CECPI-4-21

IECC®: C103.2, SECTION 202, SECTION 202 (New), C402.1, C402.1.5, Table C402.1.5 (New), C402.6 (New), C402.6.1 (New), C402.6.2 (New), C402.6.3 (New), C402.6.4 (New), C402.6.5 (New), TABLE C407.4.1(1)

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2021 International Energy Conservation Code

Revise as follows:

C103.2 Information on construction documents. Construction documents shall be drawn to scale on suitable material. Electronic media documents are permitted to be submitted where *approved* by the *code official*. Construction documents shall be of sufficient clarity to indicate the location, nature and extent of the work proposed, and show in sufficient detail pertinent data and features of the building, systems and equipment as herein governed. Details shall include, but are not limited to, the following as applicable:

1. Energy compliance path.
2. Insulation materials and their *R*-values.
3. Fenestration *U*-factors and solar heat gain coefficients (SHGCs).
4. Area-weighted *U*-factor and solar heat gain coefficient (SHGC) calculations.
5. Mechanical system design criteria.
6. Mechanical and service water-heating systems and equipment types, sizes and efficiencies.
7. Economizer description.
8. Equipment and system controls.
9. Fan motor horsepower (hp) and controls.
10. Duct sealing, duct and pipe insulation and location.
11. Lighting fixture schedule with wattage and control narrative.
12. Location of *daylight* zones on floor plans.
13. Air barrier and air sealing details, including the location of the air barrier.
14. *Thermal bridges* as identified in Section C402.6.

F-FACTOR. The perimeter heat loss factor per unit perimeter length of ~~for~~ slab-on-grade floors (Btu/h × ft × °F) [W/(m × K)].

Add new definition as follows:

PSI-FACTOR (Ψ-FACTOR). the heat loss factor per unit length of a *thermal bridge* characterized as a linear element of a *building thermal envelope* (Btu/h x ft x °F)[W/(m x K)].

CHI-FACTOR (χ-FACTOR). The heat loss factor for a single *thermal bridge* characterized as a point element of a *building thermal envelope* (Btu/h x °F)[W/K].

THERMAL BRIDGE. An element or interface of elements that has higher thermal conductivity than the surrounding *building thermal envelope*, which creates a path of least resistance for heat transfer.

Revise as follows:

C402.1 General. *Building thermal envelope* assemblies for buildings that are intended to comply with the code on a prescriptive basis in accordance with the compliance path described in Item 1 of Section C401.2.1shall comply with the following:

1. The opaque portions of the *building thermal envelope* shall comply with the specific insulation requirements of Section C402.2 and the thermal requirements of either the *R*-value-based method of Section C402.1.3; the *U*-, *C*- and *F*-factor-based method of Section C402.1.4; or the component performance alternative of Section C402.1.5.
2. Roof solar reflectance and thermal emittance shall comply with Section C402.3.
3. Fenestration in building envelope assemblies shall comply with Section C402.4.
4. Air leakage of building envelope assemblies shall comply with Section C402.5.
5. *Thermal bridges* in *above-grade walls* shall comply with Section C402.6.

Alternatively, where buildings have a vertical fenestration area or skylight area exceeding that allowed in Section C402.4, the building and *building thermal envelope* shall comply with Item 2 of Section C401.2.1 or Section C401.2.2.

Walk-in coolers, walk-in freezers, refrigerated warehouse coolers and refrigerated warehouse freezers shall comply with Section C403.11.

C402.1.5 Component performance alternative. Building envelope values and fenestration areas determined in accordance with Equation 4-2 shall be an alternative to compliance with the *U*-, *F*-, *psi-*, *chi-*, and *C*-factors in Tables C402.1.4, C402.1.5, and C402.4 and the maximum allowable fenestration areas in Section C402.4.1. *Fenestration* shall meet the applicable SHGC requirements of Section C402.4.3.

$A+B+C+D+E+T \leq Zero$ **(Equation 4-2)**

where:

A = Sum of the (UA Dif) values for each distinct assembly type of the *building thermal envelope*, other than slabs on grade and below-grade walls.

UA Dif = UA Proposed – UA Table.

UA Proposed = Proposed *U*-value × Area.

