled aggregates for road construction in Canada. The key focus for the workshop was on the use of recycled concrete material for roads and roadbase applications. See **Appendix A** for the Workshop Agenda.

Workshop objectives:

1. Examine the economic and environmental (GHG and waste reduction) benefits of using recycled aggregates in road construction.
2. Gain insights into the existing standards, specifications, and guidelines, including allowances that affect the current variable of use of recycled aggregates in road construction, as well as explore the 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. Through case studies and conversations, explore how public procurement can be an enabler to support greater uptake of recycled aggregates to drive desired outcomes.

The insights and recommendations from this Summary Report will be used to inform and prioritize next steps to address the key issues and advance the opportunities.

Participant Profile

More than 90 stakeholders participated in the workshop from across Canada, including representatives from local and provincial governments, federal agencies, standards bodies, academic institutions, industry associations, suppliers, and consultants. See **Appendix B** for the list of participating organizations.

Participants joined the workshop in order to:

- Learn about applications for recycled aggregates in roads, including new opportunities, risks, and key considerations.
- Explore opportunities to improve the value proposition and economic impact of infrastructure projects through the adoption of lower carbon and recycled materials.
- Connect with leading organizations, governments and industry leaders and share through peer-to-peer exchanges and real-world case studies, industry best practice applications, and trials.
- Examine how circular public procurement can be leveraged to deliver cost savings, environmental commitments (greenhouse gas emissions and waste reduction) and community benefits.
- Provide input that will help shape future outcome-based model specifications and standards.

2. Key Takeaways: Plenary Presentations

Participants heard from six speakers who covered various perspectives relevant to the topic of using recycled concrete aggregates for road construction.

To view a recording of the webinar, click the 'Play' button.

Presenter: **Paul Shorthouse**, Managing Director, Circular Economy Leadership Canada

Topic: Overview of the opportunities, benefits, and key challenges

Paul is Managing Director at CELC, a network of leaders from all industries and sectors who are fostering collaboration, innovation, and knowledge exchange to accelerate the transition to a circular economy in Canada.

Insights

- Recycled aggregates include both Recycled Concrete Material (RCM) and Recycled Asphalt Pavement (RAP) – see Figure 1.
- RCM comes primarily from two sources: (1) returned concrete and (2) construction and demolition streams.
    a. Returned concrete is the material that is returned to a facility when a concretemixer has an oversupply from a project for example and is relatively clean from contamination.
    b. Construction and demolition (C&D) material is what comes from the recovery of concrete material from buildings, bridges, sidewalks, and other concrete structures at end of life. Without adequate inspection procedures, the C&D stream has a higher likelihood of being contaminated with other materials, such as asphalt, or even rebar, wood or gypsum.
- Recycled concrete material is processed and crushed and then can be used in new infrastructure projects… largely for roadbase or in backfill today in Canada at various levels. In addition, a small amount of other materials such as brick and glass is often allowed.
- At present, recycled concrete aggregates are only allowed in lower percentages in ready-mix applications.
- Recycled Asphalt Pavement or RAP is a growing focus for various road construction applications, including hot-mix and cold-mix applications and road surfaces.

