BDP.
Quadrangle

Better Balconies

Low Carbon Now

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1.0 INTRODUCTION

This study has been prepared by BDP Quadrangle as a supplement to Low Carbon Now to examine residential balconies in multi-unit residential buildings through the lenses of thermal performance, embodied carbon, constructability, and cost, seeking to understand the interconnections.

Thank you to Multiplex, RWDI, Lukachko Climate Strategies, Sapphire Balconies, RES Precast, and Global Precast for their support in completing this research.

1.1 Summary

BDP Quadrangle has committed to designing all projects[1] to be net zero carbon ready[2] by 2030. As part of this commitment, we continue to explore ways to improve our performance through research. The majority of what is being built in the Toronto market continues to be multi-unit residential buildings and balconies remain an integral part of the design.

This study looks only at the technical aspects of balcony design in cast-in-place concrete buildings. If you wish to explore our thoughts on the qualitative aspects of balconies, refer to Outside In | BDP Quadrangle.

Given the combined challenges of housing availability, affordability, labour shortages and the climate emergency, we have measured the impacts of each design in terms of thermal performance, embodied carbon, constructability, and cost.

Balconies have a significant impact on the heat losses through the building envelope due to thermal bridging, increasing impacts on operational carbon and thermal comfort. Given that embodied carbon accounts for approximately 85% of our carbon emissions (Fig. 1) when we compress the timeline to 2030, all high performance alternatives must also be viewed through the lens of embodied carbon in addition to operational.

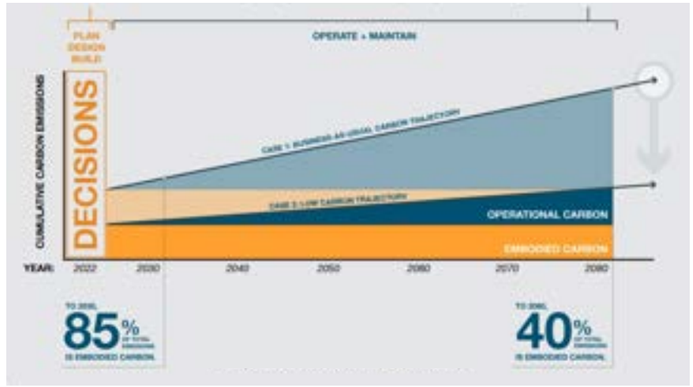


Fig. 1 Cumulative Carbon Emissions including both operational and embodied carbon over a sixty year service life.

The Toronto industry standard for balconies in high rise structures is to cast the balcony as part of the structural slab without providing a thermal break. This study starts with the typical cast-in-place balcony as the industry baseline and compares this to a couple of existing proprietary systems including a structural thermal-break and a clip-on balcony system. In addition to these, we have included a standard Juliet balcony and two precast balcony designs that integrate a precast balcony slab into the façade system.

This report looks at the relative impacts of the six balcony designs individually and then uses a ratio of thermal performance (RSI) to global warming potential (GWP), to evaluate the overall carbon intensity of each balcony design. The lower the ratio, the lower its carbon impact.

1.2 Assumptions

This study focuses on intermediate to high-rise multi-unit residential buildings which are typically built out of cast-in-place concrete. For the purposes of this study, we have assumed precast concrete wall systems for all six options.

1.3 Methodology

Balcony designs were completed by BDP Quadrangle with support from product suppliers for emerging technologies and methodologies. A balcony size of 2000 mm x 1200 mm (2.4 m^2) was assumed except for the Juliet options.

BDP Quadrangle performed the thermal calculations for one complete bay of each option to determine the effective thermal performance, including the impacts of both the clear field opaque assembly and the thermal bridging at all interface details. The purpose of studying one full bay is because this study area is more representative of the whole facade. Analysis that looked at the balcony connection in isolation would miss the holistic design issues. These were peer reviewed by RWDI and Lukachko Climate Strategies.

Costing and constructability were provided by Multiplex. One complete bay was costed for each design including the precast cladding material in all cases. Costing for the Typical Cast-In-Place Balcony is set to 1.0x and all costing is shown relative to this baseline.

OneClick LCA was used to access Environmental Product Declarations (EPDs) to find the global warming potential (GWP) of each assembly. GWP values are expressed in units of carbon dioxide mass equivalent (kgCO2e, in which all GHGs are converted to the impact of CO2) and cover phases A1 to A3 inclusive. The embodied carbon values for the concrete were taken from the Ontario Concrete Association EPDs. The GWP was peer reviewed by Multiplex.

