IRMCA 2021
Type IL Cement
Portland-Limestone Cement

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First Presenter

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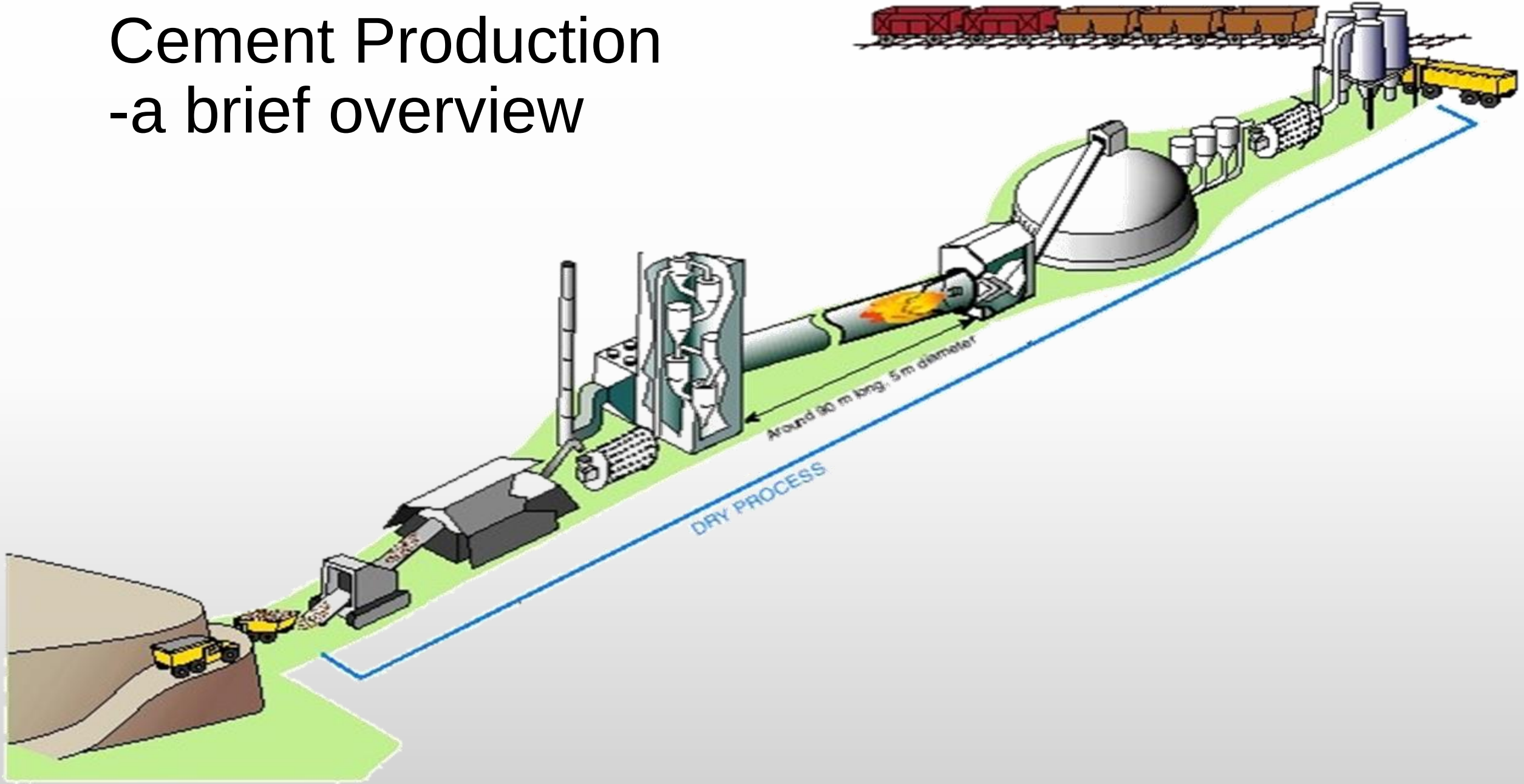
IRMCA Cement Company Members:

- Buzzi Unicem USA
- CEMEX
- Continental Cement
- Illinois Cement
- Kosmos Cement
- LafargeHolcim
- Lehigh Cement
- St. Marys Cement

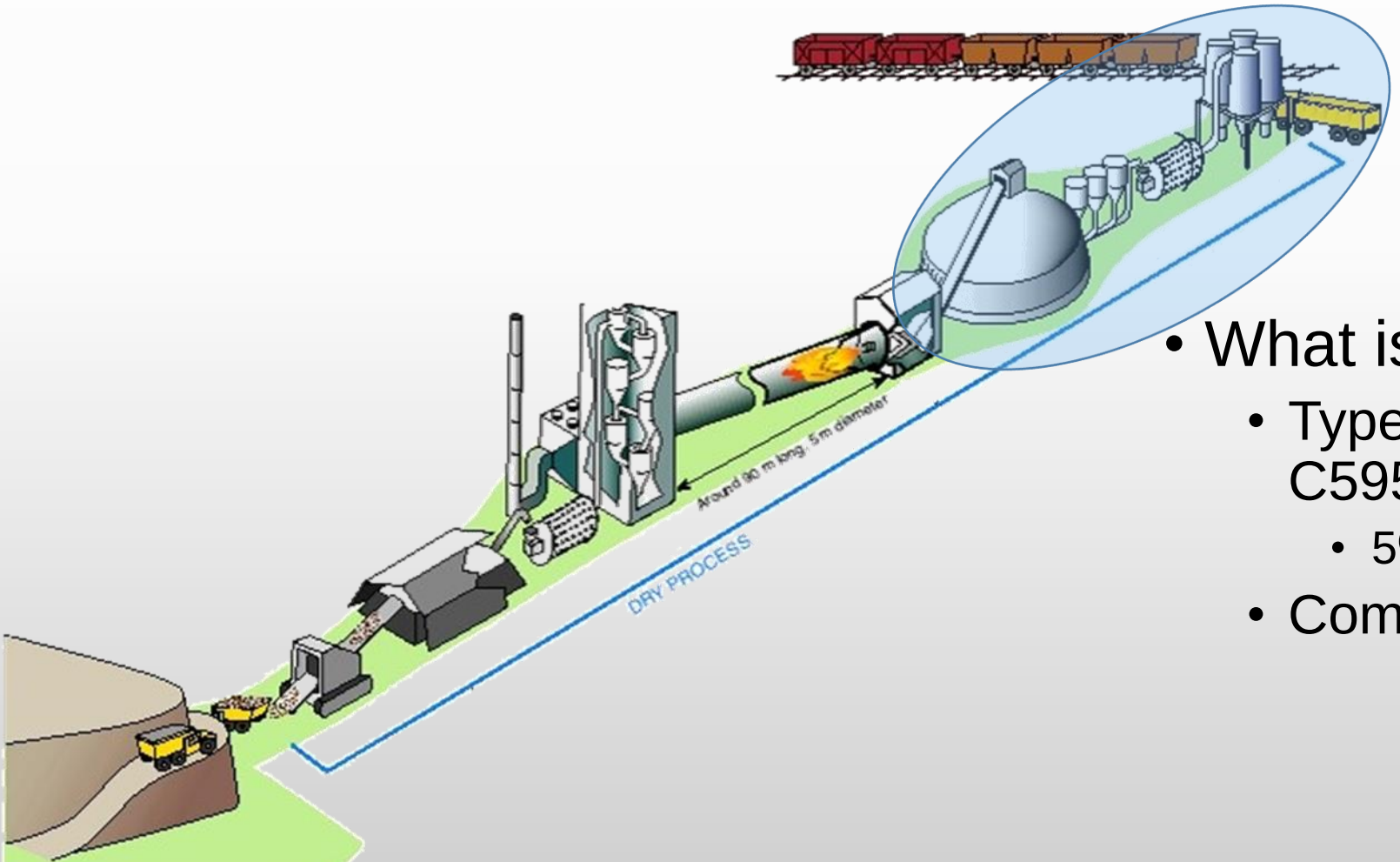
Today’s Objectives

- What is a portland-limestone blended cement
- How is it made
- Why use it
- How does it perform in concrete

