NET-ZERO IN EDMONTON

On Time and on Budget with Lean Integrated Project Delivery
Mosaic Centre

IPD Basics

Lean in Design and Sustainable Design

Co-Location
WHAT IS THE MOSAIC CENTRE FOR CONSCIOUS COMMUNITY & COMMERCE?
• $335 / sq ft
• 30,000 square feet
• Design Time: 10 months
• Construction Schedule: 11 months
• LEED Platinum Target
• Living Building Challenge target
A community with a shared vision that you can do GOOD while doing WELL, a community of businesses enabling positive social change through business.
VALUES OF THE PROJECT

• Sustainability
• Health
• Beauty
• Pragmatic
• Teamwork
• Education
<table>
<thead>
<tr>
<th>Glazing Design #</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
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</thead>
<tbody>
<tr>
<td>Envelope Level</td>
<td>R10/R30/R50</td>
<td>R20/R40/R60</td>
<td>R30/R50/R70</td>
<td>R10/R30/R50</td>
<td>R10/R30/R50</td>
<td>R30/R50/R70</td>
<td>R30/R50/R70</td>
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<tr>
<td>Heating Load [kW]</td>
<td>277 kW</td>
<td>274 kW</td>
<td>272 kW</td>
<td>268 kW</td>
<td>268 kW</td>
<td>263 kW</td>
<td>250 kW</td>
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<tr>
<td>Cooling Load [kW]</td>
<td>119 kW</td>
<td>117 kW</td>
<td>116 kW</td>
<td>110 kW</td>
<td>110 kW</td>
<td>108 kW</td>
<td>109 kW</td>
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<tr>
<td>Heat Demand [kWh/a]</td>
<td>84455 kWh</td>
<td>77381 kWh</td>
<td>72345 kWh</td>
<td>77733 kWh</td>
<td>77733 kWh</td>
<td>65620 kWh</td>
<td>48505 kWh</td>
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<tr>
<td>Cool Demand [kWh/a]</td>
<td>20180 kWh</td>
<td>20593 kWh</td>
<td>21060 kWh</td>
<td>18801 kWh</td>
<td>18801 kWh</td>
<td>19670 kWh</td>
<td>22299 kWh</td>
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<td>Lighting Demand [kWh/a]</td>
<td>27532 kWh</td>
<td>27532 kWh</td>
<td>27532 kWh</td>
<td>27532 kWh</td>
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<tr>
<td>Equipment Demand [kWh/a]</td>
<td>151340 kWh</td>
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<td>151340 kWh</td>
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<tr>
<td>Total Demand [kWh/a]</td>
<td>283507 kWh</td>
<td>276846 kWh</td>
<td>272277 kWh</td>
<td>275405 kWh</td>
<td>275405 kWh</td>
<td>264162 kWh</td>
<td>249676 kWh</td>
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<tr>
<td>Heat Intensity [kWh/m2a]</td>
<td>30.8 kWh/m2a</td>
<td>28.2 kWh/m2a</td>
<td>26.4 kWh/m2a</td>
<td>28.3 kWh/m2a</td>
<td>28.3 kWh/m2a</td>
<td>23.9 kWh/m2a</td>
<td>17.7 kWh/m2a</td>
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<tr>
<td>Cool Intensity [kWh/m2a]</td>
<td>7.4 kWh/m2a</td>
<td>7.5 kWh/m2a</td>
<td>7.7 kWh/m2a</td>
<td>6.9 kWh/m2a</td>
<td>6.9 kWh/m2a</td>
<td>7.2 kWh/m2a</td>
<td>8.1 kWh/m2a</td>
</tr>
<tr>
<td>Site Intensity [kWh/m2a]</td>
<td>103.3 kWh/m2a</td>
<td>100.9 kWh/m2a</td>
<td>99.2 kWh/m2a</td>
<td>100.4 kWh/m2a</td>
<td>100.4 kWh/m2a</td>
<td>96.3 kWh/m2a</td>
<td>91.0 kWh/m2a</td>
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<tr>
<td>Envelope Cost</td>
<td>$1,681,032</td>
<td>$1,849,882</td>
<td>$2,026,495</td>
<td>$2,138,812</td>
<td>$2,138,812</td>
<td>$2,484,274</td>
<td>$2,876,657</td>
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<tr>
<td>PV Size</td>
<td>303 kW</td>
<td>296 kW</td>
<td>291 kW</td>
<td>294 kW</td>
<td>294 kW</td>
<td>282 kW</td>
<td>267 kW</td>
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<tr>
<td>PV Cost</td>
<td>$1,210,575</td>
<td>$1,182,130</td>
<td>$1,162,623</td>
<td>$1,175,979</td>
<td>$1,175,979</td>
<td>$1,127,972</td>
<td>$1,066,117</td>
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</tbody>
</table>

