Qualifying New Magnesium Oxychloride Products for National Building Code of Canada Compliance

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NRC Construction

Introduction

- National Research Council Canada (NRC)
- Canadian building regulatory system – an overview
- Canadian Construction Materials Centre (CCMC)
- CCMC Evaluation Process, including Technical Guides
- Magnesium Oxychloride Products and potential testing issues
- Quality Control and other key technical issues

NRC: Canada's Research and Technology Organization

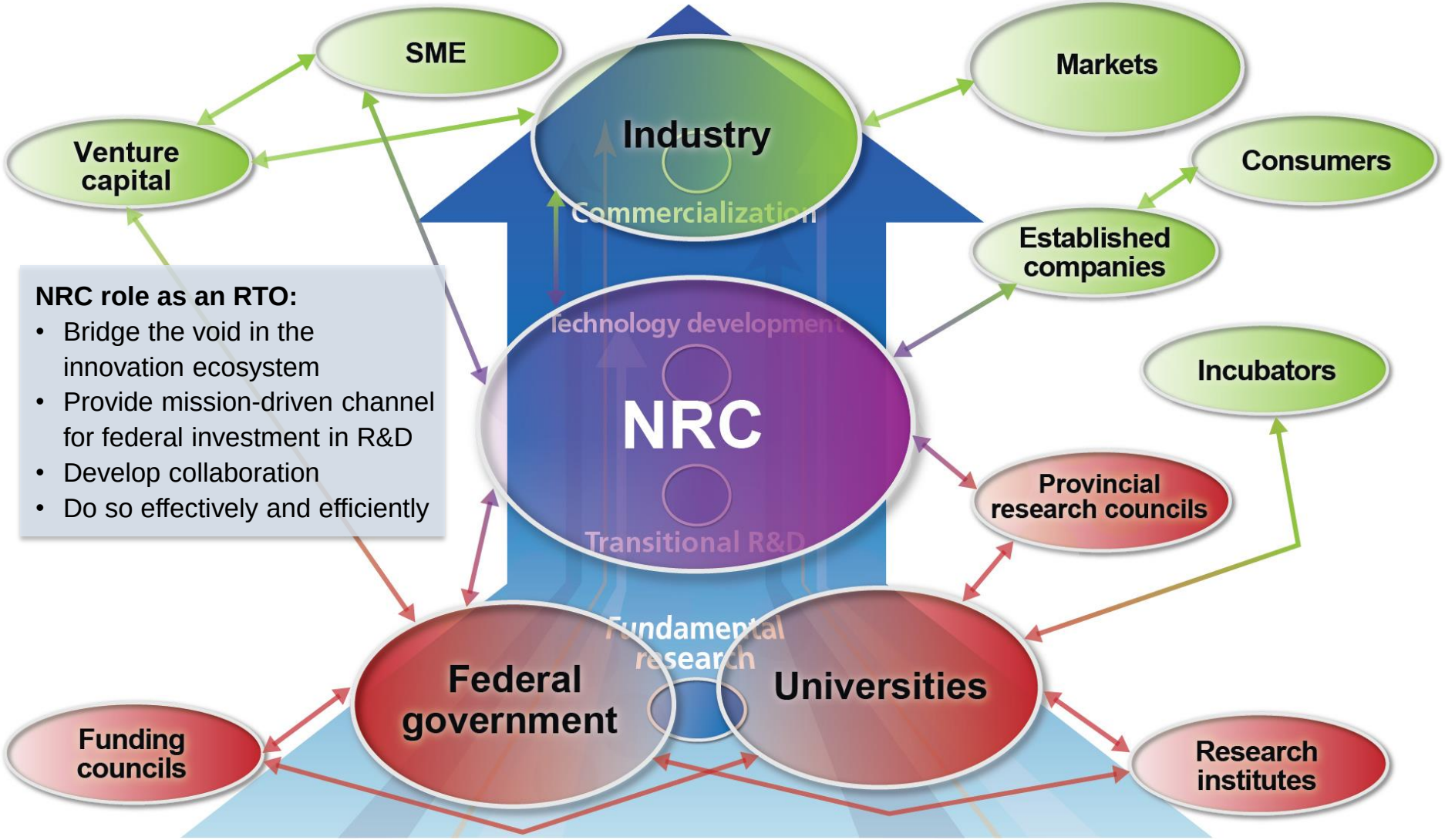
VISION

To be the most effective research and technology organization in the world, stimulating sustainable domestic prosperity

MISSION

Working with clients and partners, we provide innovation support, strategic research, scientific and technical services to develop and deploy solutions to meet Canada's current and future industrial and societal needs

NRC's role as RTO in the innovation "ecosystem"



NRC role as an RTO:

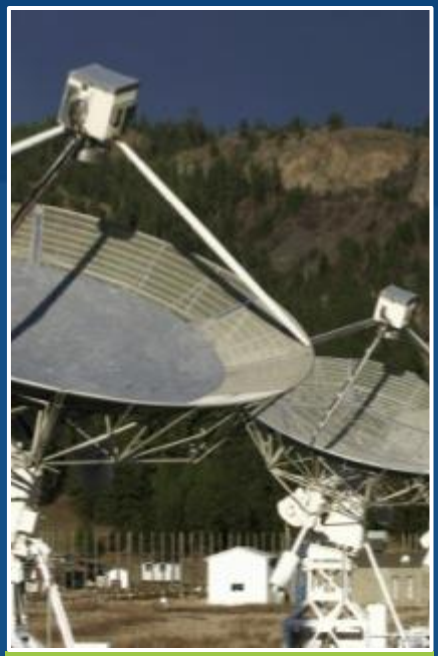
- Bridge the void in the innovation ecosystem
- Provide mission-driven channel for federal investment in R&D
- Develop collaboration
- Do so effectively and efficiently

About NRC

- NRC 2013-14 total expenditures: $894.4M
- Approximately 3550 employees

NRC business lines

Strategic Research & Development



National Science Infrastructure

Technical Services

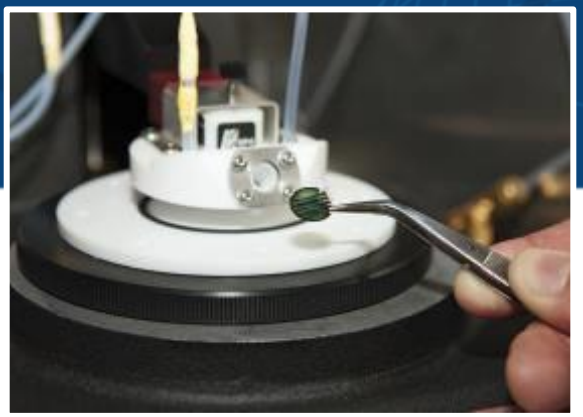
Industrial Research Assistance Program (IRAP)