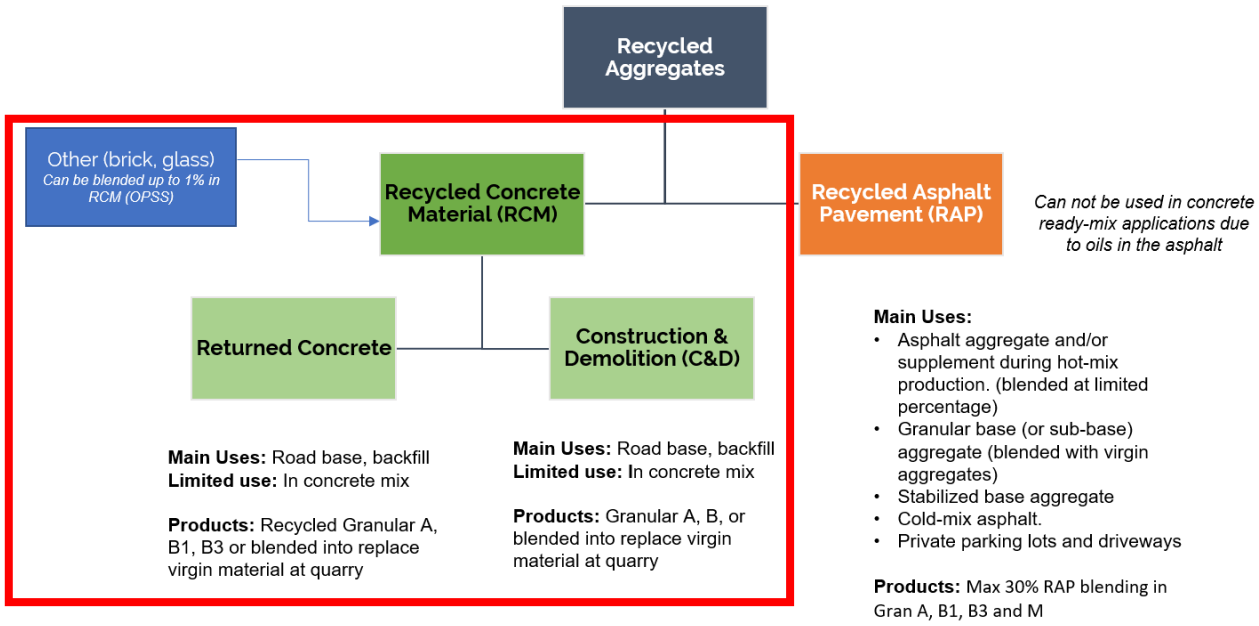

Figure 1: Recycled concrete material (RCM) for road construction was the focus for this workshop.

- With respect to road construction, it's important to consider the various layers (see Figure 2) and how much recycled aggregate materials can be incorporated into these layers; and in particular the base and sub-base layers.
- In Ontario, more than 180 million tonnes of aggregate are used annually, and less than an estimated 7% of the demand is met from recycled sources. Municipalities are the largest consumers of aggregate in Ontario, using about 35% of the total demand.
- Across Canada, there is a wide range of usage of recycled aggregates in road construction. In Ontario, for example, some local governments are following the Ontario Provincial Standard Specifications (OPSS), while others have been developing their own standards for how much recycled aggregates can be used in various layers of road construction, while others prohibit or severely limit its use all together. This can make the resource challenging to manage in terms and presents a lost opportunity for maximizing circularity.
- **Key Benefits of RCM:**

    1. **Availability:** Can be readily available based on C&D activities – with growing demand for recycling and recovering resources instead of 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, and the potential for reducing GHG emissions and wear and tear on roads from transport.

- **Challenges & Perceived Risks with using RCM:**
  1. **Quality and Consistency Concerns** – If not managed properly, contamination and deleterious materials can create environmental or performance-related challenges.
  2. **Performance Issues** – Strength when using older recycled concrete aggregates on projects could be an issue. Longer-term, durability is an important consideration, with factors such as freeze-thaw resistance and drying and wet cycles for example.
  3. **Availability and Cost** – Availability and distance travelled can affect cost, and recycled materials may not be available in less urban centres.
  4. **Prescriptive Standards** – Prescriptive specifications can create issues with maximizing the use of recycled aggregate. The alternatives is to use more outcome or performance-based standards.
  5. **Lack of Consistent Approaches** – The lack of harmonized approaches across local governments and regions makes it challenging for industry to invest in the infrastructure and provide consistent supply when demand is unreliable.
  6. **Perceived Risks and/or Business As Usual** – Sometimes, it can be a lack of familiarity with using or specifying recycled aggregate in projects, or a previously negative experience that might keep people from wanting to use it in the future.
- *The question being posed:* can today's standards and specifications potentially go further and incorporate greater amounts of recycled concrete materials than what is being allowed today?

