Sustainable Precast Concrete
LEED
Thermal Mass

John R. Fowler, P.Eng.
President
Canadian Precast/Prestressed Concrete Institute
Learning Objectives:

- Describe basic concepts related to energy conservation and condensation control (mold / mildew)
- Discuss LEED and other rating systems
- Discuss the benefits of passive and active thermal mass
- Explain the insulating properties of precast concrete sandwich panels
Cladding units include solid wall panels, window wall units, spandrels, mullions, and column covers.

- A panel’s largest dimension may be vertical or horizontal. Panels may generally be removed from the wall individually without affecting the stability of other units or the structure itself.

- Precast cladding panels can be made in a wide range of shapes and sizes.
LCA estimates the full range of environmental burdens such as embodied energy use and related fossil fuel depletion, other resource use, greenhouse gas emissions, and toxic releases to air, water and land.

LCA includes the following:

- resource extraction;
- manufacturing and transportation of materials and prefabricated components;
- on-site construction;
- building operations, including energy consumption and maintenance;
- end-of-life reuse, recycling or disposal.

_Athena Institute’s ATHENA™ Environmental Impact Estimator computer modelling tool can perform a full life cycle analysis at the whole building level (www.athenaSMI.ca)._
Energy Use:

- Canadians spend 90% of their time inside
- More than 1/3 of the total energy in Canada is used to heat, cool, and operate buildings
- Natural Resources Canada’s Commercial Building Incentive Program (CHIP)
- ASHRAE/IESNA Standard 90.1
## Energy Conservation

<table>
<thead>
<tr>
<th>Material Surface</th>
<th>Solar Reflectance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black acrylic paint</td>
<td>0.05</td>
</tr>
<tr>
<td>New asphalt</td>
<td>0.05</td>
</tr>
<tr>
<td>Black rubber or bitumen roof material</td>
<td>0.06</td>
</tr>
<tr>
<td>Aged asphalt</td>
<td>0.1</td>
</tr>
<tr>
<td>“White” asphalt shingle</td>
<td>0.2</td>
</tr>
<tr>
<td>Aged concrete</td>
<td>0.2 to 0.3</td>
</tr>
<tr>
<td>New concrete (traditional)</td>
<td>0.4 to 0.5</td>
</tr>
<tr>
<td>New concrete with white portland cement</td>
<td>0.7 to 0.8</td>
</tr>
<tr>
<td>Aged average white membrane roof</td>
<td>0.77</td>
</tr>
<tr>
<td>White acrylic paint</td>
<td>0.8</td>
</tr>
<tr>
<td>Average white membrane roof</td>
<td>0.82</td>
</tr>
</tbody>
</table>

- **Low albedo**
- **High albedo**
Woodlawn Elementary School, Woodlawn, Ohio
Architect: DNK Architects
Why is R-value important?

- Payback for client
- In some climates, increasing wall R-values by as little as 5 points can reduce energy use by 30%
- Minimum code requirements, ASHRAE 90.1
- Affects HVAC equipment sizing
- Moisture management
- Health of building
- Sustainable program: LEED

Don’t architects know this? Precasters can supply whatever R value required.
What is “Green” Design?

Design and construction practices that **significantly reduce or eliminate the negative impact of buildings on the environment and occupants**. Sustainable design applies **good design practices** and **good business principles** in addition to **preserving the natural environment**.

Sustainable development requires a **long-term vision** of industrial progress, preserving the foundations upon which quality of life depends: **respect for basic human needs and local and global ecosystems**.
### RATINGS

<table>
<thead>
<tr>
<th></th>
<th>70 Possible Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certified</td>
<td>26 - 32</td>
</tr>
<tr>
<td>Silver</td>
<td>33 – 38</td>
</tr>
<tr>
<td>Gold</td>
<td>39 – 51</td>
</tr>
<tr>
<td>Platinum</td>
<td>51 – 70</td>
</tr>
</tbody>
</table>

No construction material or product can guarantee LEED Certification of your project.

*Precast concrete solutions can contribute to the achievement of up to 23 out of 70 points, leading toward a desired level of certification.*
Insulation placed between two wythes of concrete adds energy efficiency to a precast architectural wall panel's natural benefit of high thermal mass.
Precast sandwich panels can help achieve the LEED certification in a variety of ways:

- These included their ability to be recycled, local manufacturing capability, thermal mass and insulating core.
- All of these attributes help reduce the expended energy needed to manufacture, transport and erect materials, which are key LEED requirements.