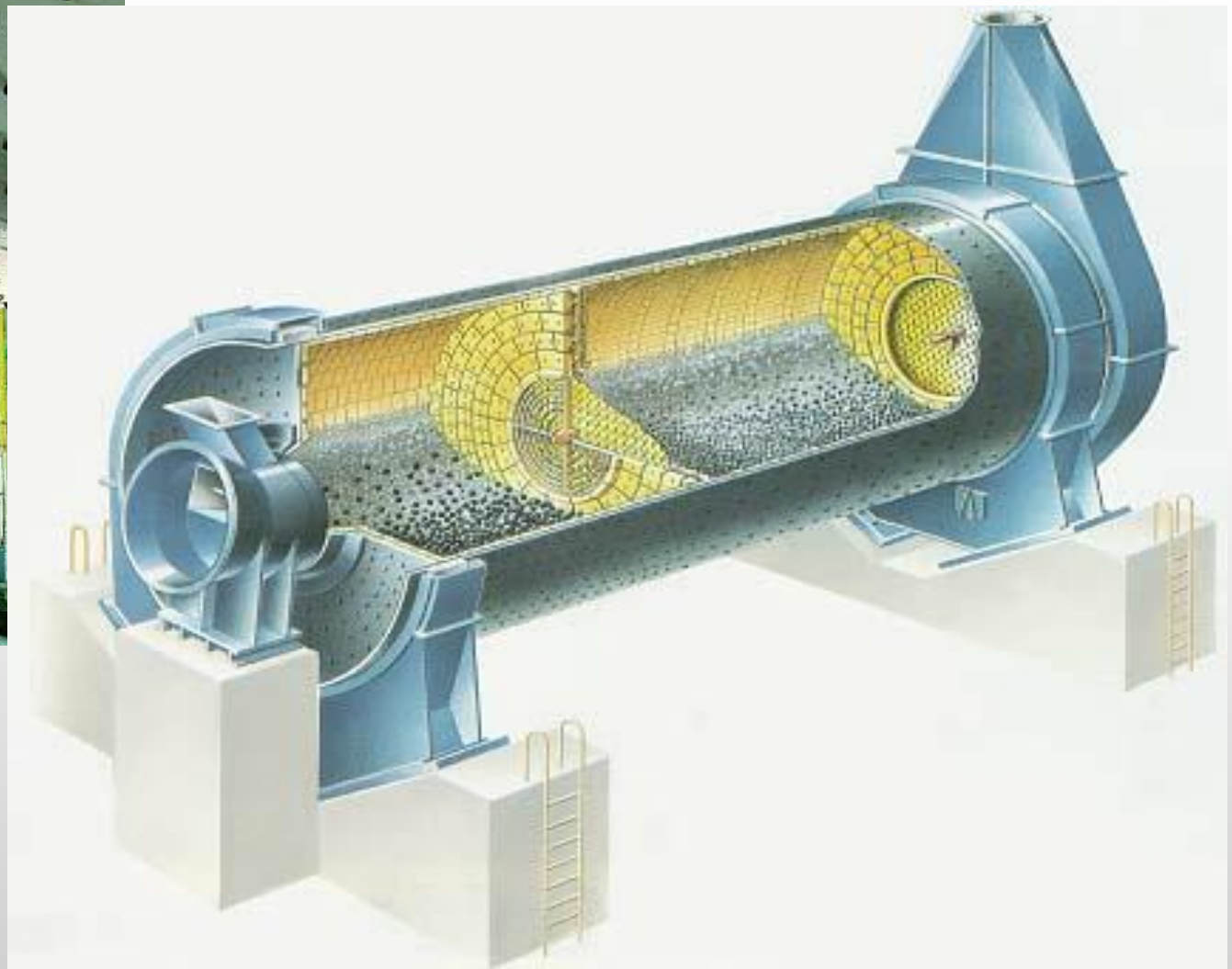
Cement Production
-a brief overview



Portland-Limestone Cement



- What is a PLC?
  - Type IL blended cement in ASTM C595/AASHTO M 240
    - 5% to 15% limestone by mass
  - Common in Europe



Portland-Limestone Cement

Various Cement Types

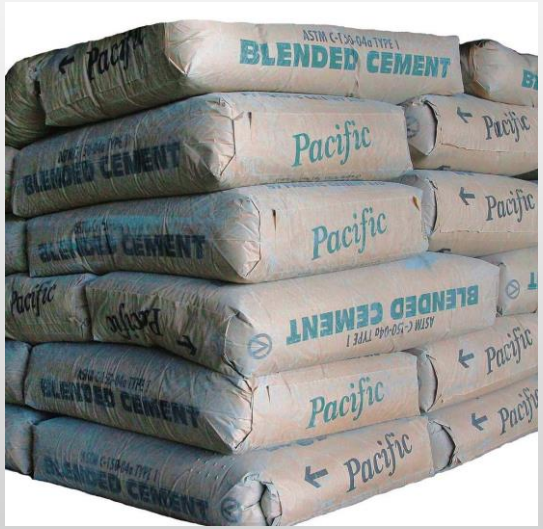
ASTM C150 – Portland Cement

- Types included in ASTM C150 standard (which is harmonized with AASHTO M85):
  - **I – Normal**
  - **II – Moderate Sulfate Resistance (C_3A Limit of 8%)**
    - I/II (All Type II cements meet Type I Specs) (Very Common)
    - II(MH) - meets moderate heat of hydration
  - III – High Early Strength
  - IV – Low Heat of Hydration (C_3A Limit of 7%)
  - V – High Sulfate Resistance (C_3A Limit of 5%)

Various Cement Types

ASTM C595 – Blended Hydraulic Cements

- Type IL – Portland-Limestone Cement (a.k.a PLC, similar to GUL in Canada)
- Types included in ASTM C595 standard (which is nearly identical to AASHTO M240):
  - IS (x) – Portland blast-furnace slag
  - IP (x) – Portland-pozzolan cement (e.g. ash)
  - **IL (x) – Portland-limestone cement**
  - IT (Ax)(By) –Ternary blended cement
    - (x) indicates nominal mass percentage of the added ingredient
- Type IL is limited to a maximum of 15% (per ASTM 595)



How is PLC Different?