NRC research divisions

Emerging Technologies

Life Sciences

Engineering



Engineering Division

PORTFOLIOS

- Aerospace
- Automotive and Surface Transportation
- **Construction**
- Energy, Mining and Environment
- Ocean, Coastal and River Engineering

NRC Construction

We provide solutions to

- Achieve higher performing, affordable buildings and infrastructure
- Accelerate technology commercialization
- Reduce compliance costs

Competencies

Building Envelope and Materials

Civil Engineering and Infrastructure

Intelligent Building Operations

Fire Safety

Building Regulations

Technical Services

Building Envelope and Materials

- Improve envelope and acoustic performance
- Evaluate and de-risk new building materials and systems
- Perform compliance assessment of building products and provide guides for commercialization through the Canadian Construction Materials Centre

Fire Safety

- Evaluate & improve the performance of construction assemblies
- Predict smoke movement and occupants behaviour

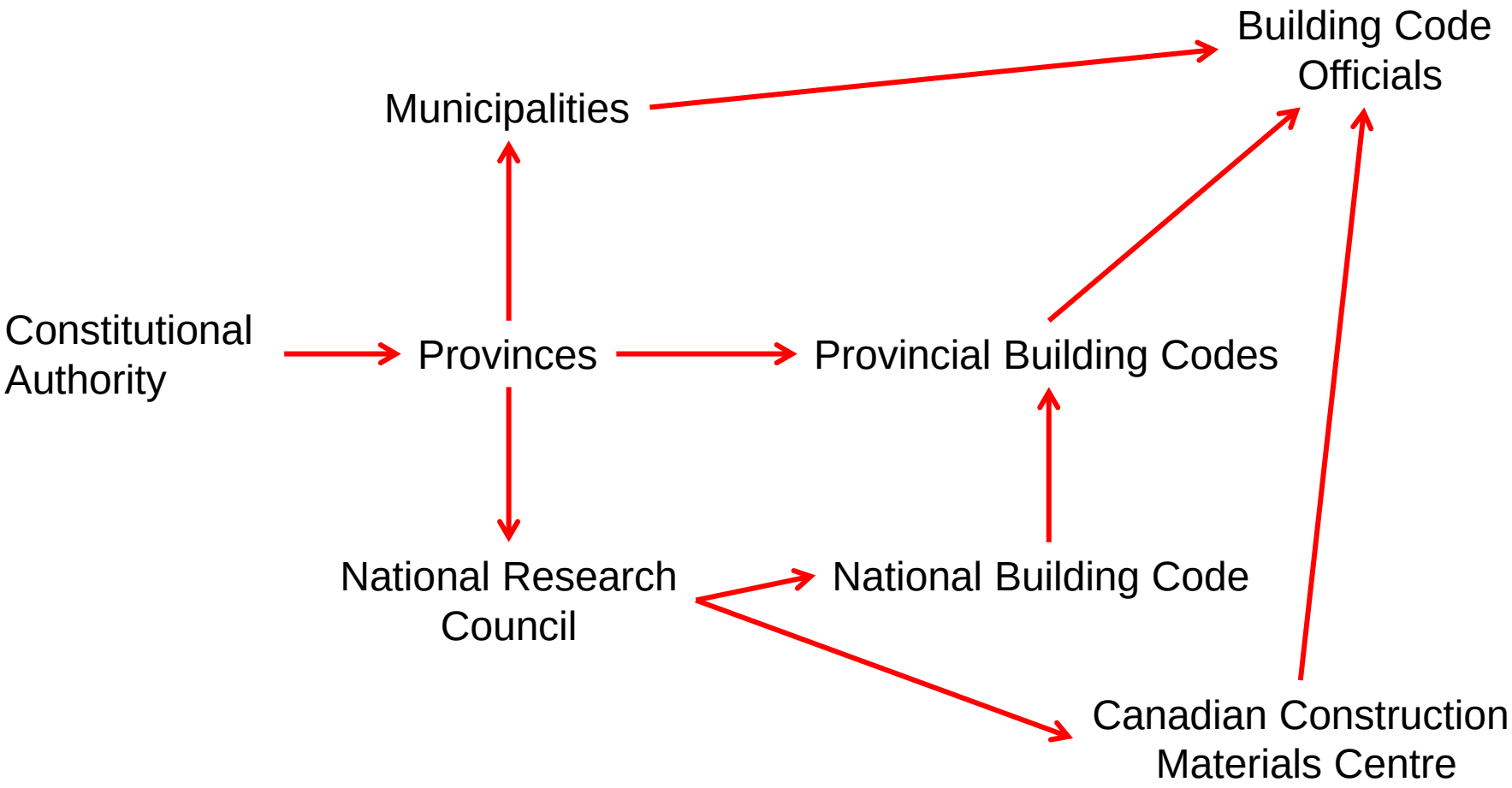
Building Regulations

- Develop and update National Model Codes in partnership with provinces and territories

Summary

- NRC Construction is part of a large, world class RTO
- NRC is part of the Canadian Federal Government
  - Reports to Minister of Industry
- NRC Construction:
  - Conducts strategic research and development for companies, other government departments and other levels of government
  - Manages the National Building Code of Canada system on behalf of the provinces
  - Evaluates new construction products for NBCC compliance

Regulatory System Outline



National Building Code of Canada (NBCC)

- NRC manages the NBCC on behalf of the provinces
- NBCC is a model code that provinces modify and adopt into legislation
- Goal: Ensure safety of building occupants
- Codes are revised on a five year cycle

Building Approvals

- Municipal building officials approve building projects, including the materials and products used in those projects
- The building officials in each community has final say about what products can be used

Differences between U.S. and Canadian Building Codes

- Material properties in U.S. code systems such as the International Construction Code (ICC) use an empirical approach
  - i.e. three samples must have an average value greater than “x”
- Canadian building codes use limit state engineering and reliability analysis
  - Need to know distribution of material strengths for structural materials
  - Design around 5% cut-off strength
- Durability issues are an inherent part of the NBCC, but are more standard dependent in the U.S.