UA Table = (*U*-factor from Table C402.1.3, C402.1.4 or C402.4) × Area.

B = Sum of the (FL Dif) values for each distinct slab-on-grade perimeter condition of the *building thermal envelope*.

FL Dif = FL Proposed – FL Table.

FL Proposed = Proposed *F*-value × Perimeter length.

FL Table = (*F*-factor specified in Table C402.1.4) × Perimeter length.

C = Sum of the (CA Dif) values for each distinct *below-grade wall* assembly type of the *building thermal envelope*.

CA Dif = CA Proposed – CA Table.

CA Proposed = Proposed *C*-value × Area.

CA Table = (Maximum allowable *C*-factor specified in Table C402.1.4) × Area.

Where the proposed vertical glazing area is less than or equal to the maximum vertical glazing area allowed by Section C402.4.1, the value of D (Excess Vertical Glazing Value) shall be zero. Otherwise:

D = (DA × UV) – (DA × U Wall), but not less than zero.

DA = (Proposed Vertical Glazing Area) – (Vertical Glazing Area allowed by Section C402.4.1).

UA Wall = Sum of the (UA Proposed) values for each opaque assembly of the exterior wall.

U Wall = Area-weighted average *U*-value of all above-grade wall assemblies.

UAV = Sum of the (UA Proposed) values for each vertical glazing assembly.

UV = UAV/total vertical glazing area.

Where the proposed skylight area is less than or equal to the skylight area allowed by Section C402.4.1, the value of E (Excess Skylight Value) shall be zero. Otherwise:

E = (EA × US) – (EA × U Roof), but not less than zero.EA = (Proposed Skylight Area) – (Allowable Skylight Area as specified in Section C402.4.1).U Roof = Area-weighted average *U*-value of all roof assemblies.UAS = Sum of the (UA Proposed) values for each skylight assembly.US = UAS/total skylight area.

T= Sum of the (ΨL Dif) and (χN Dif) values for each type of *thermal bridge* condition of the *building thermal envelope* as identified in Section C402.6. For the purposes of this section, the ΨL Dif and χN Dif values for *thermal bridges* caused by materials with a thermal conductivity less than or equal to 3.0 Btu-in/h-ft^2-F shall be assigned as zero. For buildings or structures located in Climate Zones 0 through 3, the value of T shall be assigned as zero.

ΨL Dif=ΨL Proposed -ΨL Table.

ΨL Proposed = Proposed *psi-factor* x length of the *thermal bridge* elements in the proposed *building thermal envelope*.

ΨL Table = (*psi-factor* specified as "compliant" in Table C402.1.5) x length of the *thermal bridge* linear elements.

χN Dif=χN Proposed-χN Table.

χN Proposed = Proposed *chi-factor* x number of the *thermal bridge* point elements other than fasteners, ties, or brackets in the proposed *building thermal envelope.*

χN Table=(*chi-factor* specified as "compliant" in Table C402.1.5) x number of the *thermal bridge* point elements.

A proposed *psi-* or *chi-factor* for each *thermal bridge* shall comply with one of the following as applicable:

1. Where the proposed mitigation of a *thermal bridge* is compliant with the requirements of Section C402.6, the value identified as compliant in Table C402.1.5 shall be used for the proposed *psi-* or *chi-factors*.
2. Where a *thermal bridge* is mitigated such that it does not comply with Section C402.6, the values identified as non-compliant in Table C402.1.5 shall be used for the proposed *psi-* or *chi-factors*.
3. Where the proposed mitigation of a *thermal bridge* provides a *psi-* or *chi-factor* less than the values identified as compliant in Table C402.1.5, the proposed *psi-* or *chi-factor* shall be determined by thermal analysis, testing, or other *approved* methods.