Notes:
1. All real projects with SPA date in 2030 and beyond
2. Net Zero Carbon Ready is defined as EUI 75, GHG 5, TEDI 15, and ECI 250 for MURB buildings (≤ 6 Storeys) or certified Zero Carbon Building™

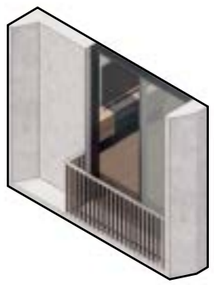
2.0 BALCONY TYPES

A
Typical Cast-in-Place Concrete Balcony

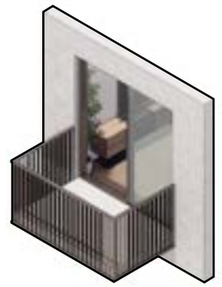
B
Cast-in-Place Balcony Thermally Broken

C
Typical Juliet Balcony

D
Enhanced Juliet Balcony



E
Integrated Precast Balcony



F
Pre-manufactured Clip-On Balcony

A

Typical Cast-in-Place Concrete Balcony

Cost:

1.0x

Effective RSI (m2·K/W):

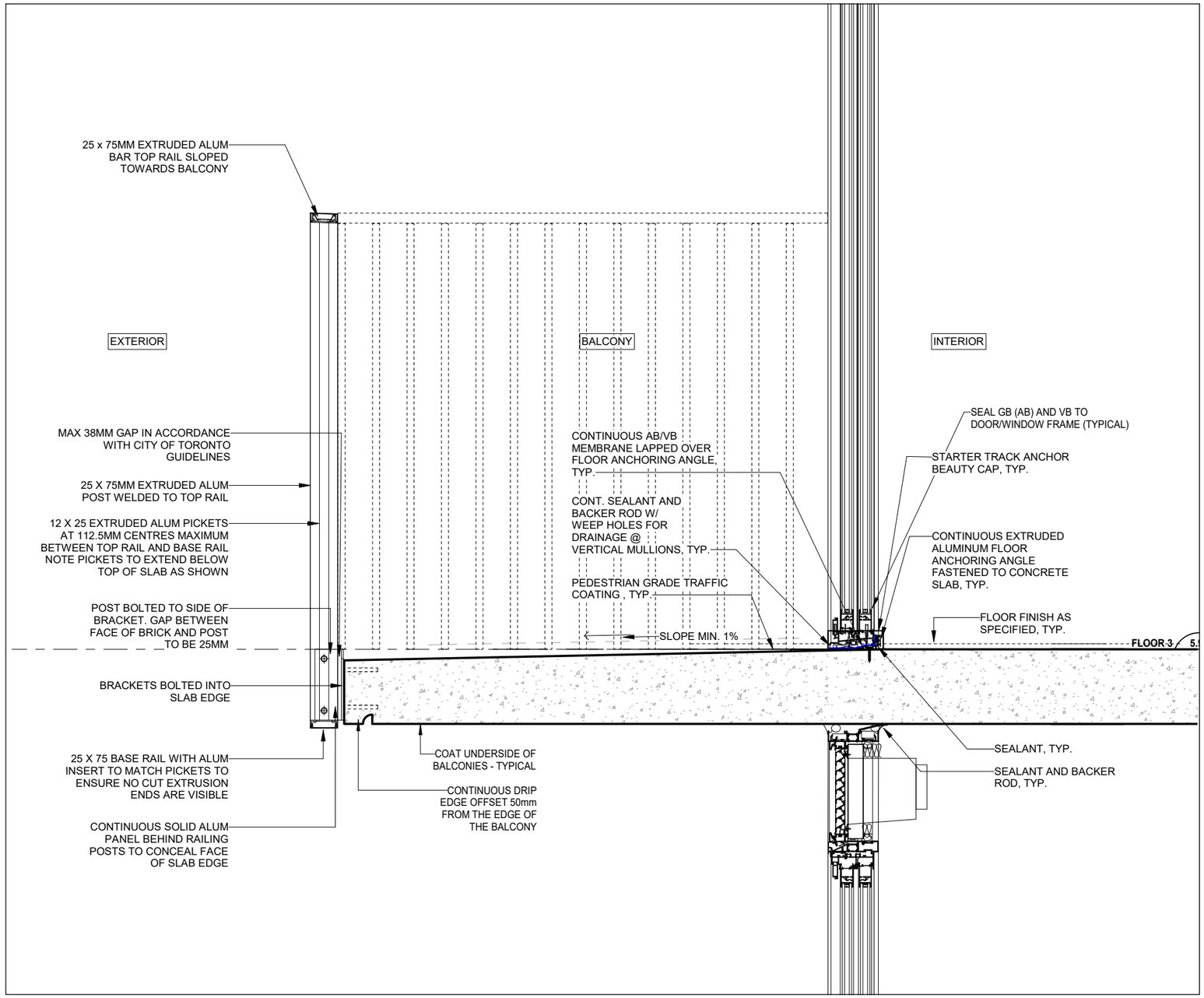
0.42

Global Warming Potential ($kgCO_2e$):

1860

Schedule Impact:
- No additional mobilizations
- Minimal impact

Notes:
- Significant comfort and energy issues
- Unlikely to be acceptable by the TGS and the building code beyond 2030



B

Cast-in-Place Balcony, Thermally Broken

Cost:

1.1x

Effective RSI (m2·K/W):