Table 2: Summary of the comparative impact of improving envelope assembly performance on the Mosaic Center designed as per DP drawing. R-values are denoted as slab/wall/roof. Semi-transparent elements were included in the model, using the R18 Solera product.
GEOEXCHANGE

32 BORE HOLES, 230 FEET DEEP UNDER THE PARKING LOT

Reduced the amount of PV required by 40,000 Watts; a cost saving of over $80,000 with the geothermal system factored in.
213 KW DC (177KW AC)

https://www.youtube.com/watch?v=1iNVwRy7mk&t=5m10s
<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>INDUSTRY</th>
<th>MOSAIC</th>
<th>COMPARABLE X</th>
<th>TRADITIONAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUBSTRUCTURE</td>
<td>4.4%</td>
<td>3.6%</td>
<td>8.2%</td>
<td>10.9%</td>
</tr>
<tr>
<td>SUPERSTRUCTURE</td>
<td>17.3%</td>
<td>22.4%</td>
<td>24.7%</td>
<td>15.5%</td>
</tr>
<tr>
<td>EXTERIOR ENCLOSURES</td>
<td>15.9%</td>
<td>20.2%</td>
<td>20.6%</td>
<td>19.1%</td>
</tr>
<tr>
<td>ROOFING</td>
<td>1.6%</td>
<td>2.8%</td>
<td>4.9%</td>
<td>2.4%</td>
</tr>
<tr>
<td>INTERIORS</td>
<td>20.5%</td>
<td>20.1%</td>
<td>8.1%</td>
<td>20.2%</td>
</tr>
<tr>
<td>CONVEYING</td>
<td>4.3%</td>
<td>1.4%</td>
<td>1.5%</td>
<td>2.9%</td>
</tr>
<tr>
<td>MECHANICAL</td>
<td>19.1%</td>
<td>17.0%</td>
<td>15.9%</td>
<td>18.4%</td>
</tr>
<tr>
<td>ELECTRICAL</td>
<td>16.9%</td>
<td>12.4%</td>
<td>16.1%</td>
<td>10.6%</td>
</tr>
<tr>
<td>SUBTOTAL</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
<tr>
<td>GENERAL CONDITIONS, FEES, OVERHEADS, PROFITS</td>
<td>25.0%</td>
<td>24.3%</td>
<td>22.0%</td>
<td>22.5%</td>
</tr>
</tbody>
</table>
MOSAIC VS PROJECT X

- Without net zero, Mosaic Centre is 12% less expensive

- With net-zero, Mosaic Centre is 2% less expensive

- Construction complete in 11 months versus 15 months
collaboration is inevitable
collaboration
what is collaboration?
• Effective communication
• Common goals / shared vision
• Open-mindedness / flexibility
  • Active listening
  • Respect
  • Trust
• Teamwork
Google

- Safety
- Respect
- Trust
- Teamwork
IPD Basics
contractual principles

- Key Participants Bound Together as Equals
- Shared Financial Risk and Reward Based on Project Outcome
- Liability Waivers between Key Participants
- Fiscal Transparency between Key Participants
- Early Involvement of Key Participants
- Intensified Design
- Jointly Developed Project Target Criteria
- Collaborative Decision Making
behavioral principles

Mutual Respect and Trust
Willingness to Collaborate
Open Communication
catalysts for IPD

Multi Party Agreement
Building Information Modeling
Lean Design and Construction
KEY DIFFERENCES