_Brampton Civic Hospital_
Brampton, ON
Project architect: Adamson and Associates
Despite vast empirical evidence, modern understanding about thermal mass has taken some time to evolve," says a report from the Environmental Council of Concrete Organizations (ECCO).

Few studies focused on the benefits provided by thermal mass prior to the oil crisis in the early 1970s. Then prescriptive relief was addressed with readily available corrective measures, focusing on insulation with minimum R values, the report says. **But R values neglect thermal-mass characteristics, leading them to be understated.**
Recent studies, including one by the U.S. Department of Energy (DOE), have demonstrated the true benefit of thermal mass, ECCO says. The DOE report indicated that mass in exterior walls reduces annual energy costs in the building.

The U.S. Department of Housing & Urban Development (HUD) and the National Institute of Standards & Technology (NIST) also have done studies, ECCO reports. Thermal mass also helps shift peak loads from mid-afternoon in the summer to after 5 PM, when loads are reduced.
Modeling and testing have proven that the combination of insulation with thermal mass forms a superior wall system exhibiting the benefits of both, according to ECCO.

The most benefit comes from placing the insulation inside the thermal mass, as in insulated sandwich wall panels.

The other commonly used approach of adding insulation to the interior wall, isolates the wall from direct contact with the interior, reducing the benefits of the wall's thermal mass.
The **guiding principle** for all thermal-mass standards has been **performance**, whether of the individual components or the overall building envelope, says the ECCO report.

These standards have successfully translated the behavior of thermal mass into understandable and easy-to-use terms. The result is that **thermal mass has become a feasible element of building design**.

With precast's ability to help in meeting LEED standards, the **benefits of thermal mass will become more apparent to designers in the future**.
From an operating energy perspective, the thermal inertia of heavy materials is well known, both in warm and cold climates.
The thermal inertia of heavy materials is well known, both in warm and cold climates.

- When used correctly, thermal mass located in a building can significantly reduce the requirement for active heating and cooling systems and the consumption of energy.
- **Thermal mass should not be confused with insulation.** Materials used for insulation typically have much lower thermal conductivity than materials used for thermal mass and generally do not have a high capacity to store heat.
- **Insulating materials can reduce unwanted heat transfer but are not significant sources of heat in themselves.**

Ideally a combination of good insulation and thermal mass can be used to achieve an optimum solution.
Buildings with high thermal mass can be **passive**, where concrete materials are used in the exterior envelope, interior walls, frame and floor and roof slabs.

Insulated precast concrete sandwich wall panels with the **interior wythe left exposed** in the finished building are ideal to allow heat to be absorbed and released, reducing energy consumption year round.

*Brampton Civic Hospital*
Brampton, ON
*Project architect: Adamson and Associates*
fib data (Europe)

- Systems have been developed to use active thermal mass in precast structures.
- Air is circulated in the voids of hollow core floor and roof slabs.
- This reduces the size of the required mechanical system and creates energy savings both for heating in the winter as well as cooling in the summer.
- For heating, energy savings in the order of 35% can be achieved with this system.
- A reduction in cooling power consumption can be about 40%.
- Savings in Canada/US can be up to 50%±
Termobuild (www.termobuild.ca) is an integrated building design method that uses the thermal mass of the concrete in hollow core slabs and topping slabs. The bulky mechanical equipment used in conventional buildings, can usually be reduced by half.
Termobuild designs buildings constructed using hollow core slabs that consume significantly less energy.

Designs are based on the interactive relationship between the outdoor environment and the energy being stored internally through the hollow core slabs.

Surplus energy is stored to heat and cool a building, naturally.
• The **heat storage capacity** of hollow core slabs varies during spring, summer, fall and winter conditions.