- PLC is made by intergrinding regular clinker with up to 15% limestone while regular portland cement contains up to 5% limestone
- PLC is a finer ground product than regular portland cement

PORTLAND CEMENT

95% Ground Clinker

5% limestone

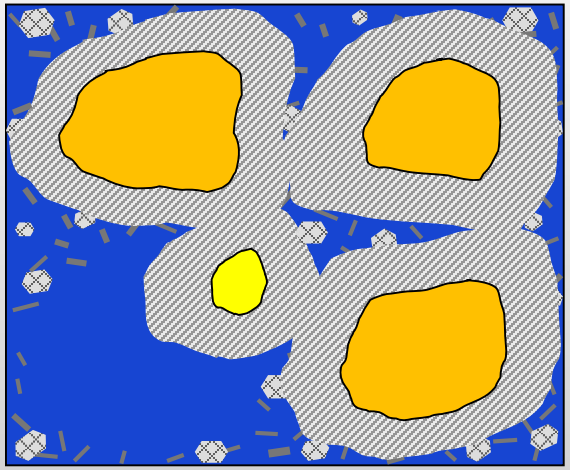
PLC

85% Ground Clinker

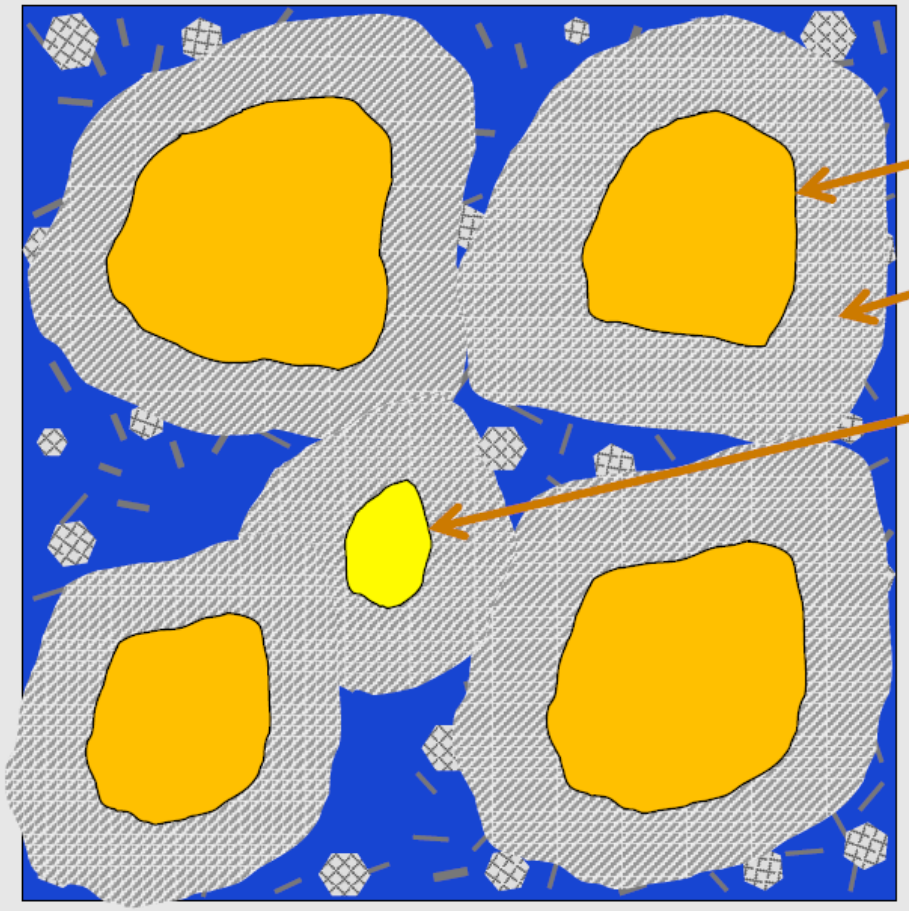
15% limestone

How Limestone Works

- Particle packing
  - Improved particle size distribution
- Nucleation
  - Surfaces for precipitation



How does Nucleation work?



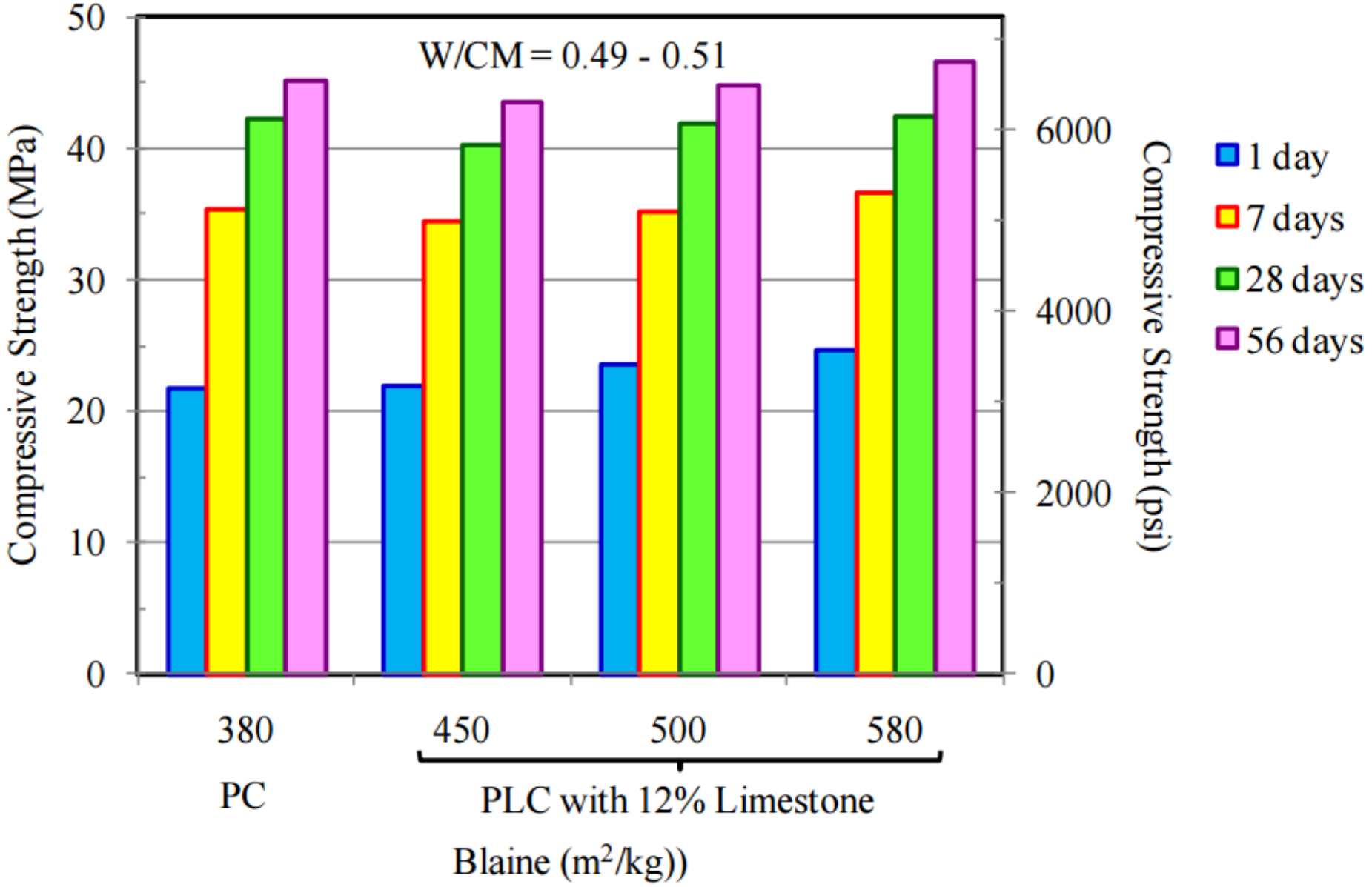
- Limestone particle serve as nucleation sites for hydration products.
- Some evidence that the limestone particles take part in the hydration process and densify the matrix.