Information
Structure
Target Value Design
Lean
Traditional design process

WHAT

HOW

REALIZE

WHO

<table>
<thead>
<tr>
<th>Predesign</th>
<th>Schematic Design</th>
<th>Design Development</th>
<th>Construction Documents</th>
<th>Agency Permit/Bidding</th>
<th>Construction</th>
<th>Closeout</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owner</td>
<td>Design Consultant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Designer</td>
<td></td>
<td>Design Consultant</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

Integrated design process

WHAT

HOW

REALIZE

WHO

Conceptualization  Criteria Design  Detailed Design  Implementation Documents

Agency  Owner  Designer  Design Consultants  Constructors  Trade Constructors  Agency Coord/Final Buyout  Construction  Closeout
‘The goal of a validation study is a go/no-go gate at the end providing the owner and the team with the right amount of information to make the best decision about the viability of a project with the least amount of money spent.

We want the maximum confidence regarding the price with a minimal investment.’

Markku Allison
Architect
# SAMPLE PROJECT COMPARISON

<table>
<thead>
<tr>
<th>LEAN IPD</th>
<th>Traditional</th>
</tr>
</thead>
<tbody>
<tr>
<td>$35M Project</td>
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</tr>
<tr>
<td>4 months to certainty (validated cost)</td>
<td>9 months to certainty (tender)</td>
</tr>
<tr>
<td>6 months to construction start</td>
<td>10 months to construction start</td>
</tr>
<tr>
<td>$500,000 to certainty</td>
<td>$1.8M to certainty</td>
</tr>
<tr>
<td>18 months to occupancy</td>
<td>32 months to occupancy</td>
</tr>
<tr>
<td>Profit defined and at risk</td>
<td>Profit hidden and fought for</td>
</tr>
<tr>
<td>Shared risk/reward</td>
<td>Risk avoided/blame others</td>
</tr>
<tr>
<td>Incentive to do a great project</td>
<td>Incentive to protect fee, do no more than required</td>
</tr>
<tr>
<td>No RFI's</td>
<td>Lots of RFI's</td>
</tr>
<tr>
<td>1 Change Order</td>
<td>Lots of Change Orders</td>
</tr>
</tbody>
</table>
## SAMPLE PROJECT COMPARISON

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</tbody>
</table>
team assembly
the deal
how costs work

$$\text{ 开销 }$$
how costs work

Electrical Engineer
Mechanical Engineer
Structural Engineer
Prime Consultant
Electrical Trade
Mechanical Trade
Drywall Trade
Curtain Wall Trade
Roofing Trade
Cladding Trade
Structural Steel Trade
Prime Contractor
how costs work

$$

- Electrical Engineer
- Mechanical Engineer
- Structural Engineer
- Prime Consultant
- Electrical Trade
- Mechanical Trade
- Drywall Trade
- Curtain Wall Trade
- Roofing Trade
- Cladding Trade
- Structural Steel Trade
- Prime Contractor

CHANDOS
how costs work

Direct Costs

Indirect Costs

Overhead

“Fluff”

Profit

Direct Costs
how costs work

Direct Costs

Indirect Costs

Overhead

“Fluff”

Profit


how costs work

Direct Costs

Indirect Costs

Overhead

Profit

“Fluff”

Direct Costs

CHANDOS
how costs work

$$
\begin{align*}
\text{Direct Costs} \\
\text{Indirect Costs} \\
\text{Overhead} \\
\text{Profit}
\end{align*}
$$
how costs work

$\text{costs} \quad \text{direct} \quad \text{indirect} \quad \text{overhead}$

$\text{profit}$
how costs work

 электроинженер
 механический инженер
 структурный инженер
 главный консультант
 электрический профession
 механический профession
 наружная обшивка
 структурная сталь
 главный подрядчик
how costs work

$$
\text{costs} \rightarrow \text{profit}
\begin{align*}
\text{direct} \\
\text{indirect} \\
\text{overhead}
\end{align*}

- Electrical Engineer
- Mechanical Engineer
- Structural Engineer
- Prime Consultant
- Electrical Trade
- Mechanical Trade
- Drywall Trade
- Curtain Wall Trade
- Roofing Trade
- Cladding Trade
- Structural Steel Trade
- Prime Contractor