Add new text as follows:

Table C402.1.5 PSI- and CHI-FACTORS TO DETERMINE THERMAL BRIDGES FOR THE COMPONENT PERFORMANCE ALTERNATIVE

Thermal Bridge per Section C402.6	Thermal Bridge Compliant with Section C402.6		Thermal Bridge Non-Compliant with Section C402.6	
	psi-factor (Btu/h-ft-°F)	chi-factor (Btu/h-ft-°F)	psi-factor (Btu/h-ft-°F)	chi-factor (Btu/h-ft-°F)
C402.6.1 Balconies, slabs, and decks	0.2	n/a	0.5	n/a
C402.6.2 Cladding supports	0.2	n/a	0.3	n/a
C402.6.3 Structural beams and columns	n/a	1.0-carbon steel 0.3-concrete	n/a	2.0-carbon steel 1.0-concrete
C402.6.4 Vertical fenestration	0.15	n/a	0.3	n/a
C402.6.5 Parapets	0.2	n/a	0.4	n

For SI: W/m-K = 0.578 Btu/h-ft-°F; 1 W/K = 1.90 Btu/h-°F

n/a = not applicable

C402.6 Thermal bridges in above-grade walls. *Thermal bridges* in *above-grade walls* shall comply with the section or an *approved* design.

Exceptions:

1. Buildings and structures located in Climate Zones 0 through 3.
2. Any thermal bridge with a material thermal conductivity not greater than 3.0 Btu/h-ft-°F.
3. Blocking, coping, flashing, and other similar materials for attachment of roof coverings.
4. *Thermal bridges* accounted for in the *U-factor* or *C-factor* for a *building thermal envelope*.

C402.6.1 Balconies and floor decks. Balconies and concrete floor decks shall not penetrate the *building thermal envelope*. Such assemblies shall be separately supported or shall be supported by structural attachments or elements that minimize thermal bridging through the building thermal envelope.

Exceptions: Balconies and concrete floor decks shall be permitted to penetrate the *building thermal envelope* where:

1. an area-weighted *U-factor* is used for *above-grade wall* compliance which includes a *U-factor* of 0.8 Btu/h-°F-ft2 for the area of the *above-grade wall* penetrated by the concrete floor deck, or
2. an *approved* thermal break device of not less than R-10 is installed in accordance with the manufacturer's instructions.

C402.6.2 Cladding supports. Linear elements supporting opaque cladding shall be off-set from the structure with attachments that allow the *continuous insulation*, where present, to pass behind the cladding support element.

Exceptions:

1. An *approved* design where the *above-grade wall U-factor* used for compliance accounts for the cladding support element *thermal bridge*.
2. Anchoring for *curtain wall* and window wall systems.

C402.6.3 Structural beams and columns. Structural steel and concrete beams and columns that project through the *building thermal envelope* shall be covered with not less than R-5 insulation for not less than 2-feet (610 mm) beyond the interior or exterior surface of an insulation component within the *building thermal envelope*.

Exceptions:

1. Where an *approved* thermal break device is installed in accordance with the manufacturer's instructions.
2. An *approved* design where the *above-grade wall U-factor* used to demonstrate compliance accounts for the beam or column *thermal bridge*.

C402.6.4 Vertical fenestration. Vertical fenestration intersections with *above grade walls* shall comply with one or more of the following:

1. Where *above-grade* walls include *continuous insulation*, the plane of the exterior glazing layer or, for metal frame fenestration, a non-metal thermal break in the frame shall be positioned within 2 inches (610 mm) of the interior or exterior surface of the *continuous insulation.*
2. Where *above-grade walls* do not include *continuous insulation*, the plane of the exterior glazing layer or, for metal frame fenestration, a non-metal thermal break in the frame shall be positioned within the thickness of the integral or *cavity insulation.*

3. The surface of the rough opening, not coved by the fenestration frame, shall be insulated with insulation of not less than R-3 material or covered with a wood buck that is not less than 1.5 inch (457 mm) thick.
4. For the intersection between vertical fenestration and opaque spandrel in a shared framing system, manufacturer's data for the spandrel *U-factor* shall account for *thermal bridges*.