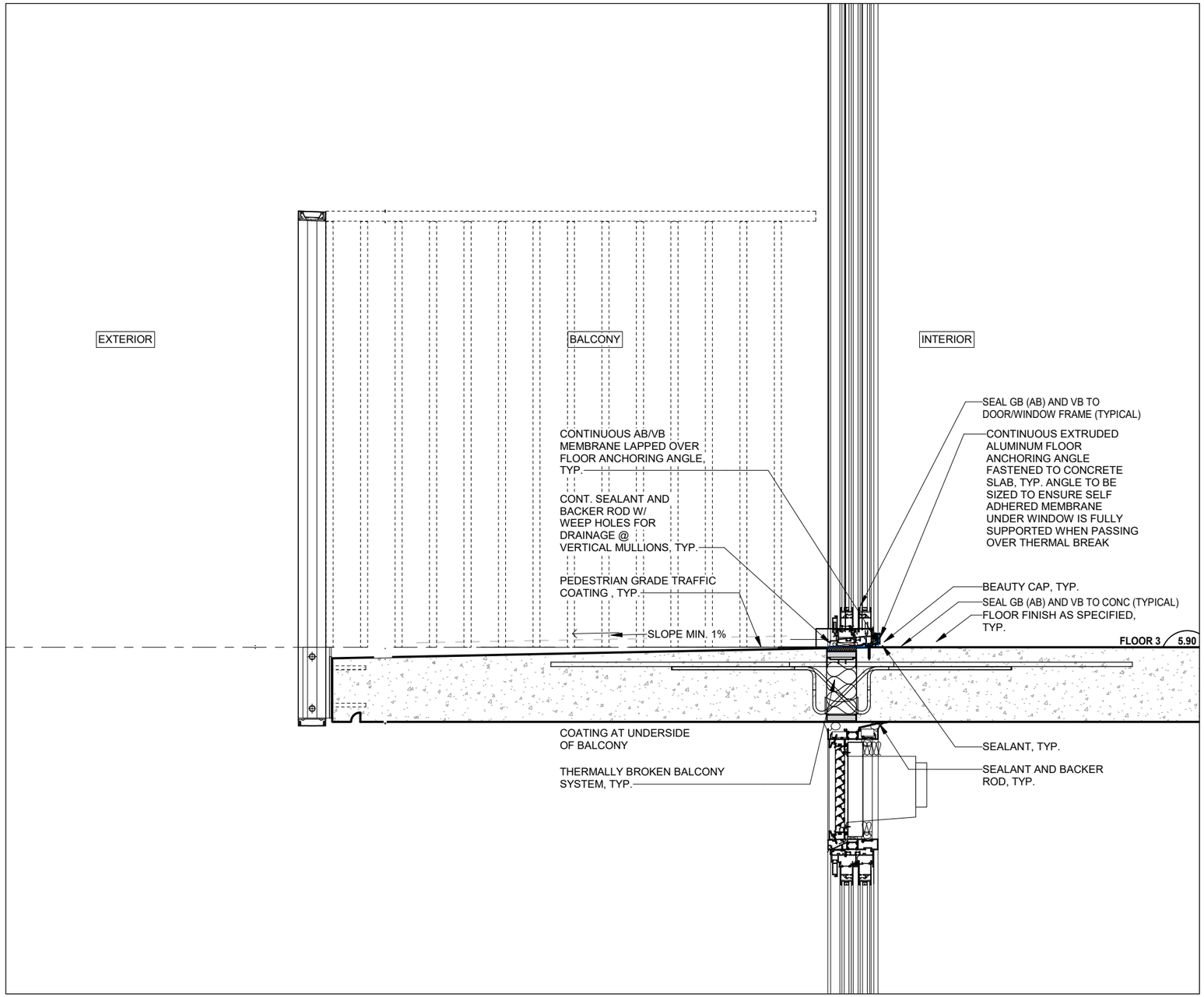
0.43

Global Warming Potential ($kgCO_2e$):

1910

Schedule Impact:
- Thermal break procured and installed by the formwork trade, second mobilization
- Trades may be unfamilliar with this solution now, not a long term issue

Notes:
- Significant improvement to comfort and energy issues



C

Typical Juliet Balcony

Cost:

0.8x

Effective RSI (m2·K/W):