Innovative Materials

- Any material that is not explicitly mentioned in the NBCC is considered innovative
  - The time the product has been on the market is not relevant
  - PVC siding is an example
- Some innovative materials are covered by recognized standards
- Others are novel enough that no Canadian Standards Association (CSA), American Society for Testing of Materials (ASTM) or other recognized standard exists
  - Sometimes an existing standard doesn't cover all of the issues relevant to the NBCC

Approvals for Innovative Materials

- There are two routes to have building officials approve the use of innovative building materials:
  - Present the official with documents stamped by a professional engineer that certify the product or products in a project meet NBCC requirements; *or*
  - Present the official with a CCMC report or listing that states that the product itself meets the requirements of the NBCC.
- In either case the official decides on the presented information

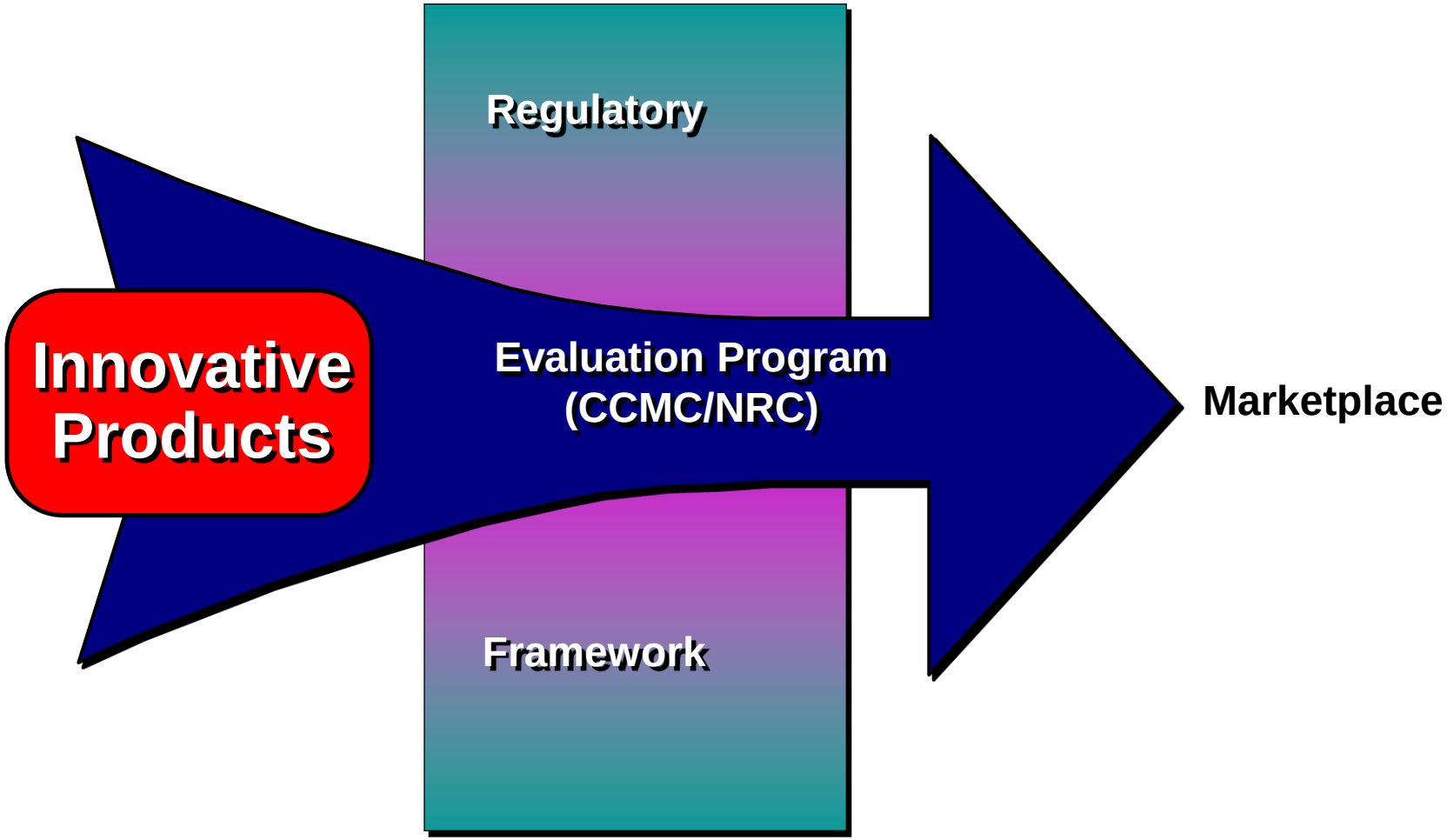
Reasons to use CCMC

- There are about 8000 building officials across Canada and many more separate construction projects
  - Needing to demonstrate compliance with the NBCC on each project is expensive and time consuming
- Some major municipalities will only accept products with a CCMC report or listing
- CCMC process can be the start of developing a CSA or ASTM standard for the product and/or eventual inclusion in the NBCC

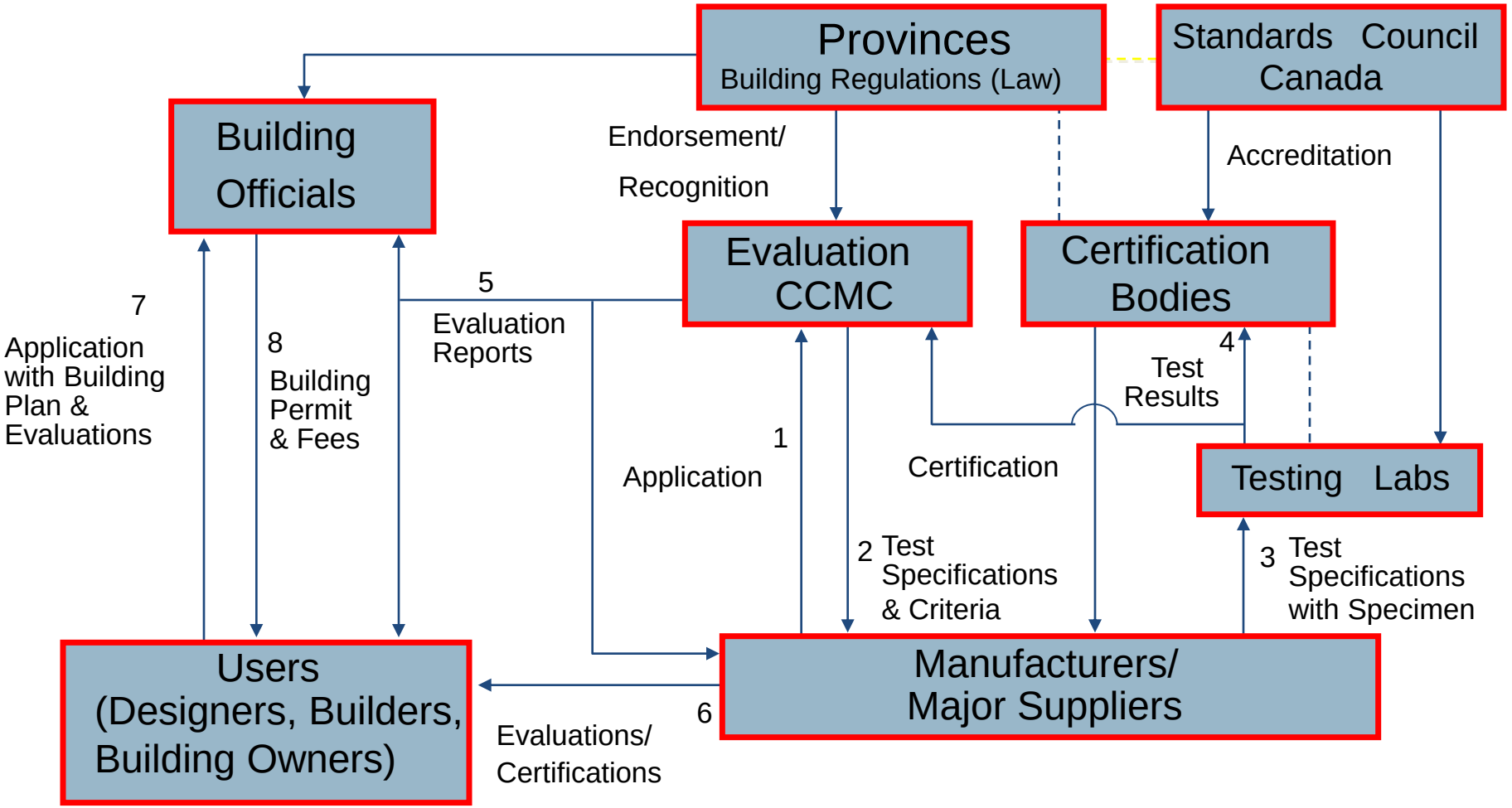
Summary – Canada's Building Regulatory System