Exceptions:

1. Where an *approved* design for the *above-grade wall U-factor* used for compliance accounts for *thermal bridges* at the intersection with the vertical fenestration.
2. Doors

C402.6.5 Parapets. Parapets shall comply with one or more of the following as applicable:

1. Where continuous insulation is installed on the exterior side of the *above-grade wall* and the roof is insulated with insulation entirely above deck, the continuous insulation shall extend up both sides of the parapet not less than 2 feet (610 mm) above the roof covering or to the top of the parapet, whichever is less. Parapets that are an integral part of a fire-resistance rated wall, and the exterior *continuous insulation* applied to the parapet, shall comply with the fire resistance ratings of the building code.
2. Where *continuous insulation* is installed on the exterior side of the above-grade wall and the roof insulation is below the roof deck, the *continuous insulation* shall extend up the exterior side of the parapet to not less than the height of the top surface of the roof assembly.
3. Where *continuous insulation* is not installed on the exterior side of the *above-grade wall* and the roof is insulated with insulation entirely above deck, the wall cavity or integral insulation shall extend into the parapet up to the exterior face of the roof insulation or equivalent R-value insulation shall be installed not less than 2 feet (610 mm) horizontally inward on the underside of the roof deck.
4. Where *continuous insulation* is not installed on the exterior side of the *above-grade wall* and the roof insulation is below the roof deck, the wall and roof insulation components shall be adjacent to each other at the roof-ceiling-wall intersection.

Exception: An *approved* design where the *above-grade wall U-factor* used for compliance accounts for the parapet *thermal bridge*.

Revise as follows:

TABLE C407.4.1(1) SPECIFICATIONS FOR THE STANDARD REFERENCE AND PROPOSED DESIGNS

BUILDING COMPONENT CHARACTERISTICS	STANDARD REFERENCE DESIGN	PROPOSED DESIGN
Space use classification	Same as proposed	The space use classification shall be chosen in accordance with Table C405.3.2(1) or C405.3.2(2) for all areas of the building covered by this permit. Where the space use classification for a building is not known, the building shall be categorized as an office building.
Roofs	Type: insulation entirely above deck	As proposed
	Gross area: same as proposed	As proposed
	U-factor: as specified in Table C402.1.4	As proposed
	Solar absorptance: 0.75	As proposed
	Emittance: 0.90	As proposed
Walls, above-grade	Type: same as proposed	As proposed
	Gross area: same as proposed	As proposed
	U-factor: as specified in Table C402.1.4	As proposed
	<u>*Thermal bridges:* Account for heat transfer consistent with "compliant" *psi-* and *chi-factors* from Table C402.1.5 for *thermal bridges* as identified in Section C402.6 that are present in the *proposed design.*</u>	<u>As proposed; *psi-* and *chi-factors* for proposed *thermal bridges* shall be determined in accordance with requirements in Section C402.1.5.</u>
	Solar absorptance: 0.75	As proposed
	Emittance: 0.90	As proposed
Walls, below-grade	Type: mass wall	As proposed
	Gross area: same as proposed	As proposed
	U-Factor: as specified in Table C402.1.4 with insulation layer on interior side of walls	As proposed
Floors, above-grade	Type: joist/framed floor	As proposed
	Gross area: same as proposed	As proposed
	U-factor: as specified in Table C402.1.4	As proposed
Floors, slab-on-grade	Type: unheated	As proposed
	F-factor: as specified in Table C402.1.4	As proposed
Opaque doors	Type: swinging	As proposed
	Area: Same as proposed	As proposed
	U-factor: as specified in Table C402.1.4	As proposed
Vertical fenestration other than opaque doors	Area 1. The proposed vertical fenestration area; where the proposed vertical fenestration area is less than 40 percent of above-grade wall area. 2. 40 percent of above-grade wall area; where the proposed vertical fenestration area is 40 percent or more of the above-grade wall area.	As proposed
	U-factor: as specified in Table C402.4	As proposed
	SHGC: as specified in Table C402.4 except that for climates with no requirement (NR) SHGC = 0.40 shall be used	As proposed
	External shading and PF: none	As proposed