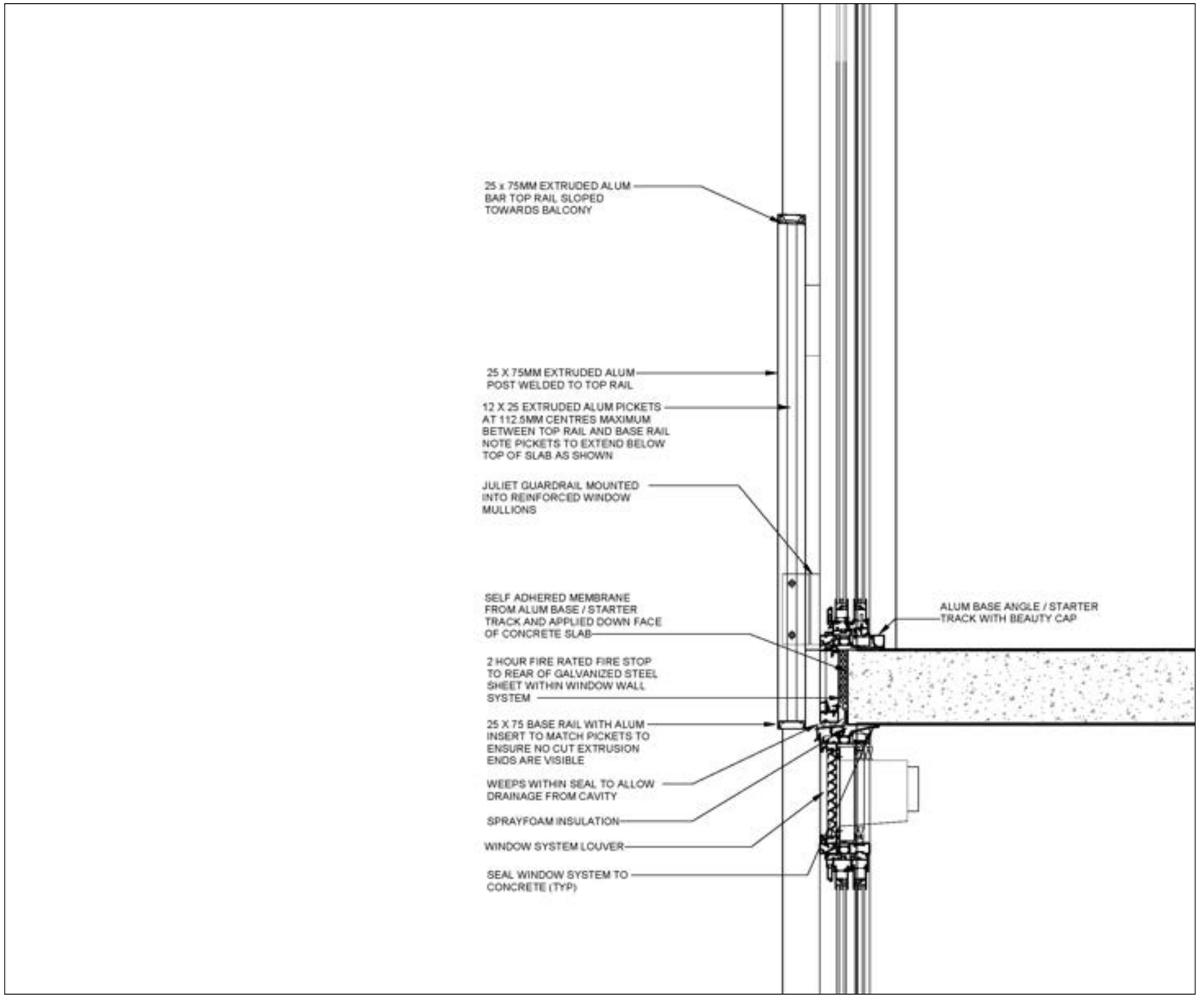
0.43

Global Warming Potential ($kgCO_2e$):

1324

Schedule Impact:
- Less concrete and reduced railing length create time savings

Notes:
- Some comfort and energy issues
- Provides access to a large opening, but no access beyond the door threshold



D

Enhanced Juliet Balcony

Cost:

1.3x

Effective RSI (m2·K/W):

0.48

Global Warming Potential ($kgCO_2e$):