Performance

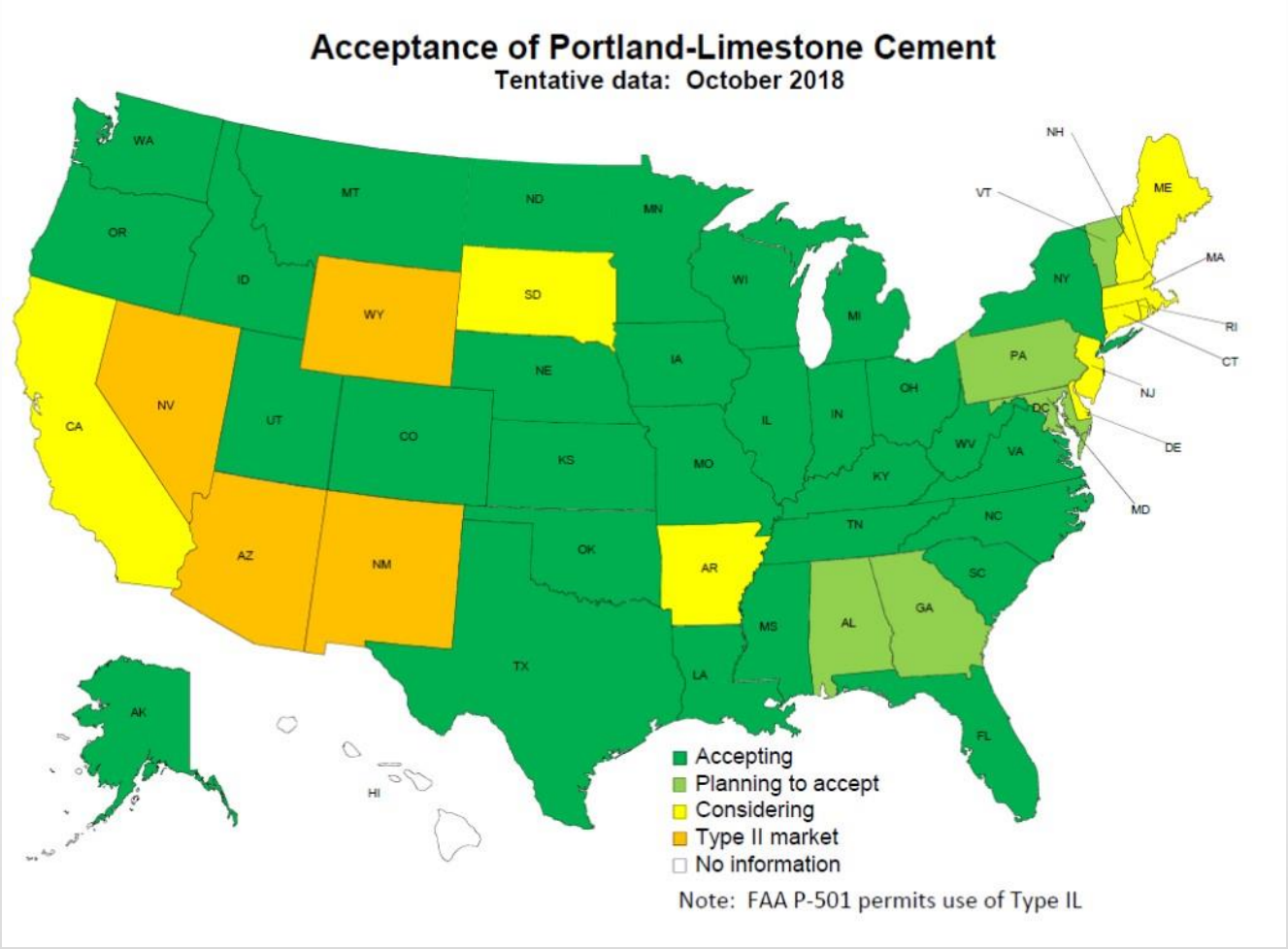
- Engineered for equivalent performance in concrete
- Always Test to Verify:
    - Strength
    - Plastic Properties / Workability
    - Permeability
    - Heat of Hydration
    - ASR
    - Sulfate Resistance

What is Blaine?

- Square Meters per Kilogram
- Cut one in Half?


W/CM = 0.49 - 0.51
Compressive Strength (MPa)
Compressive Strength (psi)
50
40
30
20
10
0
6000
4000
2000
0
1 day
7 days
28 days
56 days
380
450
500
580
PC
PLC with 12% Limestone
Blaine (m²/kg))

Acceptance by State DOTs



Do your specifications allow Type IL?

Many specifications accept PLC (ASTM C595 Type IL)

- Most national standards accept IL
  - ACI Building Codes
  - FHWA Specifications
- In the Cement section look for
  - “ASTM C595 Type IL” near where ASTM C150 is specified
  - AASHTO Specifications, “AASHTO M240 Type IL” near where AASHTO M85 Type I/II is specified
- If your not sure, contact your cement provider and they can help
- www.greenercement.com includes a link with further guidance
- See Example Specifications on the next page

Sample Specifications

- Materials
  - Portland Cement:
  - Use cement conforming to ASTM Specifications as flows:
- Type I Portland Cement; ASTM C150
- Type II Portland Cement; ASTM C150
- Type III Portland Cement; ASTM C150
- Type IP Portland-Pozzolan Cement: ASTM C595
- Type IS Portland Blast-Furnace Slag Cement; ASTM C595
- Type IL Portland-Limestone Cement: ASTM C595
- Type IT Ternary Blended Cement: ASTM C595

Best practices (not specific to PLC)

- While not specific to Type IL, the following best practices are recommended:
  - Requiring trial batches to confirm
    - Fresh and hardened properties
  - When additional requirements (e.g. ASR, heat of hydration, sulfate resistance) verify the specification allows for performance based methods.
    - IL DOT specifications do include performance based methods. (usually saves everyone money)
    - SCM usage to meet performance requirements may perform better than specialty products which are less readily available (e.g. “Low Alkali,” Type IV, Type V, or Type IL(HS) etc..)
    - Provide other durability related benefits.

Presenter Change

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Why is Portland-Limestone Cement important?

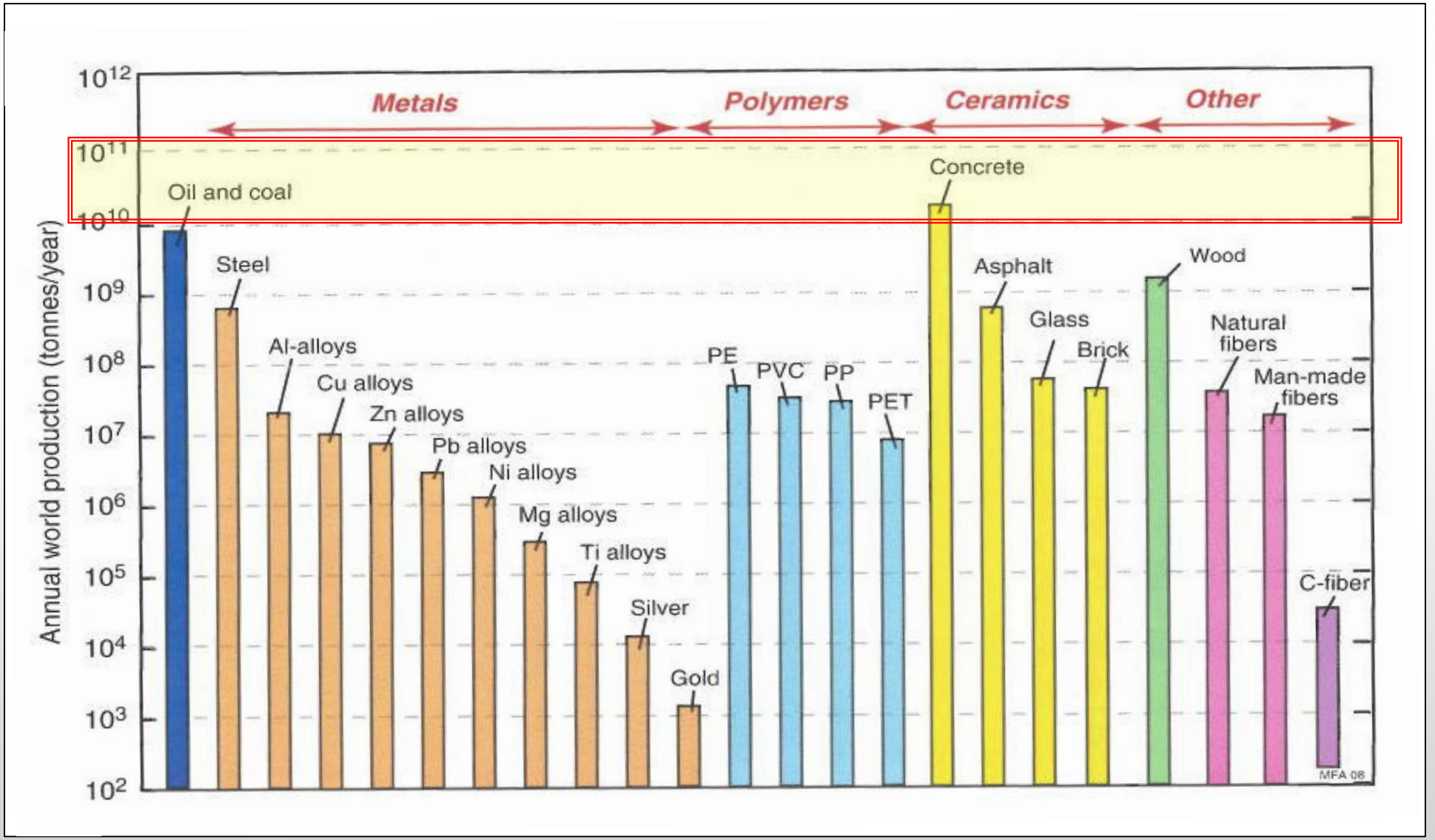
It reduces emissions and is more sustainable.