- Provinces and territories delegate decision making authority to municipal building code officials
- On behalf of the provinces and territories, NRC:
  - Manages the NBCC process
  - Evaluates innovative construction materials for NBCC compliance through CCMC
- CCMC provides a cost effective route to demonstrating NBCC compliance to building code officials across Canada

Role of CCMC – Assist Innovations to get to Market



Current Conformity Assessment System for Building Products



CCMC Services

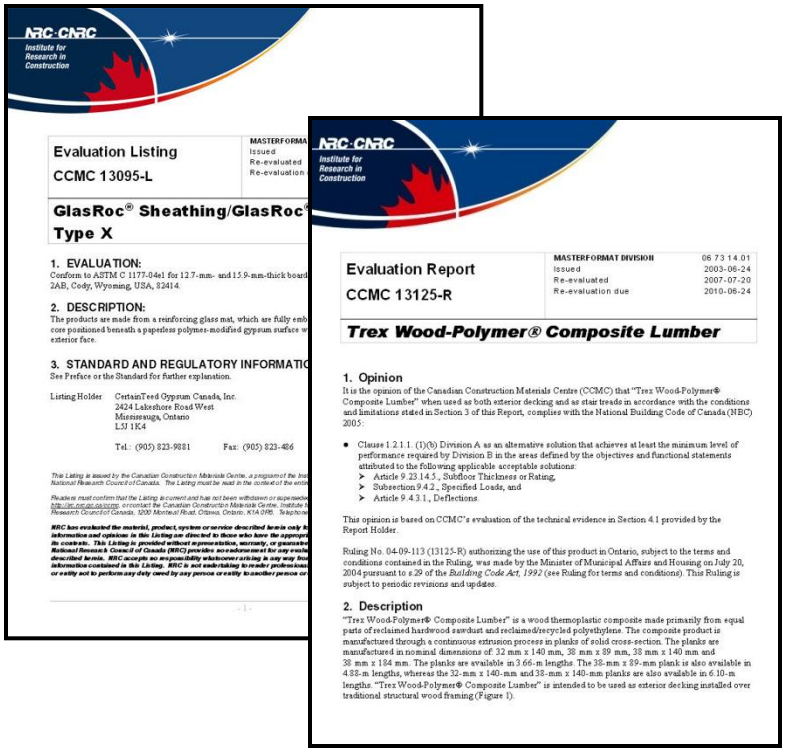
- Provide an authoritative opinion that an innovative product meets the minimum requirements of the NBC
- Products listed as “acceptable” or “alternative” solutions.
- “Acceptable” solutions are ones that are actually covered by the NBCC
- “Alternative” solutions meet the same objectives and functions of an acceptable solution

CCMC

- Produces two types of products:

  - Listings
    CCMC XXXXX-L

  - Reports
    CCMC XXXXX-R



Listings – Standardized Products

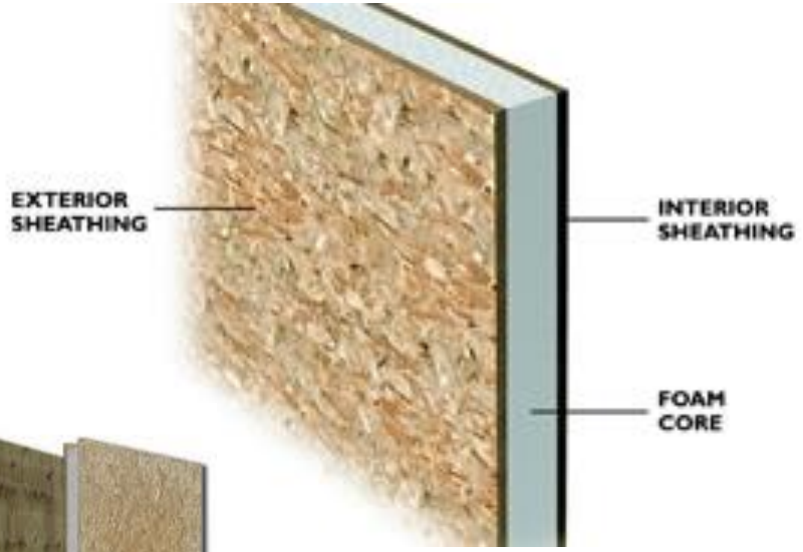
- Polyisocyanurate Insulation
- PVC Roofing Membrane
- Vinyl Siding
- Windows