• **Surplus heat**, generated from body heat, lighting, computers, sun radiation, etc, can be stored in the hollow core slabs increasing their temperature by 2-3°C during the day without affecting the comfort of the occupants.
This method provides added benefits:
- Improved ventilation and indoor air quality
- Healthier environment by constantly importing fresh, clean air into a building, and exhausting old, stale air
- **Summer**: excess heat is dissipated by lowering the slab temperature with cool night air.
- **Winter**: heat is stored in the hollow core slabs overnight and is used to maintain comfortable internal conditions for the occupants during the day.
Active Thermal Mass

- **Termobuild installations:** [www.termobuild.ca](http://www.termobuild.ca)
- HAWTHORNE VILLAGE PUBLIC SCHOOL, Milton, ON
- CENTRE for MANUFACTURING and DESIGN TECHNOLOGIES - Sheridan College – Brampton, ON
- FIRE & EMERGENCY SERVICES TRAINING INSTITUTE (FESTI) - Greater Toronto Airport Authority, Mississauga, ON
- NIAGARA HEALTH and BIOSCIENCE RESEARCH CENTRE - Brock University, St. Catharines, ON,
- NEW BUILDING ‘B’ - Humber College, Toronto, ON,
• Moisture control
• Rain penetration control
  • PER designs
• Vapour diffusion control
• Condensation control
• Ventilation
• Joint design

Reference:
“Architectural Precast Concrete Walls and Structure”
Published by CMHC: [www.cmhc.ca](http://www.cmhc.ca)
The RSI-value is a measure of the thermal resistance of a building component or assembly in a direction normal to the surface.

For an assembly, this resistance is the sum of the resistances of each layer, including air gaps when they are present, and air films contiguous to each outer surface.

Example: Calculation of RSI-Value

<table>
<thead>
<tr>
<th>Component (layer)</th>
<th>R-value (m²K/W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface air film (exterior)</td>
<td>0.030</td>
</tr>
<tr>
<td>75 mm normal density concrete</td>
<td>0.039</td>
</tr>
<tr>
<td>50 mm rigid polystyrene insulation type 1</td>
<td>1.285</td>
</tr>
<tr>
<td>150 mm normal density concrete</td>
<td>0.078</td>
</tr>
<tr>
<td>12 mm (non-vented) air space</td>
<td>0.160</td>
</tr>
<tr>
<td>10 mm gypsum board</td>
<td>0.062</td>
</tr>
<tr>
<td>Surface air film (interior)</td>
<td>0.120</td>
</tr>
<tr>
<td><strong>Total RSI-value</strong></td>
<td><strong>1.774</strong></td>
</tr>
</tbody>
</table>
The temperature gradient through a roof or wall assembly can be used to determine problems with condensation or differential thermal movement.

Temperature gradient alone is not sufficient to accurately locate the *dew point* (condensation point) within the assembly - an approximation of its location can be made - useful in estimating where condensation can occur from exfiltrating air.

Fig. 6.1.3 lists dew-point temperatures for various relative humidities and indoor temperatures. Use once a thermal gradient is determined.
832 Folsom Street
San Francisco, California
Architect: Patri-Merker Architects
formerly Whisler-Patri
Fire Testing
Standard time temperature curve
Fire Resistance

Fire endurance (heat transmission) of concrete slabs or wall panels

NBCC 2005
Appendix D gives equivalent thickness of concrete and minimum cover to prestressed and non-prestressed reinforcement.
Fire Separation (Safing) Installation

- Sealant
- Safing Insulation
- Continuous Plates
- Metal Plate Attached to Wall
- 1 1/2" to 8" Maximum
- Wall Panel
Thermally Unrestrained Elements
Elements where expansion can occur without restriction when exposed to fire from below.

Thermally Restrained Elements
Elements contained in the interior portion of a building where thermal expansion from a fire below will be resisted by compressive forces exerted by the unheated structure surrounding the heated area. *This thrust is generally great enough to increase the fire endurance significantly.*
**Sound transmission loss, (dB)**
Transmission loss (TL) is a measure of the ratio of the energy striking a wall or floor relative to the energy that is transmitted through it. The greater the sound insulation provided by a partition, the higher its TL.

**Sound Transmission Class (STC)**
Detailed TL data is replaced by a single-number rating known as the sound transmission class.

**Impact Sound Transmission (IIC)**
Laboratory and field test methods give single number ratings for the transmission of impact sound through floors with the resulting data fitted to a reference contour to obtain a single number rating - impact insulation class (IIC). The higher the IIC rating, the greater the impact noise insulation provided by the construction.
Airborne and Impact Sound Resistance

**Fig. 6.2.6** Airborne sound transmission loss (STC) and impact insulation class (IIC) ratings from tests of precast concrete assemblies. [37]