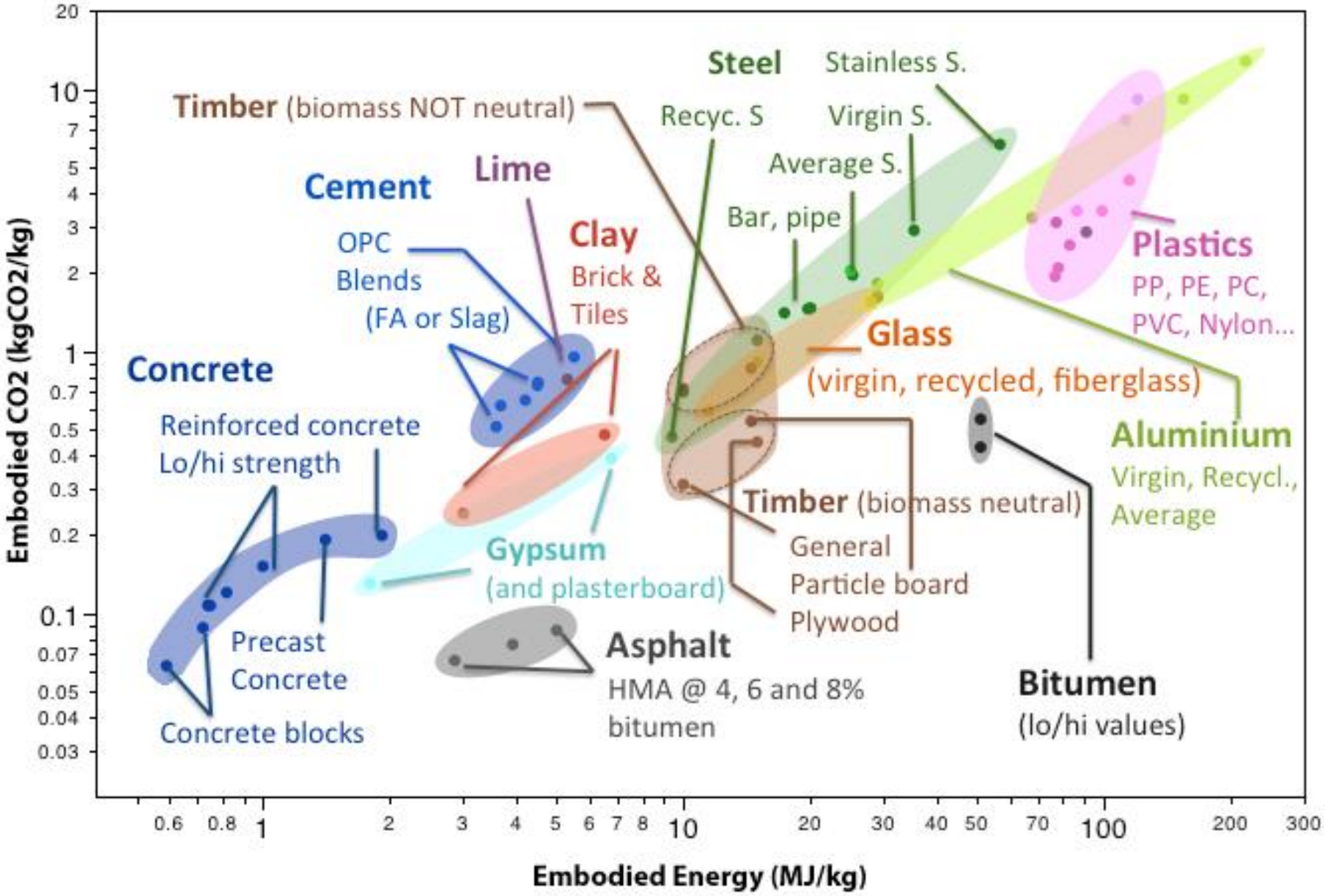
CO_2 is the most significant factor.