Reports – Innovative Products

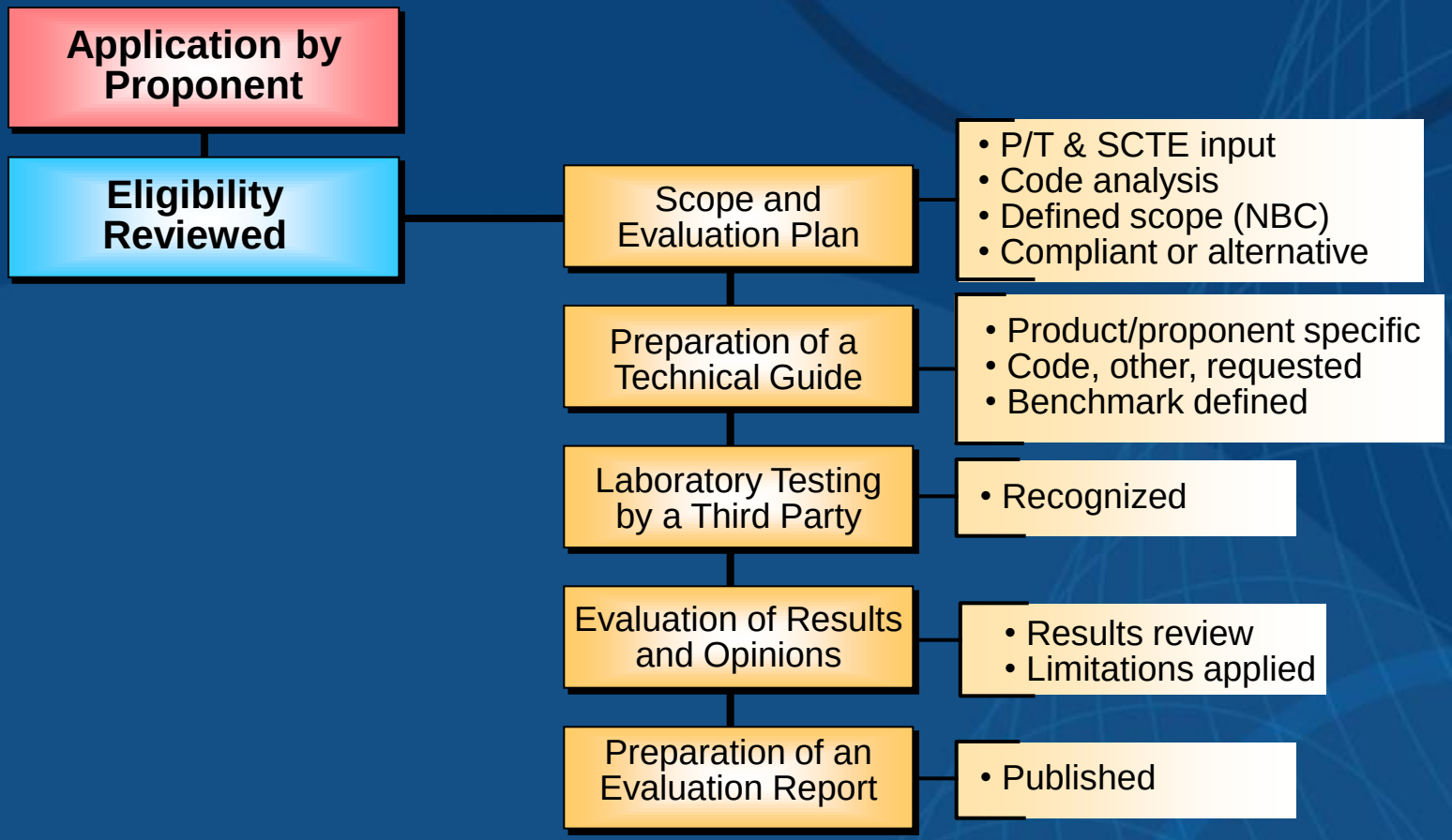
- Insulation
  - Cellulose
  - Urethane
  - Soy

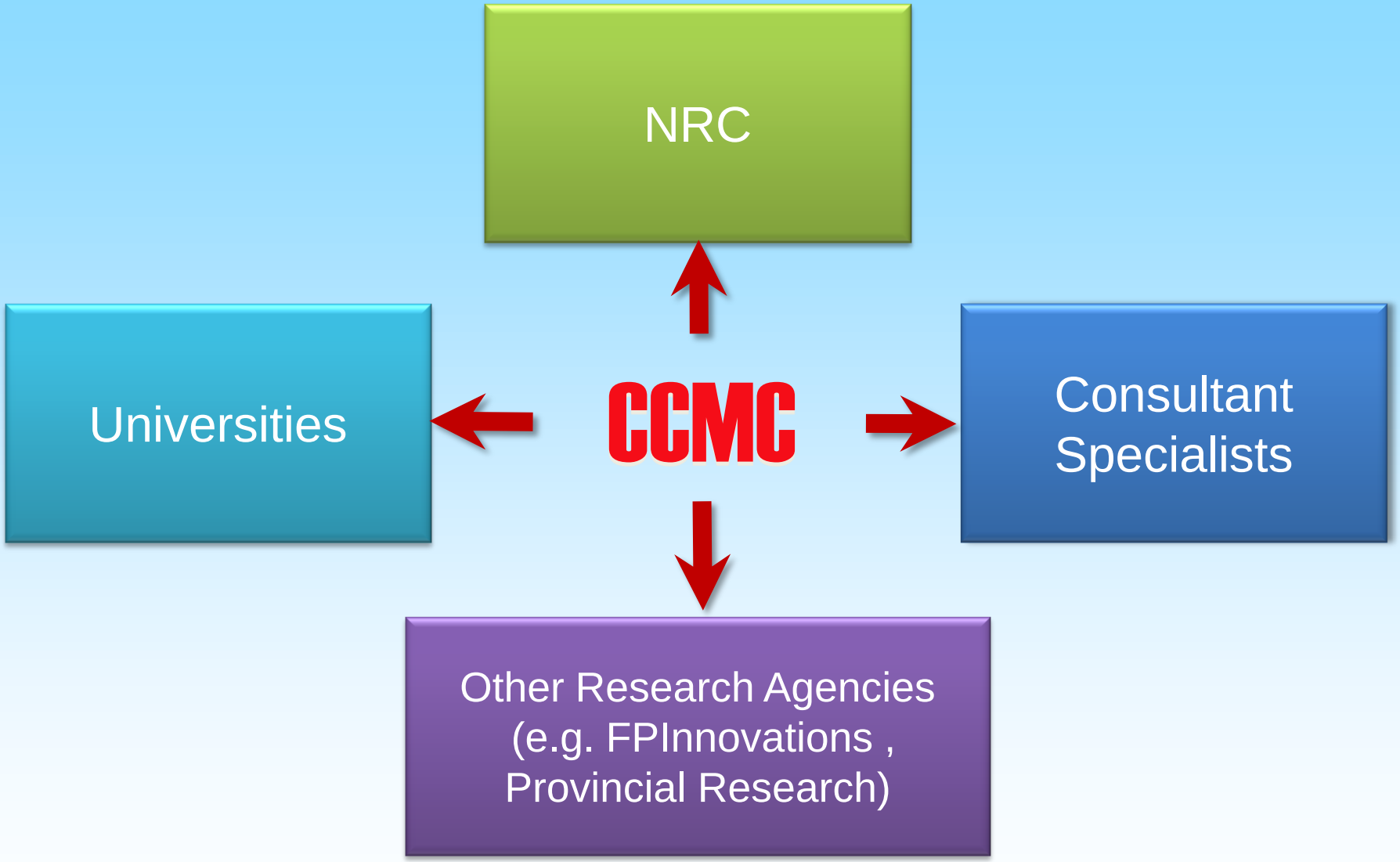
Innovative Products

- **Structural Insulated Panels**



Innovative (Non-Standardized) Product Evaluation Process




NRC
Universities
CCMC
Consultant Specialists
Other Research Agencies (e.g. FPInnovations , Provincial Research)