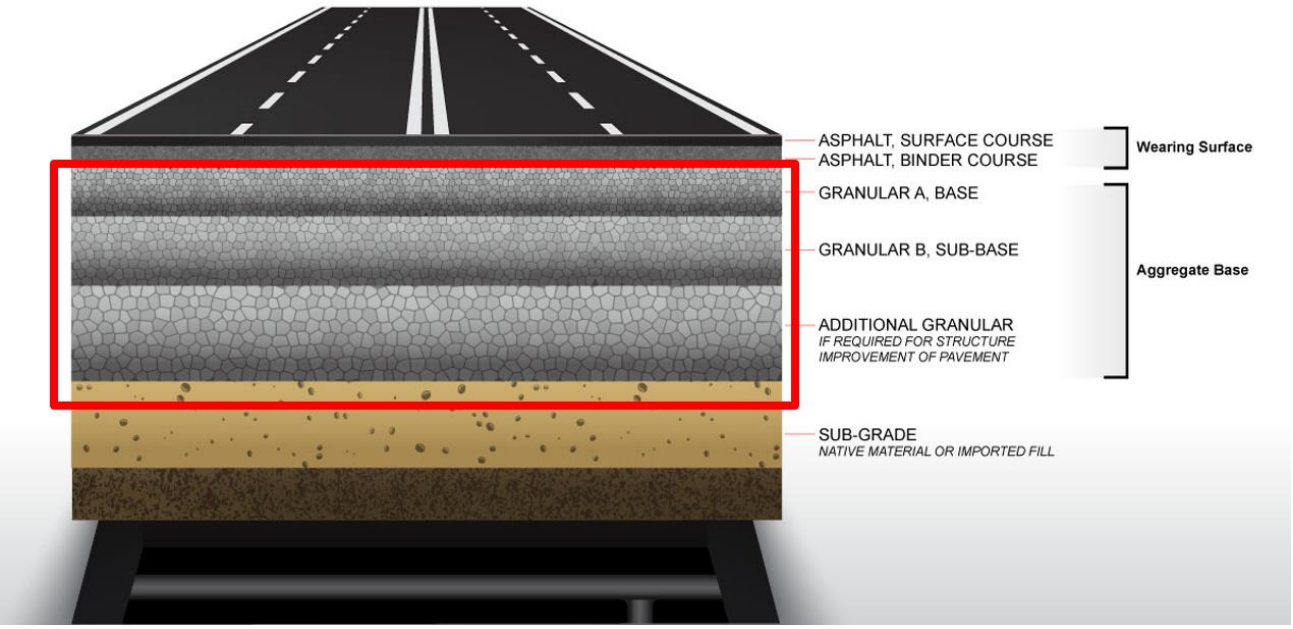

Figure 2: Road construction layers, including base and sub-base (image source: City of Barrie).

Presenter: **Leandro Sanchez**, Associate Professor, Dept. of Civil Engineering, University of Ottawa

Topic: Expanding the use of recycled aggregates in roads: opportunities and key considerations

Dr. Leandro Sanchez is an Associate Professor with the Department of Civil Engineering with the University of Ottawa. Dr. Sanchez is one of Canada's leading experts in the use of recycled concrete aggregates (RCA).

Insights:

- 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;
    - C&D waste: deleterious materials must be considered and potentially rejected;
    - Potential improvements in performance attributed to its unique microstructure (i.e., adhered mortar/cement paste incorporating unhydrated cement).
- **Perspectives from Switzerland**... 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 a special product (incentive or obligation for use);

Presenters: **Omran Maadani**, Research Officer, Road Projects & **Mohammad Shafiee**, Research Officer, Road and Pavement Engineering, National Research Council Canada (NRC)

Topic: Current standards for the use of recycled aggregates for road construction in Canada

Omran is a Research Officer with expertise in pavement and is also Task Lead for Road projects under the Climate Resilient Built Environment (CRBE). Mohammad is a Research Officer focused on climate resilient pavements and sustainability of transportation infrastructures.