Concrete is most used material next to water

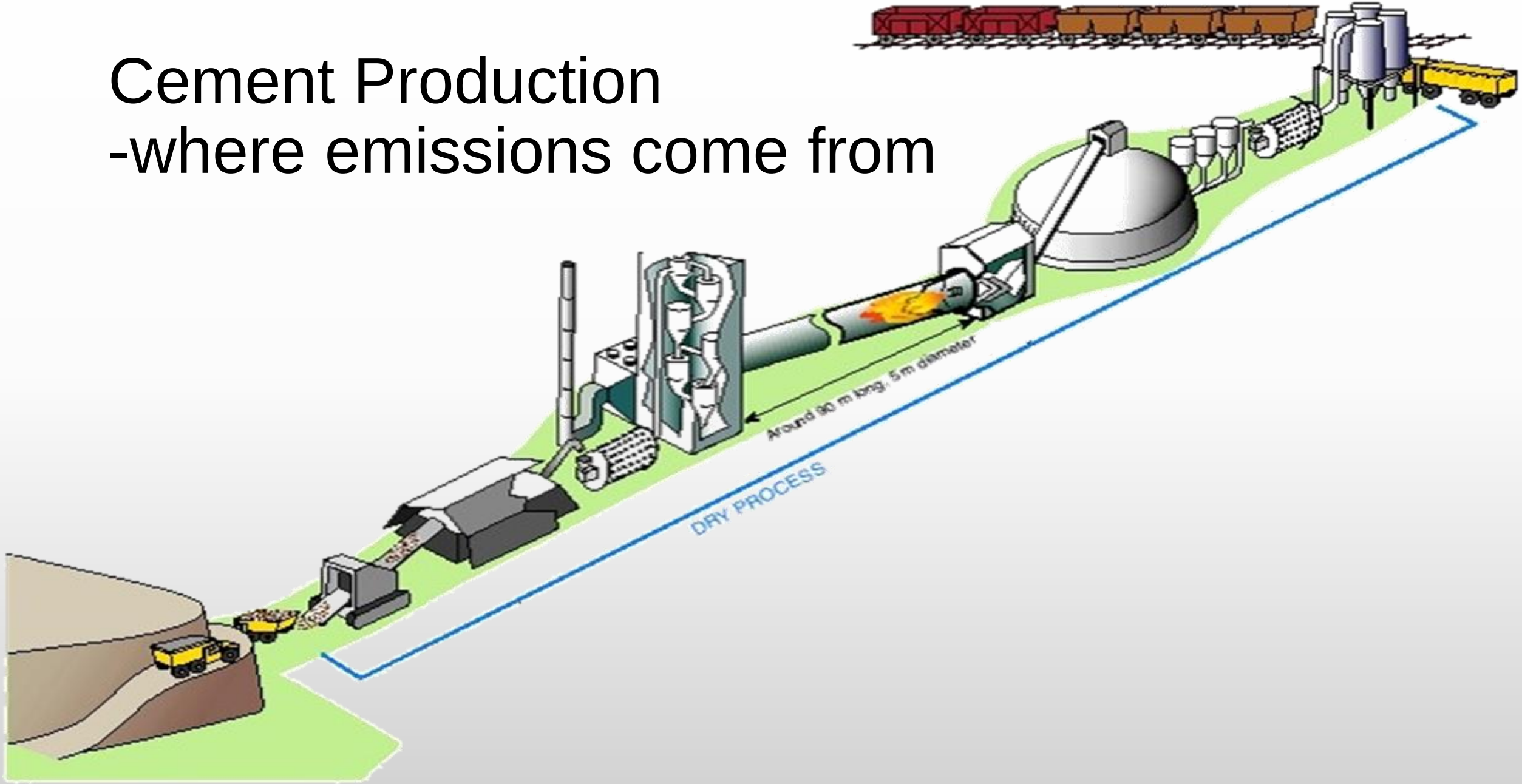
- Friendly Reminder: Concrete ≠ Cement

from Ashby (2009)




Embodied CO2 (kgCO2/kg)
20
10
7
5
4
3
2
1
0.7
0.5
0.4
0.3
0.2
0.1
0.07
0.05
0.04
0.03
0.6
0.8
1
2
3
4
5
6
7
8
10
20
30
40
50
70
100
200
300
Embodied Energy (MJ/kg)
Timber (biomass NOT neutral)
Steel
Stainless S.
Recyc. S
Virgin S.
Average S.
Bar, pipe
Lime
Cement
OPC
Blends
(FA or Slag)
Clay
Brick &
Tiles
Plastics
PP, PE, PC,
PVC, Nylon...
Glass
(virgin, recycled, fiberglass)
Concrete
Reinforced concrete
Lo/hi strength
Aluminium
Virgin, Recycl.,
Average
Timber (biomass neutral)
General
Particle board
Plywood
Gypsum
(and plasterboard)
Precast
Concrete
Concrete blocks
Asphalt
HMA @ 4, 6 and 8%
bitumen
Bitumen
(lo/hi values)

Cement Production
-where emissions come from



Concrete vs. Cement
Understanding how concrete contributes to CO_2 emissions

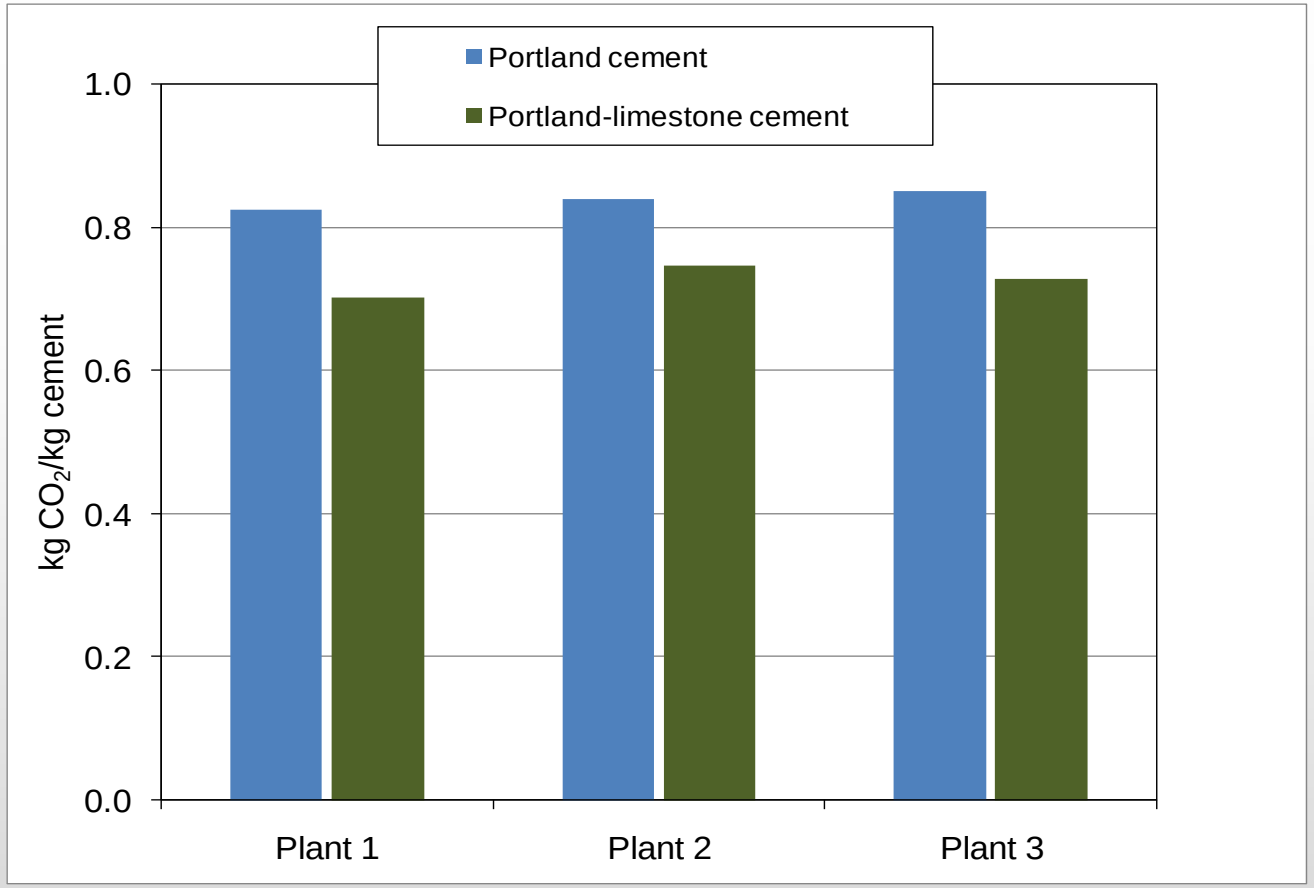
- Concrete in the most basic form is made from cement, aggregates, & water. It may also include reinforcing steel, admixtures and other products.
- Embodied CO_2 of concrete considers contributions from all constituent parts.
  - Energy
  - Production from raw materials (including cement, reinforcing steel)
  - Transport
- Much of the CO_2 is associated with the production of the cement.

Environmental Benefits

Some CO_2 Facts

- Each ton of clinker results in an unavoidable release of ~1200 pounds (~525 kg) of CO_2 due to calcination.

- This is about 60% of the total CO_2 emissions associated with cement manufacturing and occur regardless of the fuels used to support the kiln process (~1 ton CO_2 per ton of clinker)



How did CO_2 became a consideration?

- In most projects, CO_2 is not a factor in product choice.
  - CO_2 becomes important when Green Initiatives are included in project requirements. The majority of concrete placed does not need to meet these requirements.
  - Customers are more aware of these initiatives now, so the use of PLC can provide a marketing benefit
  - Since PLC is an equivalent product, it can provide these environmental benefits even when not “required.” PLC can exhibit some performance benefits that make it a preferable product to Type I/II (e.g. higher early strength can allow for expedited building schedules).
- How do I know if CO_2 is included in my Project Requirements?
  - There are a number of organizations that accredit projects and require consideration.
  - One of the more common ones is the USGBC LEED (U.S. Green Building Council, Leadership in Energy and Environmental Design), but there are others.