Technical Guide Contents

- NBCC Compliance Requirements (Mandatory)
  - Material/prescriptive properties
  - Performance requirements
  - Design requirements
  - Modeling
  - Field requirements
- Optional Requirements:
  - Additional health and safety data identified by third parties
  - Additional performance data
  - Additional CCMC requirements

Technical Guide Contents

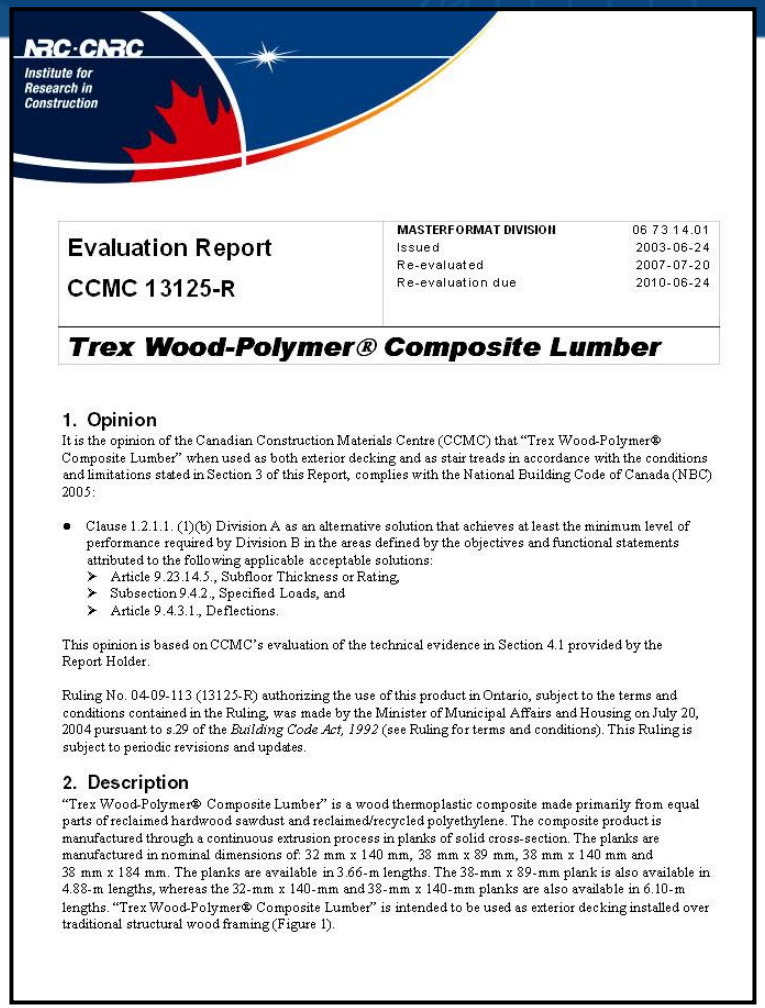
- Additional Documentation
  - Installation manual
  - Quality assurance manual
  - Labelling requirements

Testing Phase

- Sampling
  - 3rd party
  - Technical guide specifies number and size of samples
- Testing
  - Accredited or recognized laboratories
  - US or Canada
  - Can be done in conjunction with the technical guide development
  - First tests may be required to be done by technical guide developer

CCMC Evaluation Report

- Effective for three years
  - Yearly re-affirmation
- Re-evaluation mandatory after three years



NRC·CNRC
Institute for Research in Construction

Evaluation Report CCMC 13125-R	MASTERFORMAT DIVISION	06 73 14.01
	Issued	2003-06-24
	Re-evaluated	2007-07-20
	Re-evaluation due	2010-06-24

Trex Wood-Polymer® Composite Lumber

1. Opinion

It is the opinion of the Canadian Construction Materials Centre (CCMC) that "Trex Wood-Polymer® Composite Lumber" when used as both exterior decking and as stair treads in accordance with the conditions and limitations stated in Section 3 of this Report, complies with the National Building Code of Canada (NBC) 2005:

- Clause 1.2.1.1. (1)(b) Division A as an alternative solution that achieves at least the minimum level of performance required by Division B in the areas defined by the objectives and functional statements attributed to the following applicable acceptable solutions:
  - Article 9.23.14.5., Subfloor Thickness or Rating,
  - Subsection 9.4.2., Specified Loads, and
  - Article 9.4.3.1., Deflections.

This opinion is based on CCMC's evaluation of the technical evidence in Section 4.1 provided by the Report Holder.

Ruling No. 04-09-113 (13125-R) authorizing the use of this product in Ontario, subject to the terms and conditions contained in the Ruling, was made by the Minister of Municipal Affairs and Housing on July 20, 2004 pursuant to s.29 of the *Building Code Act, 1992* (see Ruling for terms and conditions). This Ruling is subject to periodic revisions and updates.

2. Description

"Trex Wood-Polymer® Composite Lumber" is a wood thermoplastic composite made primarily from equal parts of reclaimed hardwood sawdust and reclaimed/recycled polyethylene. The composite product is manufactured through a continuous extrusion process in planks of solid cross-section. The planks are manufactured in nominal dimensions of: 32 mm x 140 mm, 38 mm x 89 mm, 38 mm x 140 mm and 38 mm x 184 mm. The planks are available in 3.66-m lengths. The 38-mm x 89-mm plank is also available in 4.88-m lengths, whereas the 32-mm x 140-mm and 38-mm x 140-mm planks are also available in 6.10-m lengths. "Trex Wood-Polymer® Composite Lumber" is intended to be used as exterior decking installed over traditional structural wood framing (Figure 1).

CCMC Registry of Product Evaluations

website: www.nrc-cnrc.gc.ca/eng/solutions/advisory/ccmc/evaluations

Summary - CCMC

- CCMC operates on behalf of Canadian provinces and territories
- Standardized products are evaluated and given a CCMC listing
- Innovative, non-standard products require the development of a Technical Guide
- Products are then tested according to the Technical Guide and the results evaluated by CCMC
- A successful evaluation results in a CCMC report and eases market entry

Experience with MgOCl boards to date

Introduction

- Will not discuss results from specific evaluations
  - Technical Guides have restricted access for three years after completion
  - Other parties need to share the cost of TG development with the original proponent if they want to use the TG
  - Test results are proprietary to the proponent
- Will discuss general issues and approach to testing
  - Generic graphs will be used to illustrate certain points

Products submitted to CCMC for evaluation

- Proponents have discussed a variety of MgOCl products with NRC in the last three years
  - Interior wallboard
  - Tile backerboards
  - Floor underlay
  - Exterior wall sheathing
  - Siding
  - Rain screen
  - Structural insulated panels
- Some products would be easier to qualify than others

Existing Reports and Evaluations

- One proponent has a CCMC report covering backerboard use and another covering floor underlay
- One other product currently moving from the technical guide to the evaluation phase
- Discussions under way on other products

Major Technical Concerns (I)