Insights:

Standards in different jurisdictions?

- **Recycled Aggregates in Canada: OPSS-1001**
  - 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**
  - 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)
    - Marshal versus Superpave
  - Unbound materials (OPSS-1010)
    - Compaction effort (Moisture density relationship); Resilient modulus; Absorption test; and F/T; Abrasion test
- **Optimization of concrete mixture design:**
  - 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)

Conclusions:

- RCA is a sustainable product that has been proven as a high-performance material for an increasing number of applications.
- Commitment to increasing the use of RCA and RAP includes:
  - Continuously reviewing policies;
  - Benchmarking with other municipalities;
  - Conducting research to identify best practices; and
  - State of the art literature review and identifying gaps.
- Promote performance-based guidelines and standards based on:
  - Laboratory testing; and
  - Field investigation.

Presenter: **Jo-Anne St. Godard**, Executive Director, Circular Innovation Council

Topic: Leveraging public procurement

Jo-Anne is Executive Director with the Circular Innovation Council, formerly known as the Recycling Council of Ontario. She also leads the Circular Procurement Center of Excellence, bringing a wealth of expertise to the development of policies and practices in environmental outcomes, using a market-based approach.

Insights:

- **What is 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. *Focuses on outcomes rather than specifications.*
- In a smallish market like Canada public procurement is a significant market driver and considerable part of the economy – public procurement in Canada represents on average 15% of Canada's GDP.
    - **Role of local governments**? Represent 80% of all public procurement in Canada = $160 billon annually.
- **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, including developing market standards, training, and employment
- **Why is construction so important?**
    - Biggest category spend of all levels of government
    - Key to stimulus spending and job creation
    - Knock off effects
    - Showcases of our values / culture and innovations
- **What is the value that outcomes-based standard address?**
    - Minimize risks
    - Mitigate issues of quality control
    - Level the playing field for procurers and suppliers alike
    - Standardize testing
    - Reduce barriers
    - Improve compliance and increase usage
    - Ensures consistent application
    - Easily adopted/embedded in procurement documents
    - Specifications based on outcomes allows market to best respond to needs
- Lowest price is often king… can use the tendering process to ask the market (suppliers and vendors) and how they will help meet environmental and social objectives, while also providing the lowest price or best-value.

Presenter: **Robert Klimas**, Senior Engineer, Engineering & Construction Services, City of Toronto

Topic: Local government case study

Robert has extensive management experience leading an inter-divisional group to create, update, and maintain 25 sewer and watermain and 40 road works construction and material specifications.

Insights:

- 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.
- Important that the design work look at frost susceptibility of subgrade, drainage, time of year, and water soluable sulphates.
- City of Toronto evaluated the performance of recycled concrete use in road construction projects through three phases:
    1. **Desktop study of the current state-of-the-practice and city issues**
        - Specifications review and recommendations
        - Reviewed TS 1010 (2004)
            - May contain up to 100% 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
        - Contractors to provide quality control plan for RCM sources
    2. **Sampling and testing of typical RCM in City projects**
        - RCM involved in case studies generally meets City specification requirements – similar to the properties of virgin materials
        - Inspected and photographed the RCM source stockpiles – noted wide variability of material types
            - Road and stockpile samples were tested in accordance with TS 1010 (2014) in lab
            - Results compared against typical virgin aggregates – results demonstrated importance of quality control of stockpile – confirmed the need for QC / QA procedures
    3. **Update of City's field inspection and design guides**
        - Contractor/supplier QC plans
            - 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
            - Provide documentation showing control of the physical properties testing including evaluation of water soluable sulphates during production
            - Provide a written certificate expressly stating that no construction or demolition waste building materials have been used in the production
        - Also provided training to City staff on the outcomes.