BUILDING COMPONENT CHARACTERISTICS	STANDARD REFERENCE DESIGN	PROPOSED DESIGN
Skylights	Area 1. The proposed skylight area; where the proposed skylight area is less than that permitted by Section C402.1. 2. The area permitted by Section C402.1; where the proposed skylight area exceeds that permitted by Section C402.1.	As proposed
	U-factor: as specified in Table C402.4	As proposed
	SHGC: as specified in Table C402.4 except that for climates with no requirement (NR) SHGC = 0.40 shall be used.	As proposed
Lighting, interior	The interior lighting power shall be determined in accordance with Section C405.3.2. Where the occupancy of the building is not known, the lighting power density shall be 1.0 watt per square foot based on the categorization of buildings with unknown space classification as offices.	As proposed
Lighting, exterior	The lighting power shall be determined in accordance with Tables C405.5.2(1), C405.5.2(2) and C405.5.2(3). Areas and dimensions of surfaces shall be the same as proposed.	As proposed
Internal gains	Same as proposed	Receptacle, motor and process loads shall be modeled and estimated based on the space use classification. End-use load components within and associated with the building shall be modeled to include, but not be limited to, the following: exhaust fans, parking garage ventilation fans, exterior building lighting, swimming pool heaters and pumps, elevators, escalators, refrigeration equipment and cooking equipment.
Schedules	Same as proposed **Exception:** Thermostat settings and schedules for HVAC systems that utilize radiant heating, radiant cooling and elevated air speed, provided that equivalent levels of occupant thermal comfort are demonstrated by means of equal Standard Effective Temperature as calculated in Normative Appendix B of ASHRAE Standard 55.	Operating schedules shall include hourly profiles for daily operation and shall account for variations between weekdays, weekends, holidays and any seasonal operation. Schedules shall model the time-dependent variations in occupancy, illumination, receptacle loads, thermostat settings, mechanical ventilation, HVAC equipment availability, service hot water usage and any process loads. The schedules shall be typical of the proposed building type as determined by the designer and approved by the jurisdiction.
Mechanical ventilation	Same as proposed	As proposed, in accordance with Section C403.2.2.
Heating systems	Fuel type: same as proposed design	As proposed
	Equipment type[a]: as specified in Tables C407.4.1(2) and C407.4.1(3)	As proposed
	Efficiency: as specified in the tables in Section C403.3.2.	As proposed
	Capacity[b]: sized proportionally to the capacities in the proposed design based on sizing runs, and shall be established such that no smaller number of unmet heating load hours and no larger heating capacity safety factors are provided than in the proposed design.	As proposed
	Fuel type: same as proposed design	As proposed

BUILDING COMPONENT CHARACTERISTICS	STANDARD REFERENCE DESIGN	PROPOSED DESIGN
Cooling systems	Equipment type[c]: as specified in Tables C407.4.1(2) and C407.4.1(3)	As proposed
	Efficiency: as specified in Tables C403.3.2(1), C403.3.2(2) and C403.3.2(3)	As proposed
	Capacity[b]: sized proportionally to the capacities in the proposed design based on sizing runs, and shall be established such that no smaller number of unmet cooling load hours and no larger cooling capacity safety factors are provided than in the proposed design.	As proposed
	Economizer[d]: same as proposed, in accordance with Section C403.5.	As proposed
Service water heating[e]	Fuel type: same as proposed	As proposed
	Efficiency: as specified in Table C404.2	For Group R, as proposed multiplied by SWHF. For other than Group R, as proposed multiplied by efficiency as provided by the manufacturer of the DWHR unit.
	Capacity: same as proposed	As proposed
	Where no service water hot water system exists or is specified in the proposed design, no service hot water heating shall be modeled.	

For SI: 1 watt per square foot = 10.7 w/m^2.

SWHF = Service Water Heat Recovery Factor, DWHR = Drain Water Heat Recovery.

a. Where no heating system exists or has been specified, the heating system shall be modeled as fossil fuel. The system characteristics shall be identical in both the standard reference design and proposed design.

b. The ratio between the capacities used in the annual simulations and the capacities determined by sizing runs shall be the same for both the standard reference design and proposed design.

c. Where no cooling system exists or no cooling system has been specified, the cooling system shall be modeled as an air-cooled single-zone system, one unit per thermal zone. The system characteristics shall be identical in both the standard reference design and proposed design.

d. If an economizer is required in accordance with Table C403.5(1) and where no economizer exists or is specified in the proposed design, then a supply-air economizer shall be provided in the standard reference design in accordance with Section C403.5.

e. The SWHF shall be applied as follows:

1. Where potable water from the DWHR unit supplies not less than one shower and not greater than two showers, of which the drain water from the same showers flows through the DWHR unit then SWHF = [1 – (DWHR unit efficiency × 0.36)].
2. Where potable water from the DWHR unit supplies not less than three showers and not greater than four showers, of which the drain water from the same showers flows through the DWHR unit then SWHF = [1 – (DWHR unit efficiency × 0.33)].
3. Where potable water from the DWHR unit supplies not less than five showers and not greater than six showers, of which the drain water from the same showers flows through the DWHR unit, then SWHF = [1 – (DWHR unit efficiency × 0.26)].
4. Where Items 1 through 3 are not met, SWHF = 1.0.