- Technical issues depend on application
- Durability issues are a concern for outdoor applications
  - More than half of recent academic publications were on durability issues
- Leaching is a particular concern
  - Also relevant to indoor applications where water exposure is possible
  - Loss of strength
  - Free chloride ions → corrosion of fasteners
    damage to adhesive bonds

Major Technical Concerns (II)

- Material porosity can be an advantage or disadvantage
  - Beneficial for exterior applications as it permits water vapour to leave the wall interior
  - Not desirable for interior applications where water exposure is possible
- Interaction with soil chemistry is not well understood
  - Potential for chemical attack by soil constituents would need to be investigated if products would be in contact with soil
  - A large, long term research project would be required to fully understand the potential deterioration mechanisms, their time scale and how to test for soil compatibility

Summary

- Material properties that are important to a successful evaluation depend on the product and how it would be used
- Products intended for use in some applications may have more difficulty in demonstrating NBCC compliance than others
- General areas of concern with respect to fundamental behaviour include:
  - Durability, especially related to leaching;
  - Porosity;
  - Soil Chemistry;

Product Variability and Quality Control

Variability of MgOCl materials

- Quality control appears to be significant impediment to acceptance of magnesium oxychloride boards in North America
- All Technical Guides contain quality control provisions
- The expectation is that batch to batch materials properties will be consistent
- Analysis of materials to date shows highly variable material properties compared to other construction materials

Key areas with poor consistency

- Board chemistry
- Mechanical strength
- Effects of leaching

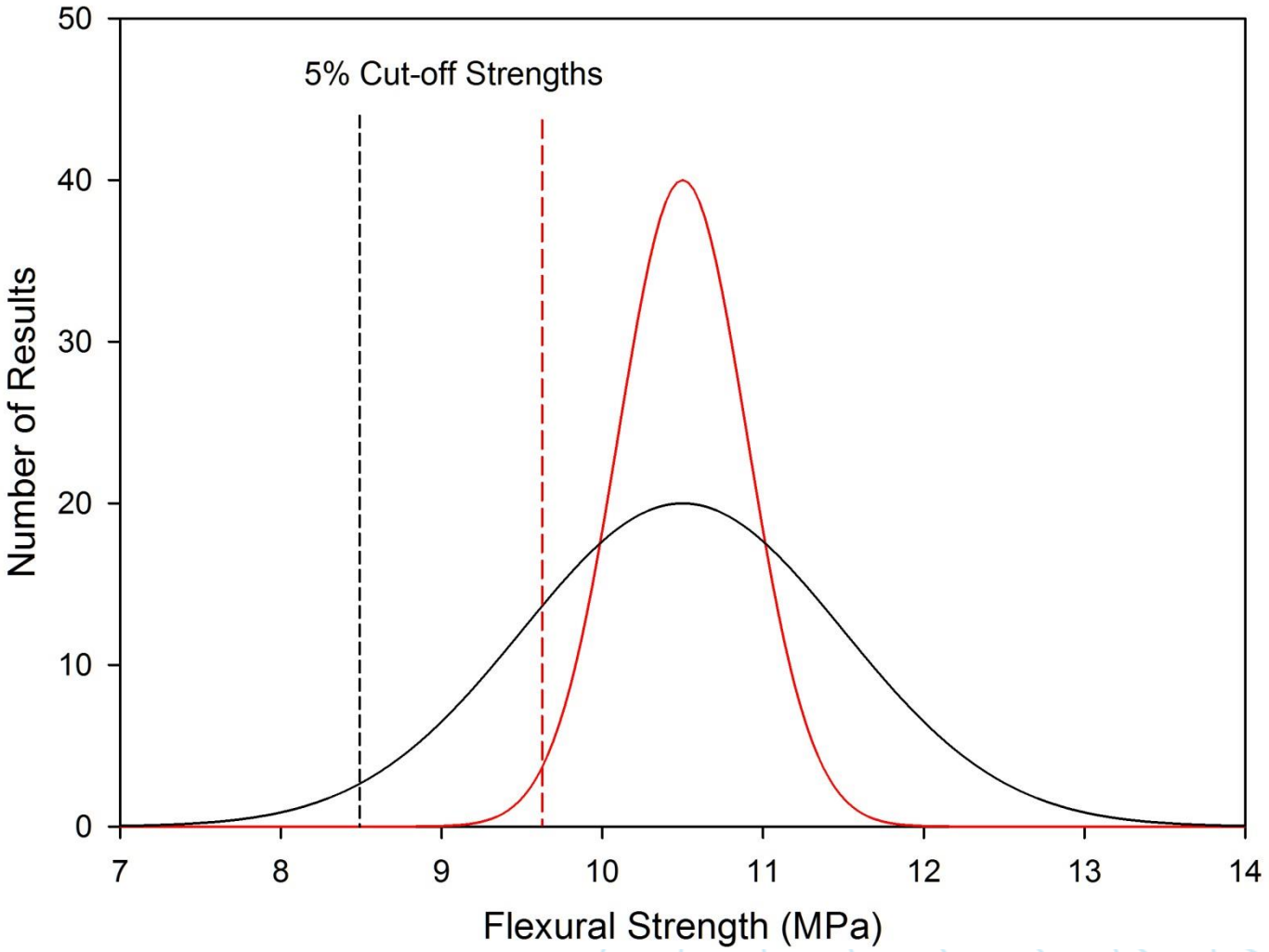
Board Chemistry

- Measured by X-ray diffraction, x-ray fluorescence
- Expectation is that the chemical constituents and the crystalline components of the boards are essentially the same between batches of boards produced at the same plant
- Trace elements may differ, although toxic elements must not be present
- Tests on commercial boards from the same supplier can show wide variability
  - May be indicative of supply from different plants or production problems
- Regular checks on board chemistry are likely to be required for proper quality control

Mechanical Behaviour (I)

- Measured by flexural strength or other mechanical test methods
- Any structural use requires knowledge of not only average strength, but also strength distribution of the material
- The five percent cut-off strength is used for structural design
- Within batch material variability reduces the design strength even if the average strength remains the same as a less variable material