3. Key Take-aways: Breakout Discussions

Following the context-setting presentations, participants from across Canada joined breakout room discussions. The breakout rooms were led by experienced facilitators who guided the discussions using four key questions:

- **Question #1:** How is your organization currently using recycled aggregates in road construction and what standards are you following?
- **Question #2:** How do you think quality control and quality assurance could be improved given current practices?
- **Question #3:** Where do you see opportunities for using more recycled aggregates in road construction and what are the key challenges or barriers to keep in mind?
- **Question #4:** What key factors / criteria must be considered for moving toward a more harmonized, outcome-based standard for road construction?

Participants were invited to share their knowledge and apply learnings to tackle challenges, and outline the next steps using open discussion and the chat box. Below is a summary of key points from the breakout room discussion.

Current Usage & Standards of Practice

- There is no equivalent to a 'National Building Code' that recognizes the use of RCM / RAP for road construction in Canada at the moment.
- Many allow it in road sub-base layer provided it meets specs (i.e., gradation, California Bearing Ratio and modulus testing, etc.), as well as for paved shoulders, sewer bedding, culverts, and fill. Using Granular A or B (Type II) for many road projects.
- Use is regional and depends on sources of RCM versus virgin materials. Most local governments are not specifying the use of RCM in road projects – it's up to the contractor if they want to use it. In some regions, virgin aggregates are more expensive and, in others, they are cheaper – this impacts its usage / adoption.
- Many local governments in Ontario are following the Ontario Provincial Standard Specifications (OPSS) 1010, but this can vary widely in terms of the actual level of adoption. OPSS currently allows for 30% RAP at the moment.
- Variations in standards may also be linked to ground conditions which is why some local governments amend the provincial standard.
- Smaller municipalities often look to the larger municipalities to lead the way, and then they copy those standards of practice.
- A couple of the leading jurisidictions state in their procurement documents that they prefer to source recycled materials as a first priority (e.g., City of Toronto).
- Some are not using RCM at all in base layers or in travelled portions of the road, nor for pipe bedding, often because of having had issues in the past.

Current Challenges & Issues

Quality and Performance Issues

- Several local governments have experienced issues in the past due to poor quality control from the suppliers. The challenge comes down to minimizing contamination / deleterious materials, as well as perceived risks and concerns around its long-term life cycle / durability.
- For example, if adding recycled aggregate to a road project which is designed for 20 years but only get 10 years out of the road, the environmental benefits are lost because the road has to be replaced more frequently.

Cost Challenges

- Cost may be prohibitive depending on location, hauling distances, and proximity to supply. The cost of storage creates additional challenges in terms of where to store the materials until its time to reuse them.
- Municipal governments have to think about life cycle and costs at end of life - which is why they tend to be risk adverse on a product if it is more costly down the road or creates issues (e.g., contaminated product that adds extra costs at disposal).
- Challenge is to do more lifecycle costing analysis – there is a need to find out the real impact of the various materials and applications, which can be fairly place-based.

Environmental Concerns

- Some are concerned about possible issues with respect to leachate and water contamination from hydrocarbons from RAP in granular mixes (concerns around pH and heavy metals).
- Some experienced additional costs to haul away material at end of life due to the hydro-carbons in RAP when the testing agencies (e.g., following guidelines from Ministry of Environment, Conservation, and Parks in Ontario) suggested it should be considered 'contaminated' or hazardous waste.

Capacity Issues

- Many local governments don't have the capacity (i.e., staff) or ability to inspect the product or do their own testing – rely on third parties which adds costs.
- Many feel the burden for quality should not be placed on local governments since they don't often have the capacity to do testing, sampling, or go out to facilities to inspect the quality of the recycled materials.

Resistance to Change

- In some areas, there exists a general mistrust and lack of understanding of the aggregates supply industry. Municipal engineers are risk adverse; if they had a negative experience in the past (5 or 10 years ago), they might not allow it in the future – there is often some resistance to change.