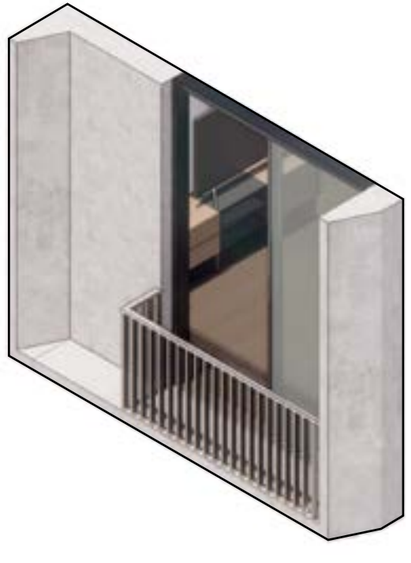
1832

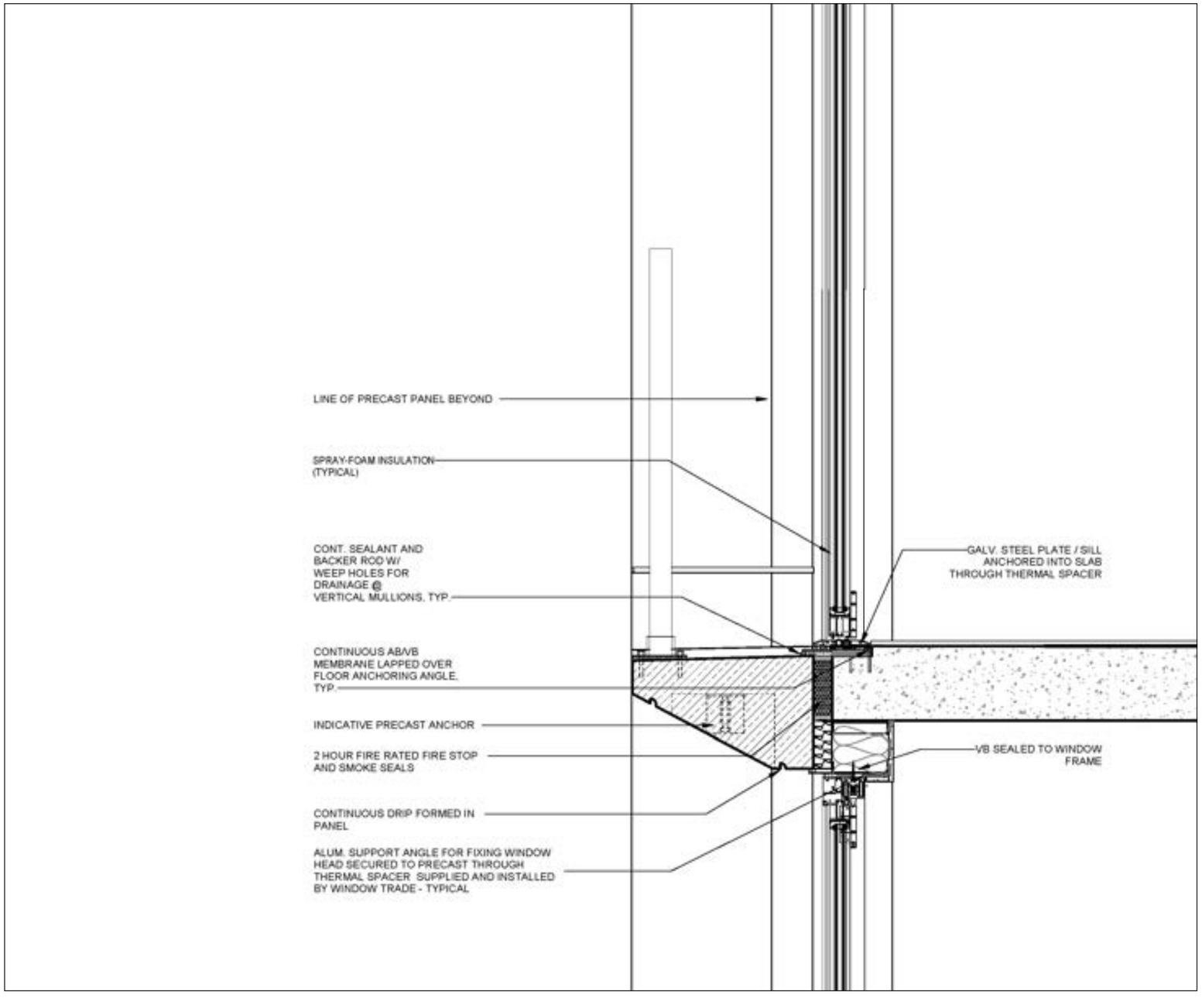
Schedule Impact:

- Balcony is part of the envelope installation
- Requires close coordination with precast and concrete trades
- Requires additional lead time

Notes:

- Significant improvement to comfort and energy issues
- Maintains standing access to outdoors





E

Integrated Precast Balcony

Cost:

1.5x

Effective RSI (m2·K/W):

0.56

Global Warming Potential ($kgCO_2e$):