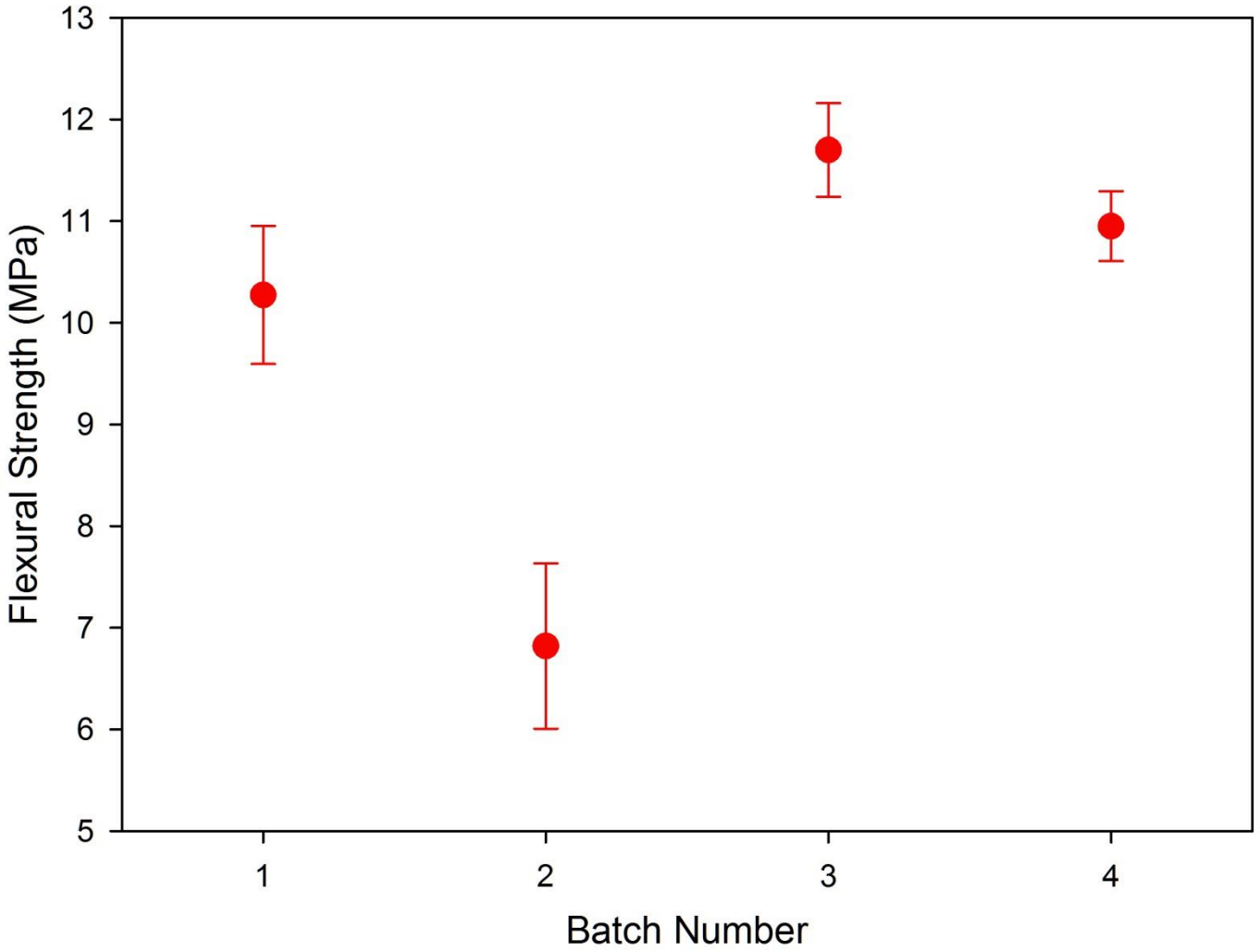
Mechanical Behaviour (II) – Sample Variability



Mechanical Behaviour (III) – Batch to Batch Variability

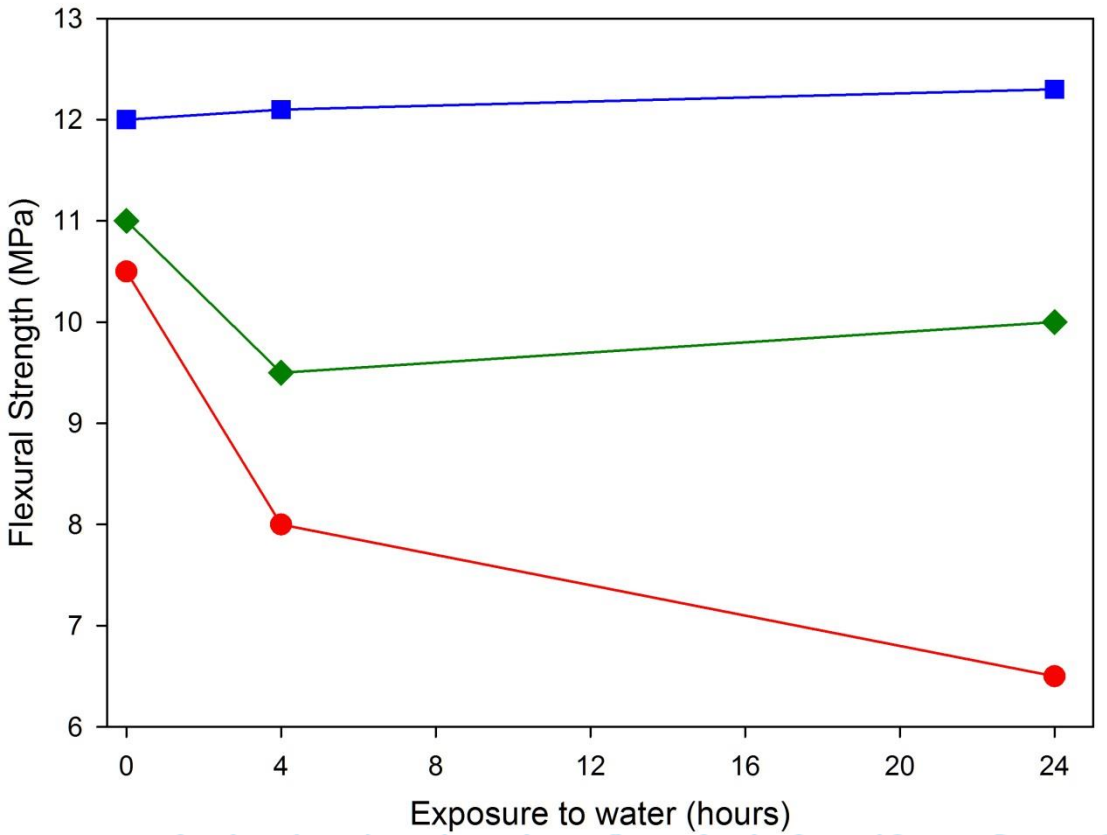
- Batch to batch mechanical strength measurements must be statistically the same
- Measurements will be done on multiple samples from each batch
- Analysis of variance (ANOVA) done on samples to check similarity
- Batches must have the same strength within a 95% confidence level
- Some batches nominally from the same plant show very different results

Mechanical Behaviour (IV) – Batch Variability



Mechanical Changes due to Leaching

- Flexural strength and other mechanical properties should be minimally affected by water exposure
- The batch to batch properties of the boards after exposure to water should also be statistically the same
- Some boards show wide batch to batch variability



Summary

- Consistent material properties are essential for demonstrating compliance with the NBCC
- Canadian suppliers of magnesium oxychloride boards must have quality control manuals for a successful product evaluation by CCMC
- Products must be consistent between batches
- Quality will be checked using methods capable of assessing batch to batch variability
- **Good quality control is essential for a successful product**

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Thank you

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