CHANDOS
Target Cost: 11.0 M

- profit
- costs
actual = target
Actual Cost = Target Cost

11.0 M

Electrical Engineer
Mechanical Engineer
Structural Engineer
Prime Consultant
Electrical Trade
Mechanical Trade
Drywall Trade
Curtain Wall Trade
Roofing Trade
Cladding Trade
Structural Steel Trade
Prime Contractor

actual = target
Actual Cost 11.0 M
Target Cost
profit costs
profit costs

actual = target
Actual Cost = Target Cost

Actual = Target

11.0 M

Costs

Profit

Electrical Engineer
Mechanical Engineer
Structural Engineer
Prime Consultant
Electrical Trade
Mechanical Trade
Drywall Trade
Curtain Wall Trade
Roofing Trade
Cladding Trade
Structural Steel Trade
Prime Contractor

100%

less than 100%
Actual Cost 11.0 M
Target Cost

actual < target

profit costs
profit costs
profit costs
Actual Cost vs. Target Cost

actual < target

11.0 M

more than 100%

100%

Electrical Engineer
Mechanical Engineer
Structural Engineer
Prime Consultant
Electrical Trade
Mechanical Trade
Drywall Trade
Curtain Wall Trade
Roofing Trade
Cladding Trade
Structural Steel Trade
Prime Contractor
Actual Cost - Target Cost

Costs: 11.0 M, 10.5 M, 11.5 M

Profit: Actual > Target

CHANDOS
Actual Cost > Target Cost

Actual Cost: 11.0 M
Target Cost: 10.5 M

Electrical Engineer
Mechanical Engineer
Structural Engineer
Prime Consultant
Electrical Trade
Mechanical Trade
Drywall Trade
Curtain Wall Trade
Roofing Trade
Cladding Trade
Structural Steel Trade
Prime Contractor

100%
Actual Cost > Target Cost

Actual Cost: 11.0 M
Target Cost: 11.5 M

Costs:
- Electrical Engineer
- Mechanical Engineer
- Structural Engineer
- Prime Consultant
- Prime Contractor
- Electrical Trade
- Mechanical Trade
- Drywall Trade
- Curtain Wall Trade
- Roofing Trade
- Cladding Trade
- Structural Steel Trade

Profit:
- 0%
- 100%

actual > target
• The IPD Team is guaranteed their costs but their profit is at risk

• The owner gets the benefit of any savings, but risks paying costs if they exceed the profit pot
target value design

THREE NUMBERS

ALLOWABLE COST
What Owner Can Spend
Owner Business Case

EXPECTED COST
Team Consensus: This is Expected Market Cost
Comparable Buildings Program / Dialog / “Sliders” Collective Experience High Level Elemental Estimate

TARGET COST
Team Consensus: This is What We Believe We Can Do
TVD Process Validation Study
Target value design

- Allowable Cost
- Expected Cost
- Trade-off Decisions
- Get this gap as close as possible!
- Do we have a path to Target Cost?
- Is this line trending down consistently?
- Can we predict? Are we confident?
- Somewhere in here we commit

(from DPR Construction)
target value design
target value design
target value design
target value design
target value design
target value design
what’s different

ipd is about understanding the ramifications of design decisions at the time the decisions are made
what’s different

design to detailed estimate vs estimating detailed design
what’s different

make everything visual, explicit, transparent
go slow to go fast
LEAN

Provide customer value, through streamlined processes, practicing continuous improvement
What is Lean design?
cost effectiveness / performance to budget
efficiency
productivity (construction)
environmental (sustainable) impact
embodied energy
energy use
maintenance costs
improved enterprise outcomes
worker satisfaction
productivity (users)
health
fit to use
flexibility
ROI
context / community
beauty
cost effectiveness / performance to budget
efficiency (construction)
productivity (construction)
embodied energy
improved enterprise outcomes
ROI
energy use
environmental (sustainable) impact
maintenance costs
user satisfaction
productivity (users)
user health
fit to use
flexibility
context / community
beauty

cost effectiveness / performance to budget
efficiency (construction)
productivity (construction)
embodied energy