Transparency in Green Building

LIVING
BUILDING
CHALLENGE

BREEAM®

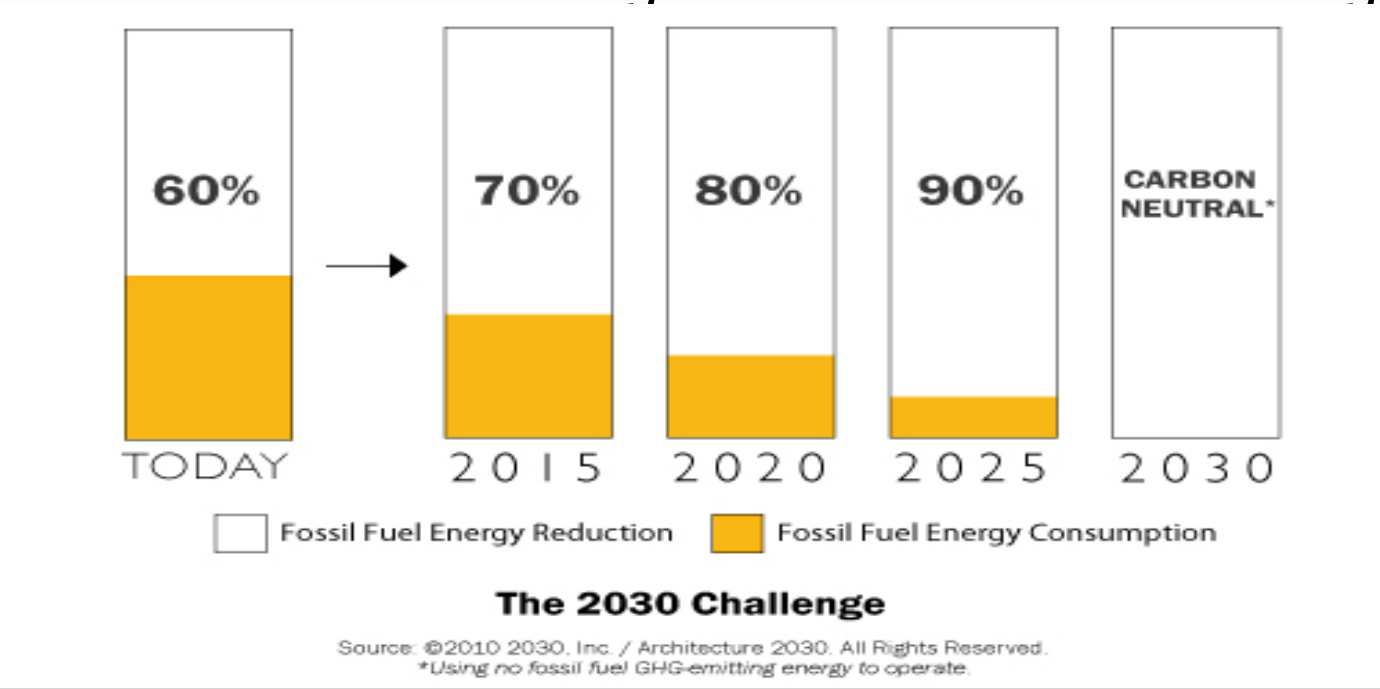
The Green Movement Players

Corporate & Investors
GSA
EPA
DOE
HUD
State Governments
Reglious Insitutions

Environmental Initiatives

Market Drivers Architecture 2030 and City 2030 districts

- New bldgs., developments and major renovations designed to meet a fossil fuel, GHG-emitting, energy consumption performance standard of 60% below average/median for that building type.



Transparency Loop

REPORTING
ENABLES
EVALUATION

EVALUATION
ENABLES
PREFERENTIAL
SELECTION

PREFERENTIAL
SELECTION
GUIDES
INNOVATION

INNOVATION
NECESSITATES
REPORTING

EPDs

EPDs are like food labels

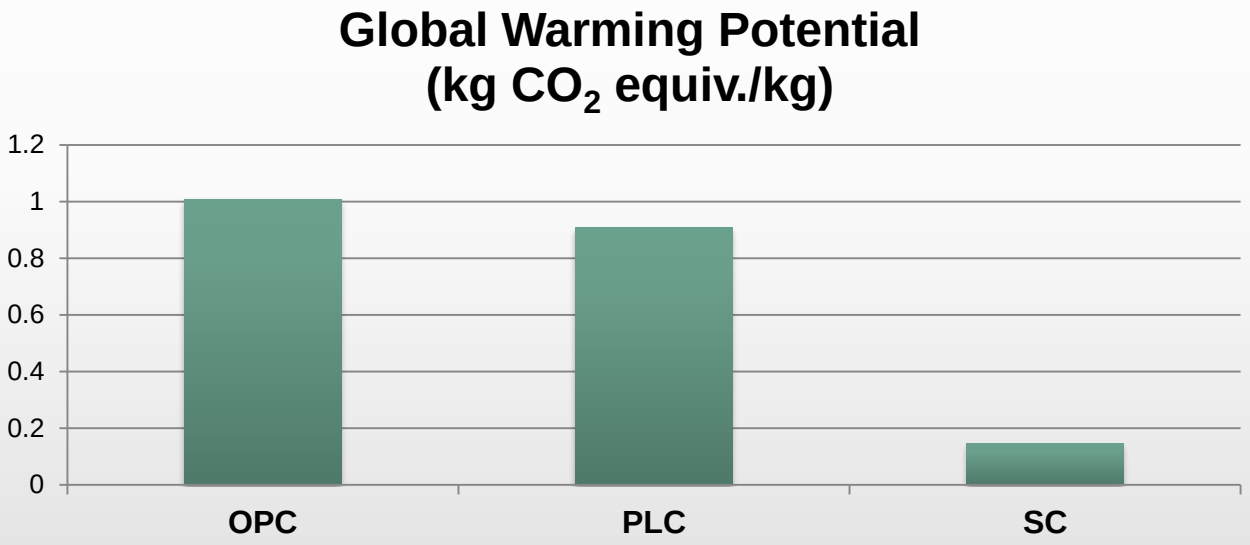
- Comparable to nutrition labels on food products
  - Credible
  - Consistently formatted
  - Third-party verified
- Enable designers to accurately compare similar materials
- Model those impacts on building products
- Like food labels, the presence of an EPD does not mean the product is “healthy”
- EPDs for PLC are available and treated the same as for Type I/II

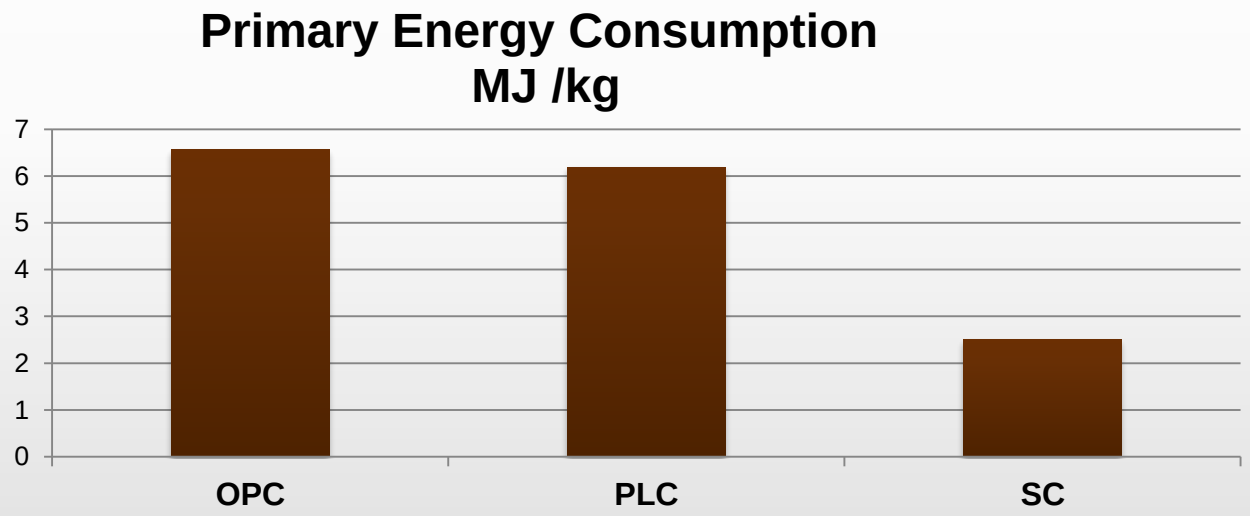
LCAs and CO_2?