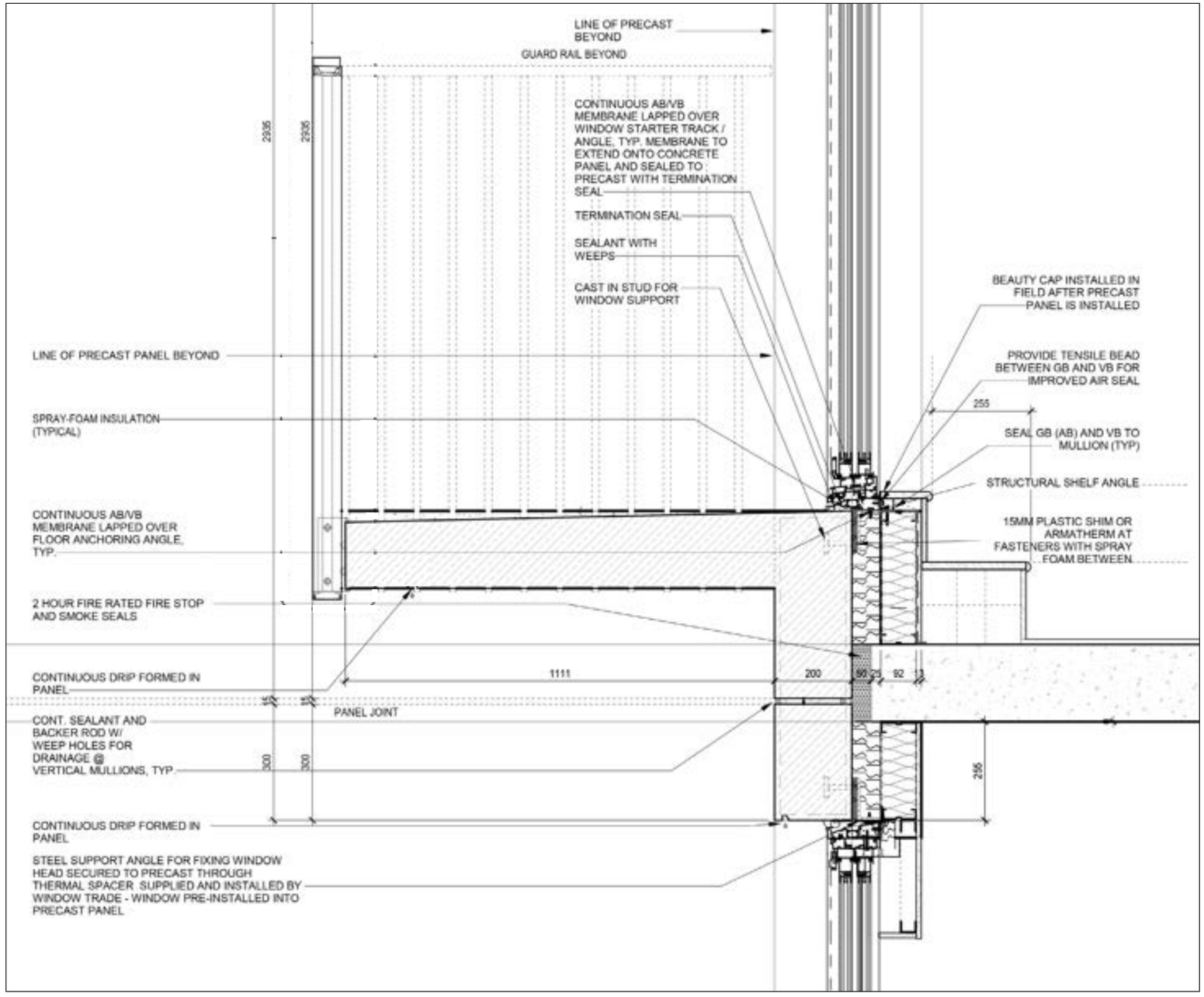
2107

Schedule Impact:

- Balcony is part of the envelope installation
- Requires close coordination with precast and concrete trades
- Requires additional lead time

Notes:

- Significant improvement to comfort and energy issues
- Maintains full access to outdoors



F

Pre-Manufactured Clip-On Balcony

Cost:

1.3x

Effective RSI (m2·K/W):

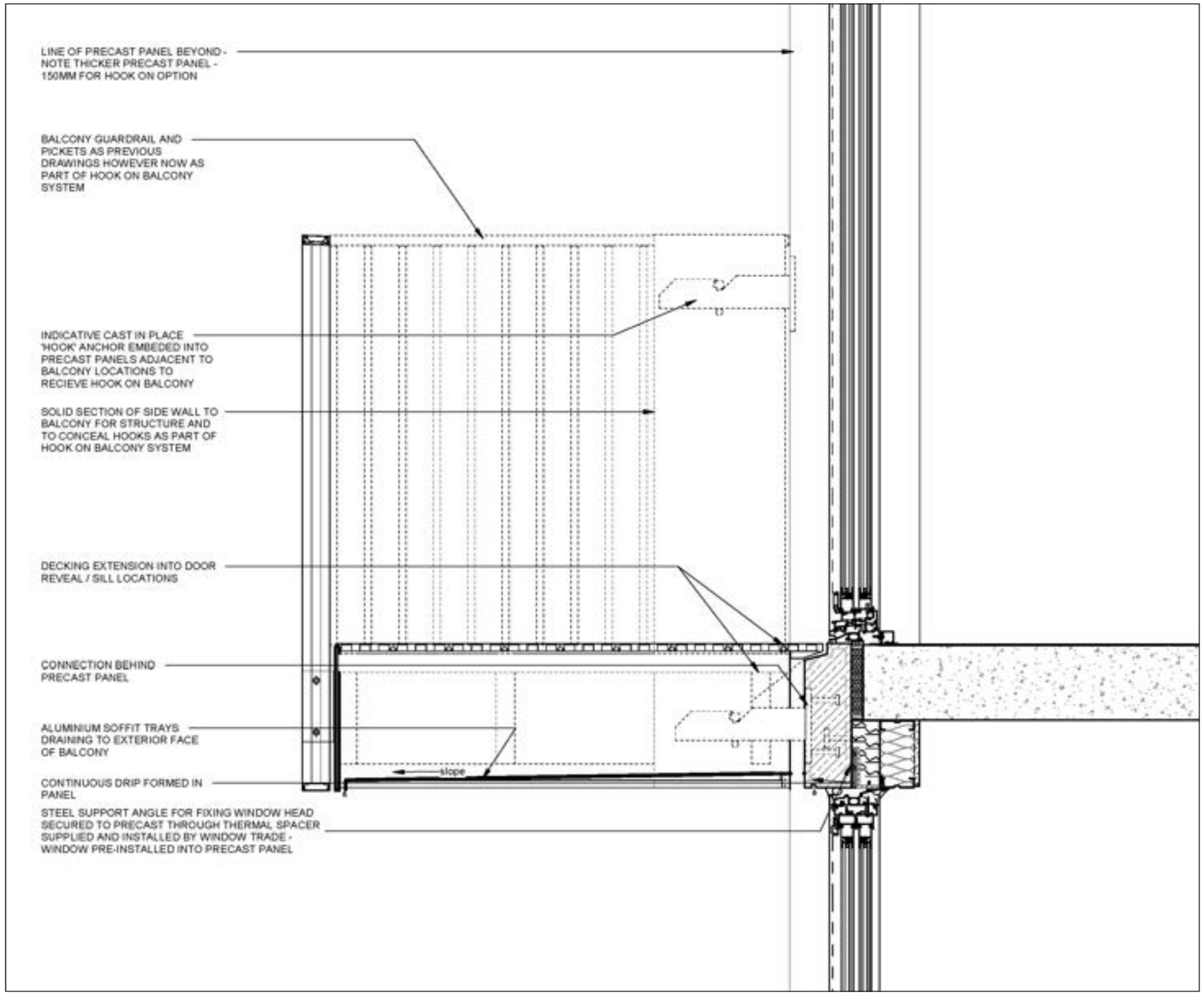
0.49

Global Warming Potential ($kgCO_2e$):