<table>
<thead>
<tr>
<th>Assembly No.</th>
<th>Description</th>
<th>STC</th>
<th>IIC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wall Systems</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>100 mm flat panel, 240 kg/m²</td>
<td>49</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>150 mm flat panel, 360 kg/m²</td>
<td>55</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>Assembly 2 with &quot;Z&quot; furring channel, 26 mm insulation and 12 mm gypsum board, 390 kg/m²</td>
<td>62</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>Assembly 2 with wood furring, 12 mm insulation and 12 mm gypsum board, 390 kg/m²</td>
<td>63</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>Assembly 2 with 12 mm space, 40 mm metal stud row, 75 mm insulation and 12 mm gypsum board</td>
<td>63(1)</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>200 mm flat panel, 480 kg/m²</td>
<td>58</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>355 mm prestressed tees with 100 mm flange, 360 kg/m²</td>
<td>54</td>
<td>-</td>
</tr>
<tr>
<td><strong>Floor-Ceiling Systems</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>203 mm hollow core prestressed units, 280 kg/m²</td>
<td>50</td>
<td>28</td>
</tr>
<tr>
<td>9</td>
<td>Assembly 8 with carpet and pad, 285 kg/m²</td>
<td>50</td>
<td>73</td>
</tr>
<tr>
<td>10</td>
<td>203 mm hollow core prestressed units with 12 mm wood block flooring adhered directly, 290 kg/m²</td>
<td>51</td>
<td>47</td>
</tr>
<tr>
<td>11</td>
<td>Assembly 10 except 12 mm wood block flooring adhered to 12 mm sound-deadening board underlayment adhered to concrete, 300 kg/m²</td>
<td>52</td>
<td>55</td>
</tr>
<tr>
<td>12</td>
<td>Assembly 11 with acoustical ceiling, 305 kg/m²</td>
<td>59</td>
<td>61</td>
</tr>
<tr>
<td>13</td>
<td>Assembly 8 with quarry tile, 20 mm reinforced mortar bed with 10 mm nylon and carbon black spinorette matting, 400 kg/m²</td>
<td>60</td>
<td>54</td>
</tr>
<tr>
<td>14</td>
<td>Assembly 13 with suspended 16 mm gypsum board ceiling with 90 mm insulation, 435 kg/m²</td>
<td>61</td>
<td>62</td>
</tr>
<tr>
<td>15</td>
<td>355 mm prestressed tees with 50 mm concrete topping, 365 kg/m²</td>
<td>54</td>
<td>24</td>
</tr>
<tr>
<td>16</td>
<td>Assembly 15 with carpet and pad, 370 kg/m²</td>
<td>54</td>
<td>72</td>
</tr>
<tr>
<td>17</td>
<td>Assembly 15 with resiliently suspended acoustical ceiling with 40 mm mineral fiber blanket above, 375 kg/m²</td>
<td>59</td>
<td>51</td>
</tr>
<tr>
<td>18</td>
<td>Assembly 17 with carpet and pad, 380 kg/m²</td>
<td>59</td>
<td>82</td>
</tr>
<tr>
<td>19</td>
<td>100 mm flat slabs, 240 kg/m²</td>
<td>49</td>
<td>25</td>
</tr>
<tr>
<td>20</td>
<td>130 mm flat slabs, 310 kg/m²</td>
<td>52</td>
<td>24</td>
</tr>
<tr>
<td>21</td>
<td>130 mm flat slab concrete with carpet and pad, 315 kg/m²</td>
<td>52(1)</td>
<td>68</td>
</tr>
<tr>
<td>22</td>
<td>150 mm flat slabs, 360 kg/m²</td>
<td>52(1)</td>
<td>34</td>
</tr>
<tr>
<td>23</td>
<td>200 mm flat slabs, 480 kg/m²</td>
<td>55</td>
<td>34(1)</td>
</tr>
<tr>
<td>24</td>
<td>250 mm flat slabs, 600 kg/m²</td>
<td>58</td>
<td>31</td>
</tr>
<tr>
<td>25</td>
<td>250 mm flat slab concrete with carpet and pad, 605 kg/m²</td>
<td>50(1)</td>
<td>74</td>
</tr>
</tbody>
</table>

(1) Estimated values.
Leaks and Flanking

- All noise that reaches a space by paths other than through the primary barrier is called flanking noise.
- Common flanking paths are openings around doors or windows, electrical outlets, telephone and television connections, and pipe and duct penetrations.
- Suspended ceilings in rooms where walls do not extend from the ceiling to the roof or floor above also allow sound to travel to adjacent rooms by flanking.