- LEED and other programs can invoke Life Cycle Assessments (LCAs). When an LCA is considered the benefits of PLC become apparent.
  - Not all LEED projects will include a LCA
  - More common when higher levels of accreditation are pursued
  - When such requirements are present you will likely be dealing with a LEED advisor to coordinate the gathering of appropriate information

Life Cycle Assessment (LCA) Results

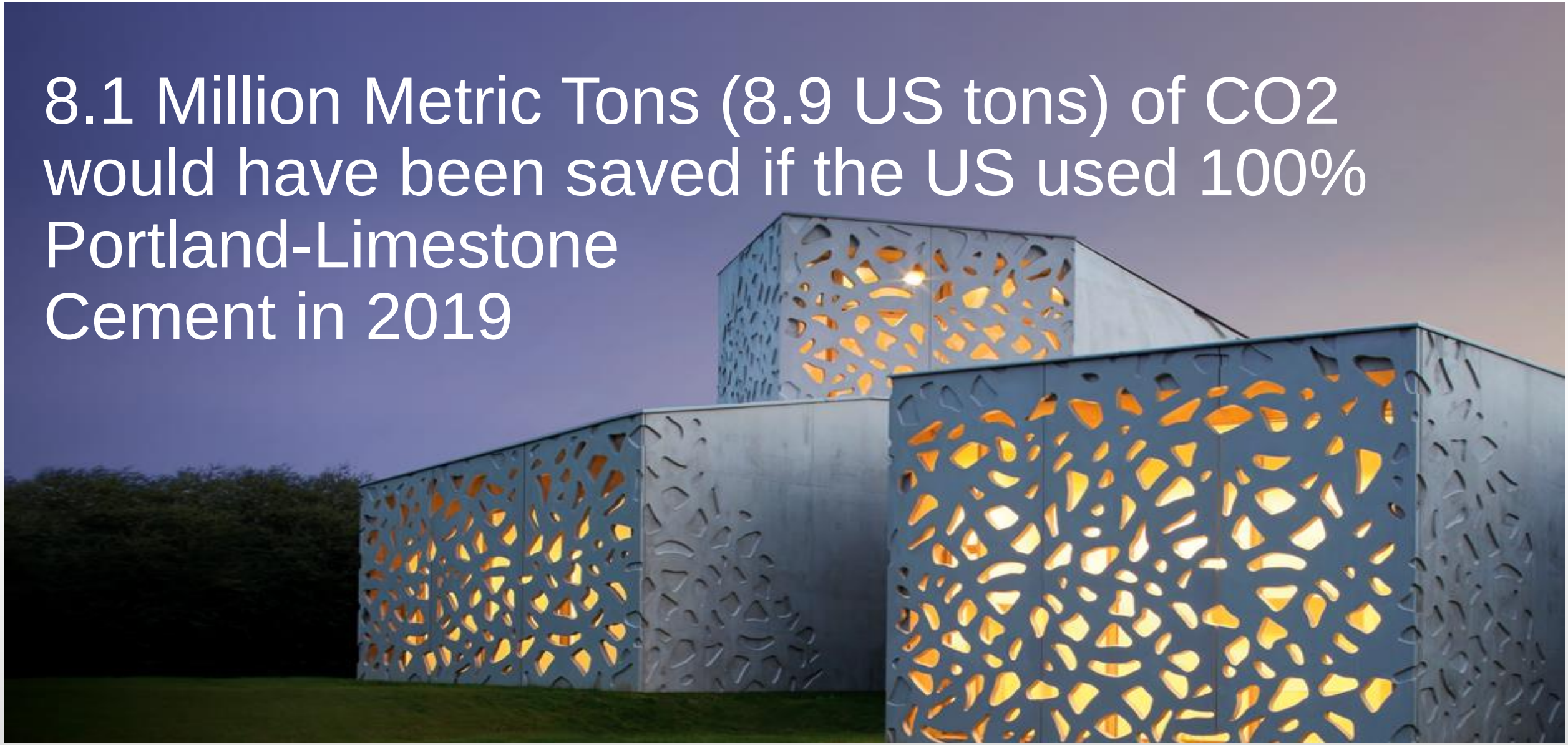
Ordinary Portland Cement, Portland Limestone Cement & Slag





OPC – 92% clinker, 3% limestone, 5% gypsum
PLC – 82% clinker, 13% limestone, 5% gypsum

8.1 Million Metric Tons (8.9 US tons) of CO_2 would have been saved if the US used 100% Portland-Limestone Cement in 2019



Statement taken from greenercement.com (PCA); Image from Cement Association of Canada contempora promotion

Source: greenercement.com, which provides a link to the USEPA Greenhouse equivalence calculator
Photo taken from Cement Association of Canada contempra promotion

Type IL Usage in Illinois

- Illinois Tollway – Composite Jointed Plain Concrete Pavement
  - Westbound lanes of I-90 (milepost 24.9 - 45.5), completed in 2014
  - Specification allows for PLC meeting AASHTO M240
  - Roughly 70,000 cubic yards of PLC concrete
  - Results – PLC concrete pavement had similar performance to regular PCC with no issues during construction
  - PLC performance met or exceeded tollway expectations; PLC remains an alternative option to regular PCC in all Tollway mixes
  - https://www.slagcement.org/casestudies/id/20/illinois-tollway-i-90.aspx
- Note there is ample information on PLC from academia and other areas (Canada, Europe, etc. with more widespread use)

Can I play a role in embracing PLC?

- **Developers:** Tell the engineering firm you hired you want to use concrete in the parking lot or in the building that has some type of CO2 reducing technology such as Portland Limestone Cement

- **Engineers:** Educate the clients you work for on the Technologies available to reduce the amount of CO2 associated with Concrete in their floors and parking lots and ask them if they want you to alter the specification to allow these technologies such as Portland Limestone Cement

How do I find PLC in my Market?

- Talk to your concrete or cement supplier about availability.
- Most producers can supply PLC though availability can be affected by aspects of the supply chain.
- The following IRMCA member companies can provide more information regarding products in your market area
  - Buzzi Unicem USA
  - CEMEX
  - Continental Cement
  - Illinois Cement
  - Kosmos Cement Company
  - LafargeHolcim
  - Lehigh Cement
  - St. Marys Cement

CONCLUSIONS

- Type IL reduces the embodied carbon by ~10%
- Type IL cement is an engineered product that provides equivalent performance to the more common Type I/II cement
  - Type IL can be used in place of Type I/II, requiring only minor admix adjustments
  - Type IL can be used with SCMs and other technologies in the same way as Type I/II
  - Type IL may have favorable benefits (e.g. higher early strength)
- Hopefully the information presented today has demonstrated that Type IL is a preferable product choice for concrete projects, even if embodied carbon is not a driving factor