---

CHANDOS
improved enterprise outcomes
ROI
energy use
environmental (sustainable) impact
maintenance costs
user satisfaction
productivity (users)
user health
fit to use
flexibility
context / community
beauty

cost effectiveness / performance to budget
efficiency (construction)
productivity (construction)
embodied energy
Wood Structure
GEOEXCHANGE
ELECTRICAL DESIGN
lean design

= 

long term value for the owner
lean design
=
Sustainable design
Co-Location
<table>
<thead>
<tr>
<th>ITEM UNDER CONSIDERATION</th>
<th>INSULATING THE 2ND AND 3RD FLOOR SLABS</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOTES</td>
<td>HELPS WITH THE STC RATING OF THE FLOOR AIDS IN HIDING THE ELECTRICAL CONDUIT IN SLAB TO REMOVE IT FROM SIGHT</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DECISION MADE (+ ANY BACKUP)</th>
<th>The beauty is more important than the cost of $8000.00 to add insulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFFECT of DECISION</td>
<td>POS</td>
</tr>
<tr>
<td>SUSTAINABILITY</td>
<td></td>
</tr>
<tr>
<td>BEAUTY</td>
<td></td>
</tr>
<tr>
<td>HEALTH</td>
<td></td>
</tr>
<tr>
<td>PRAGMATIC</td>
<td></td>
</tr>
<tr>
<td>TEAMWORK</td>
<td></td>
</tr>
<tr>
<td>LEGACY</td>
<td></td>
</tr>
</tbody>
</table>
Lessons Learned
And
Evidence
culture
not
contracts
quality waste reduction problem solving
Why this is Good for Us

Increased productivity / Less time in documentation
Fewer RFI’s and conflicts
More informed decision making
Better project cost control / Improved budget management
Minimization of Waste
Better use of resources
Greater understanding and control over the construction process and long term project outcomes
IPD: Performance, Expectations, and Future Use
A Report On Outcomes of a University of Minnesota Survey

September 25th, 2015
Projects | Distribution

59 unique projects

outside North America

University of Minnesota
Driven to Discover™

CHANDOS
Projects | Breakdown

59 unique projects
- 48 in U.S.
- 9 in Canada
- 2 outside of North America

Project Types
- Education (K-12)
- Education (college/university)
- Health Care
- Cultural
- Recreational
- Office
- Industrial
- Mixed Use
- Government/Civic
- Single Family Residential
- Multi-Family Residential
- Utilities Power/Water/Sewer
- Other

Project Scopes
- Under $10M
- $10M to $25M
- $25M to $50M
- Over $50M

Project Status
- Design
- Construction
- Complete
Compared to your experience on non-IPD projects, rate your impression of the performance of this project in each of the categories below.

- Schedule predictability
- Cost and budget control
- Quality of building outcome (design goals)
- Quality of building outcome (technical performance goals)
- Changes (quantity)
- Changes (handling)
- Morale of stakeholders
- Overall value delivered

**Performance | All Responses**

- Significantly better
- Better
- Same
- Worse
- Significantly worse

**Survey Results**

- Schedule predictability: n = 106
- Cost and budget control: n = 106
- Quality of building outcome (design goals): n = 102
- Quality of building outcome (technical performance goals): n = 100
- Changes (quantity): n = 100
- Changes (handling): n = 100
- Morale of stakeholders: n = 107
- Overall value delivered: n = 105
Identify the likelihood for each of the following statements:

1. On a project of similar type and scope, the likelihood I would want to use IPD again
   - neutral
   - likely
   - significantly likely
   - n = 102

2. The likelihood of me wanting to use IPD in general on other projects
   - neutral
   - likely
   - significantly likely
   - n = 103

3. The likelihood of me recommending IPD as a delivery methodology to others
   - neutral
   - likely
   - significantly likely
   - n = 101
Can this be done on all projects?

or

Is this a fit for all projects?
Jen Hancock
jhancock@chandos.com

Brandy Burdeniuk
brandyb@ecoammo.com