2162

Schedule Impact:
- Installation is not on critical path
- Faster installation than other methods
- Proprietary system, lead time subject to plant capacity

Notes:
- Significant improvement to comfort and energy issues
- Maintains full access to outdoors
- Simplified future maintenance



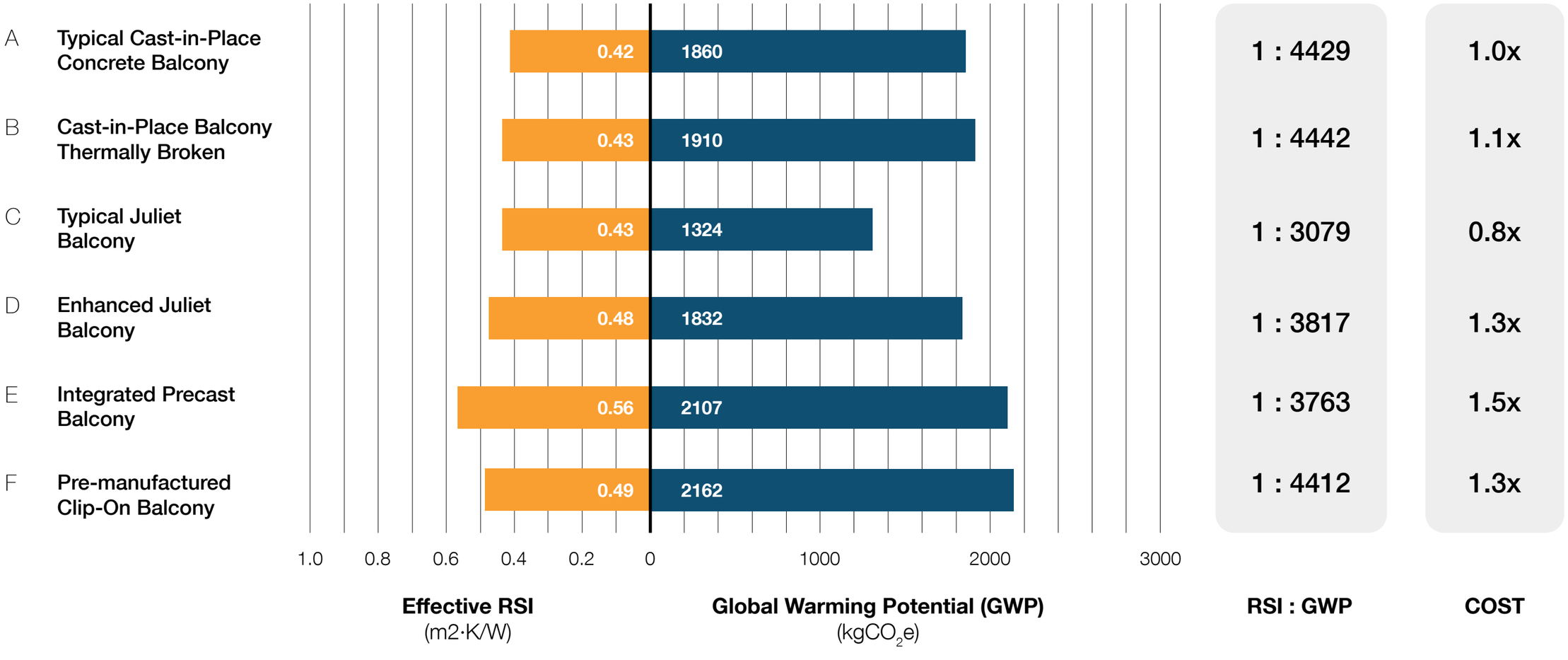
3.0 COMPARATIVE ANALYSIS

RSI relates to energy savings, operational carbon savings and increased thermal comfort. The higher the RSI the better. GWP refers to the global warming potential or the embodied carbon. Using a ratio of thermal performance (RSI) to global warming potential (GWP), we can begin to evaluate the overall carbon intensity of each balcony system. The lower the ratio, the lower its carbon impact. The ratio range varies significantly from 1: 3079 to 1: 6045.

Using the Typical Cast-in-Place Concrete Balcony as the baseline for costing, we have indicated the cost increase or decrease relative to the baseline.

Note that the thermal modeling includes the impacts of the entire bay including glazing and the thermal bridging details including window to wall interfaces which are the most impactful. As the balcony interface in this bay is minimal compared with the window detail, you will see that the effective RSI impact is less than one might assume. As window to wall interface details and glazing quality are improved, the impact of the balcony detail on thermal performance will increase.

As a general rule, we would look to improve the window quality and details first. We then ensure that we have good effective RSI-values for the walls. When those things are done, we examine the details, especially the window-to-wall interface and the balcony connections as they are generally the most impactful in terms of thermal resistance as well as strongly affecting both comfort of residents and moisture durability. Window-to-wall details are often limited by choices already made, so, this case study examines fine-tuning of the balcony design to achieve better thermal performance AND better comfort and durability.