Opportunities for Greater Usage

- Opportunities exist for greater usage in base layers and, to a lesser degree, the sub-base layers. Opportunities also exist for other uses, such as temporary roads, parking lots, or non-road applications such as trench backfilling and non-structural applications like light fixture bases.
- Recycled concrete could actually be a higher quality / superior product for Granular A usage than virgin since it's originally coming from concrete applications (i.e., it started as a high quality aggregate product), where as virgin Granular A typically is from a lower quality aggregate.

- Gradation for a recycled aggregate is often easier than for virgin product because concrete has a high stone to sand ratio.

- Another application is Full Depth Reclamation (FDR). Here, all the layers are reused as a base layer, and the new asphalt is laid on top. A challenge with using FDR is non-uniformity of existing roads (for example, roads may be 30 years old). But if agencies use 100% of the existing material as the base material, they may not have these problems.

- Europe allows much greater usage (double what is allowed in Canada). In Switzerland (EMPA Research Institute), they have an example of roads using 100% RCM in base layer and 100% RAP in top layer. What are the differences and how do they allow so much more given Europe has very stringent environmental standards? More investigation here would be helpful.

- In the United States, 100% recycled concrete was used for base and had very good results with both RCM and RAP, even for roads that were 15-20 years old across Eastern states. Asphalt was often considered as hazardous waste if taken up, but not if it was left in place. Practice in some parts of the U.S. therefore recycles it and turns it into new base onsite. If they have too much, would bring it back to the facility to mix with asphalt. To address quality concerns in some Eastern states, no stockpiling of construction debris was allowed to mix with the piles of RCM / RAP – these had to be taken to a hazardous waste disposal site and could not be blended with RCM / RAP.

Other Key Take-aways

- Many in Canada still view recycled aggregate as waste, unlike in Europe where it is viewed as a valuable resource.

- There is a lack of good data / information on the current supply and demand for RCM and RAP across Canada, making it challenging at times to incorporate it into tenders or projects, invest in the suitable infrastructure, etc. Better data is needed on how much is being used currently, where, and to what extent.

- Many local governments are interested in the potential for using more, but remain concerned about the risk of getting poor quality materials from suppliers that don't perform as well as virgin and/or may create future issues over the lifetime of the road if it fails early or adds costs during removal (e.g., found to be contaminated or hazardous material). Standards could be modified to allow for more usage, but unlikely there will be much greater uptake until the quality issues have been addressed at the source.

- At present, industry suppliers are self-regulating, which comes down to how they manage the recycled material processing at the facility. Some companies are supplying a high-quality product while others don't have the same quality control and assurance practices in place.

- There is wide variation in terms of how suppliers manage their quality control procedures: how they collect, separate, and sort materials; how they remove various deleterious materials; the frequency of their sampling and testing of processed materials; onsite inspections; and overall ethics.

- Some suppliers invite customers out to inspect the piles and crushers at their facilities (although smaller local governments don't always have the capacity to make these site visits). If the Granular A and B materials pass the test at the facility as well as on the construction site, some suggest there may not also be a need to inspect the piles prior to processing.

- With current procurement practices, the lowest bid often wins and, without something for tenders to point to with respect to quality of supply (e.g., a certification or standard of practice), the bid may go to the supplier that offers the lowest price that may also offer unreliable quality. This, in turn, may result in issues with using RCM and greater hesitation from governments to use it in the future. Suppliers need to have a clearly articulated quality control (QC) plan.

- Procurement doesn't create the specifications – tenders and bid documents come from the engineering teams. However, there is a need to embed QC aspects and rules within tenders. Municipalities can't sole source; they must go to tender. With no quality-focused certification to point to, it's often a race to the bottom. The lower cost bidders often win the contracts as long as on paper they suggest they can meet the specs; but they often don't have the same quality control procedures in place.

- Performance-based standards and specifications allow for quality issues to be addressed. For example, once a road has been built, field testing is done to ensure that it meets the performance standards. Samples can be taken to ensure that the road meets the standards that are expected for supporting the desired outcomes. The difference with specification-based standards is that the specifications are prescriptive in nature.