Performance of a building section with an otherwise adequate STC can be seriously reduced by a relatively small hole (or any other path) that allows sound to bypass the acoustical barrier.

![Diagram of a building section with STC ratings.](image)

<table>
<thead>
<tr>
<th>Combined Transmission Loss</th>
<th>No closure</th>
<th>With steel bent plate closure</th>
<th>With 4 in. thick sainging insulation and steel bent plate added</th>
<th>With 6 in. thick sainging insulation and steel bent plate added</th>
</tr>
</thead>
<tbody>
<tr>
<td>STC</td>
<td>14</td>
<td>28</td>
<td>30</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Blast Resistance

Protection for a commercial building, which comes in active and passive forms, will impact the potential damage sustained by the building and the rescue efforts of the emergency workers.

- The primary approach is to create a **standoff distance** that ensures a minimum guaranteed distance between the blast source and the target structure.
- The **standoff distance** is vital in the design of blast-resistant structures since it is the key parameter that determines, for a given bomb size or charge weight, the blast overpressures that load the building cladding and its structural elements.
Aerobics, dancing and other rhythmic human activities are sources of annoying vibration in buildings.

Main Factors:

**Resonance** – occurs when the natural frequency of the floor structure is equal to or close to a forcing frequency of rhythmic activity.

**Presence of other occupancies in a building**, such as offices or residences, where people are sensitive to the vibrations generated by others.
CPCI Design Manual Examples

6.10  Hollow core floor – walking vibration

6.11  Stadium seats on stiff supports – lively concert/sports event

6.12  Vibration isolation
Integrating mechanical systems in precast concrete structures
Lighting and air duct system in double tee construction

Openings through floor and roof slabs
Methods of attaching ceilings, crane rails and other loads
Your local CPCI producers can assist with:

- Sizes, thicknesses, shapes, connections and building envelope considerations for architectural precast concrete applications.
- Framing concepts, systems, layout and connection types to ensure the entire structure will function and be economical for structural precast concrete applications.
• Your local CPCI Ontario producers:
  
  • **ARTEX SYSTEMS INC.**
    Tel: (905) 669-1425 Fax: (905) 669-1572
    523 Bowes Road, Concord, Ontario L4K 1B2
  
  • **CENTRAL PRECAST INC.**
    Tel: (613) 225-9510 Fax: (613) 225-5318
    23 Bongard Avenue, Nepean, Ontario K2E 6V2
  
  • **CORESLAB STRUCTURES (ONT) INC.**
    Tel: (905) 689-3993 Fax: (905) 689-0708
    91 Highway #5 West, Dundas, Ontario L9H 7L6
  
  • **WESTERN ONTARIO PRECAST INC.**
    Tel: (519) 366-2253 Fax: (519) 366-2312
    R. R. #1, Chepstow, Ontario NoG 1K0
• Your local CPCI Ontario producers:

  • **GRANITE PRESTRESSED CONCRETE LIMITED**
    Tel: (705) 566-1740 Fax: (705) 566-4813
    2477 Maley Drive, Sudbury, Ontario P3A 4R7

  • **HANSON PIPE & PRECAST, LTD.**
    Tel: (905) 640-5151 Fax: (905) 640-5154
    5387 Bethesda Road, Stouffville, Ontario L4A 7X3

  • **PRE-CON INC.**
    Tel: (905) 457-4140 Fax: (905) 457-5323
    35 Rutherford Road S, Brampton, Ontario L6W 3J4

  • **PRE-CON INC.**
    Tel: (519) 537-6288 Fax: (519) 537-7741
    1100 Dundas Street, Woodstock, Ontario N4S 7V9
Your local CPCI Ontario producers:

- **PRESTRESSED SYSTEMS INCORPORATED**
  Tel: (519) 737-1216 Fax: (519) 737-6464
  P.O. Box 517, Windsor, Ontario N9A 6M6

- **RES PRECAST INC.**
  Tel: (705) 436-7383 Fax: (705) 436-7386
  3450 Thomas Street, Innisfil, Ontario L9S 3W6

- **TRI-KRETE LIMITED**
  Tel: (416) 746-2479 Fax: (416) 746-6218
  152 Toryork Drive, Weston, Ontario M9L 1X6

Thank You

www.cpci.ca
www.precastcertification.ca
www.sustainableprecast.ca
T: 1-877-937-2724