4.0 FINAL THOUGHTS

C

Typical Juliet Balcony

Cost:

0.8x

Effective RSI (m2·K/W):

0.43

Global Warming Potential ($kgCO_2e$):

1324

Ratio RSI: GWP

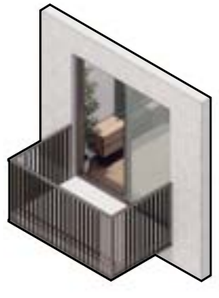
1 : 3079

Schedule Impact:
- Less concrete and reduced railing length create time savings

Notes:
- Some comfort and energy issues
- Provides access to a large opening, but no access beyond the door threshold

E

Integrated Precast Balcony



Cost:

1.5x

Effective RSI (m2·K/W):

0.56

Global Warming Potential ($kgCO_2e$):

2107

Ratio RSI: GWP

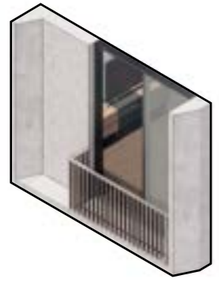
1 : 3763

Schedule Impact:
- Balcony is part of the envelope installation
- Requires close coordination with precast and concrete trades
- Requires additional lead time

Notes:
- Significant improvement to comfort and energy issues
- Maintains full access to outdoors

D

Enhanced Juliet Balcony



Cost:

1.3x

Effective RSI (m2·K/W):

0.48

Global Warming Potential ($kgCO_2e$):

1832

Ratio RSI: GWP

1 : 3817

Schedule Impact:
- Balcony is part of the envelope installation
- Requires close coordination with precast and concrete trades
- Requires additional lead time

Notes:
- Significant improvement to comfort and energy issues
- Maintains standing access to outdoors

F

Pre-manufactured Clip-On Balcony

Cost:

1.3x

Effective RSI (m2·K/W):

0.49

Global Warming Potential ($kgCO_2e$):

2162

Ratio RSI: GWP

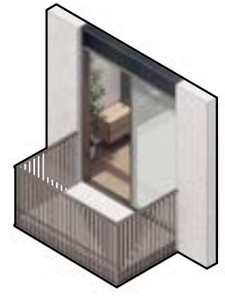
1 : 4412

Schedule Impact:
- Installation is not on critical path
- Faster installation than other methods
- Proprietary system, lead time subject to plant capacity

Notes:
- Significant improvement to comfort and energy issues
- Maintains full access to outdoors
- Simplified future maintenance

A

Typical Cast-in-Place Concrete Balcony



Cost:

1.0x

Effective RSI (m2·K/W):

0.42

Global Warming Potential ($kgCO_2e$):

1860

Ratio RSI: GWP

1 : 4429

Schedule Impact:
- No additional mobilizations
- Minimal impact

Notes:
- Significant comfort and energy issues
- Unlikely to be acceptable by the TGS and the building code beyond 2030

B

Cast-in-Place Balcony Thermally Broken

Cost:

1.1x

Effective RSI (m2·K/W):

0.43

Global Warming Potential ($kgCO_2e$):

1910

Ratio RSI: GWP

1 : 4442

Schedule Impact:
- Thermal break procured and installed by the formwork trade, second mobilization
- Trades may be unfamilliar with this solution now, not a long term issue

Notes:
- Significant improvement to comfort and energy issues

Balconies are shown in order of lowest to highest RSI:GWP ratio.

4.0 FINAL THOUGHTS

The Typical Juliet Balcony (C) has the lowest RSI to GWP ratio and the lowest cost while also giving residents access to outside through a large opening.

The two balcony designs integrated with the precast wall assembly (D and E) have potential for reducing overall carbon impact and improving thermal performance and comfort, though they are currently more expensive than alternative systems. These systems would be installed as part of the envelope system and will require close coordination between the precast manufacturer and the concrete trade.

The Enhanced Juliet (D) gives people enough depth to stand outside without creating a space for extraneous storage. This model can be further enhanced with a larger bi-fold opening.

The two proprietary systems did not perform as well as expected overall, the Thermally Broken balcony (B) in terms of thermal performance and the Clip-On Balcony (F) in terms of embodied carbon, though this might be further refined through careful material selection. The Clip-On Balcony has the potential to increase construction speed and has excellent potential for simplifying maintenance in the future, a significant benefit to rental or long-term ownership.

We will continue to be required to meet higher levels of performance in terms of both operational and embodied carbon so ensuring we examine systems holistically is key. Given our current housing crisis, we will need to bring more housing online quickly. To do this we will need to find ways to reduce construction timelines while addressing issues of affordability.

We need to be judicious in our design thinking, including finding ways to enhance the lives of residents. Designing modest balconies that are thoughtfully located and selecting the right balcony design for the right location goes a long way to reducing material quantities and subsequently both cost and carbon. It also increases the likelihood of the balcony being used and enjoyed by residents. Modern methods of construction offer some real promise to speed up construction timeliness and we expect that the rise of both operational and embodied carbon reporting will inspire the industry to continue to innovate on current design.

If you wish to explore our thoughts on the qualitative aspects of balconies, refer to Outside In | BDP Quadrangle.

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