- The NRC are developing a "pavement support" tool. Using this tool, stakeholders can model different percentages of RCM and model flexible roads and their performance. This can optimize concrete mixes to different municipal needs (structural versus road use).

4. Summary of Key Actions & Next Steps

Participants identified the top areas for action to accelerate the adoption and use of recycled concrete aggregates for road construction in Canada. These areas, summarized below, should be considered as opportunities for further engagement, research, and action to address barriers and advance the opportunities.

Addressing Concerns Around Quality

1. Recommend that all industry suppliers develop detailed QC plans that can be shared with contractors and project developers and can be referenced in tenders for road construction. This includes considerations for how inbound recycled materials are managed in stockpiles and at facilities during processing (i.e., feedstock management).
2. Ensure adequate 3rd party verification exists to remove the risk to government procurement. This could include ensuring adequate support for local governments exists with respect to sampling and testing of recycled aggregate materials to address capacity issues.
3. Consider developing a 3rd party certification / standard for recycled aggregate materials (i.e., for suppliers or at the facility level) focused on addressing quality and variability concerns and which could be referenced by local governments and others in tenders. While referring to a suitable ISO Standard may be an option to explore, additional mechanisms could be established which could consider:
    - In Ontario, developing something similar to what the Ontario Ministry of Transportation (MTO) does for concrete plants and suppliers, where they have certified sources and go in and inspect these on a regular basis, taking the burden off of local governments.
    - Ontario Road Builders Association's certification program for asphalt plants (i.e., Trillium Award) – which at the moment is a self-assessment program based on environmental ratings and meeting certain requirements, but could serve as a suitable platform for expansion.

Developing a National Approach to Outcomes-based Standards / Specifications

4. Consider how quality control and assurance procedures should be integrated within existing standards for road construction in order to enable greater use of recycled aggregates.
5. Continue to evolve standards that allow for the greater use of recycled aggregates in various layers of road construction and other applications, based on performance and outcomes (including addressing environmental risks, adjusting for local conditions, etc.), rather than prescriptive specifications.
6. Work with NRC and other key stakeholders to develop a national, harmonized, performance-based standard for the use of recycled aggregates in road construction (equivalent to a 'National Building Code' for road construction).

Undertaking Further Research & Stakeholder Engagement

7. Undertake research efforts to collect better data on the demand for and supply / availability of recycled aggregate materials across Canada at regional and provincial levels to better inform policy, infrastructure investments, and the business case for greater use.
8. Undertake research efforts examining best practices out of Europe and the United States where greater usage of recycled aggregates in road construction is common practice to examine how practices in those jurisdictions may apply to Canada.
9. Continue to research any measurable environmental risks from using recycled aggregates (particularly the impact of RAP in sub-base layers) in line with leachate concerns. This could include undertaking research to support geo-textile selection to better understand permeability of compacted asphalt and/or using RAP for an unbound layer as potential solutions to preventing contamination from getting into sub-grade and drainage.
10. Continue to undertake lab and field work on various granular materials in different road layers, as well as resilience models for road performance as it relates to greater integration of RCM and RAP. This could start with a literature review and gap analysis, followed by targeted layer-by-layer analysis to understand performance and risks in various geographic regions.
11. Continue to engage key stakeholders on the opportunities for maximizing the use of regcycled aggregatges for road construction in Canada, including local and provincial governments (engineering and procurement), federal departments, contractors and road builders, recycled aggregate suppliers, relevant industry associations, the research community, and standards bodies.

Appendix A – Workshop Agenda

Below is the agenda from the workshop hosted on February 10, 2022.

Time	Agenda Item	Format
9:30am PDT / 12:30pm EDT	**Meeting Begins**	
9:30-9:45am PDT / 12:30-12:45pm EDT **15 mins**	**Welcome & Introductions:** Setting the stage for a productive and collaborative workshop • Welcome and introductions (CELC & CIC) • Workshop objectives, overview of the agenda, and expected outcomes (CELC) • Setting the context, including: (CELC) ○ Overview of current use, key benefits, opportunities, and risks	Plenary
9:45-10:05am PDT / 12:45-1:05pm EDT **20 mins**	**Presentation:** Expanding the Use of Recycled Aggregates in Roads: Opportunities and key considerations (15 min + 5 min Q&A) • **Leandro Sanchez**, Associate Professor, Dept. of Civil Engineering, University of Ottawa	Plenary
10:05-10:30am PDT / 1:05-1:30pm EDT **25 mins**	**Presentation:** Current Specifications and Standards for the Use of Recycled Aggregates for Road Construction in Canada (20 min + 5 min Q&A) • **Omran Maadani,** Research Officer, National Research Council Canada (NRC) • **Mohammad Shafiee,** Research Officer, Road and Pavement Engineering, National Research Council Canada (NRC)	Plenary
10:30-10:40am PDT / 1:30-1:40pm EDT	**10-minute Break**	
10:40-11:00am PDT / 1:40-2:00pm EDT **20 mins**	**Presentation:** Leveraging public procurement: (15 mins + 5 mins Q&A) • Why focus on public procurement? • Benefits of harmonization and model specifications • **Presenter: Jo-Anne St. Godard,** Executive Director, Circular Innovation Council	Plenary
11:00-11:15am PDT / 2:00-2:15pm EDT **15 mins**	**Local government case study** (10 mins + 5 mins Q&A) • **Presenter: Robert Klimas**, Senior Engineer, Engineering & Construction Services, City of Toronto	Plenary

Time	Agenda Item	Format

11:15am-12:15pm PDT / 2:15-3:15pm EDT
 	
60 mins
	Breakout Groups: Interactive exercise to collect input on key questions
	• Workshop breakout rules of engagement
	• Facilitated breakout out room discussions
	• Begin with brief round of introductions in each breakout (5 mins max).
	• Explore the following areas re. the use of recycled concrete aggregates in Canada:
	  ○ Project examples and best practices
	  ○ Opportunities for expanding use of recycled aggregates in road construction
	  ○ Current challenges / barriers for expanding use of recycled aggregates in road construction
	  ○ Considerations around quality control and assurance
	  ○ Considerations for developing a harmonized approach in Canada and standardized specifications
		Facilitated Breakout Discussions

12:15pm-12:30pm PDT / 3:15-3:30pm EDT **15 mins**	**Report back and summary of next steps** • Brief report back (2 mins for each breakout group) • Summary of next steps	Plenary
12:30pm PDT / 3:30pm EDT	**Meeting Adjourned**	

Appendix B – Participating Organizations

Bayview Construction Ltd.
B.C. Ministry of Transportation
Cambium
Circular Economy Leadership Canada
Circular Innovation Council
City of Brampton
City of Calgary
City of Edmonton
City of Guelph
City of Kingston
City of Ottawa
City of Regina
City of Richmond
City of Surrey
City of Toronto
City of Victoria
City of Winnipeg
Concordia University
County of Peterborough
CRH Canada Group Inc.
CSA Group
Dufferin Aggregates
Lafarge Canada
Lehigh Hanson Materials Ltd.
Manitoba Heavy Construction Association
Metro Vancouver
Municipal Engineers Association of Ontario
Nelson Aggregate Co.
NRC-CNRC
Ontario Ministry of Transportation
Ontario Stone Sand & Gravel Association
Province of Manitoba
Regional Municipality of Durham
Regional Municipality of Peel
Regional Municipality of Waterloo
Regional Municipality of York
Rocky Road Recyling
RW Tomlinson Limited
Smart Prosperity Institute
The Delphi Group
Treasury Board Secretariat
University of Ottawa
University of Toronto
University of Waterloo
Winnipeg Metropolitan Region

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