Reason: As requested by the sub-committee, this proposal is a combination of CEPI-33, 40, 45 which now provides prescriptive, component performance alternative and total building performance compliance paths and a requirement to note thermal bridges on the construction documents. It combines the best of the individual proposals, plus improvements and modifications provided by the subcommittee and other interested parties. It also adds language for the component performance alternative compliance path, which was not present in the individual proposals.
The key rationale for specifying the minimum performance of thermal bridges at key interfaces is that currently they are ignored in the IECC, which therefore assumes no thermal performance degradation at assembly interfaces and penetrations of the building thermal envelope.

Ignoring thermal bridges at interfaces leads us to believe that our building thermal envelopes perform much better than they do, and to the widely recognized performance gap between as-designed/code compliant design and as-built [1]. According to the Building Envelope Thermal Bridging Guide created by Morrison Hershfield for BC Housing [2], thermal bridging can reduce the thermal performance of the opaque building envelope by between 20-70%. Non-thermally broken cladding attachments can degrade the thermal performance of opaque panel assemblies by 50% [2]. Morrison Hershfield have also found that 13% of the heat loss through a typical steel stud wall with punched opening windows is due to the window to wall transition and they found it to be even higher with poorer edge details. This is a huge degradation in performance that the code is currently ignoring and must be addressed to improve the energy performance of as-built structures.

Also, in the 2021 IECC, the definition for above-grade wall (shown below) was changed in a way that supports a need to address thermal bridging at intersections of above-grade walls with floors, roofs, and fenestration, which were previously ignored.

"WALL, ABOVE-GRADE. A wall associated with the building thermal envelope that is more than 15 percent above grade and is on the exterior of the building or any wall that is associated with the building thermal envelope that is not on the exterior of the building. **This includes, but is not limited to, between-floor spandrels, peripheral edges of floors, roof knee walls, dormer walls, gable end walls, walls enclosing a mansard roof and skylight shafts."**[bold added for emphasis]

In order to achieve net-zero performance we need to address these significant energy losses through thermal bridges at the building thermal envelope. This proposal seeks to take a small step towards recognizing and accounting for thermal bridges that are typically present in conventional construction. It seeks to recognize and account for current design and construction practices, not to drive a large change in construction practices. The proponents believe that this is a good first step to move building thermal envelope performance and to get the design and construction industry thinking about thermal bridges in the design process.

Inclusion in construction documents

The inclusion of thermal bridge details on construction documents will encourage design teams to identify and address thermal bridging. The requirements for what thermal bridges to identify on the construction documents is referenced to section C402.6 where the types of thermal bridges are identified. This will ensure that only the main thermal bridges need be shown. A definition for thermal bridges is also proposed to support the proposal.

Definitions

New definitions psi-factor and chi-factor are introduced to describe linear and point thermal bridges in the *building thermal envelope* in a similar way to the existing F-factor for heat loss for slab-on-grade floors. These definitions are used in the component performance alternative and the performance compliance paths. We have chosen to call them psi and chi-factors as this is how they are commonly referred to, and we wanted to avoid confusion.

A new definition for thermal bridges is included and incorporates comments from the subcommittee.

Prescriptive path

In the prescriptive path, we have taken the route of CEPI-33 in creating a simple yet flexible approach, focusing on a few thermal bridge conditions that have the most impact, and which have practical and available means to effectively manage the bridging. In every case, alternative means and methods are permitted with an approved design to avoid any unnecessary restriction or inflexibility. The proponents feel that this is an appropriately abbreviated and enforceable way to address this topic in the energy code.

The goal was to create a simple, prescriptive, effective, and flexible means to begin to address and reasonably mitigate the effects of major thermal bridges which are now identified in the new definition (IECC 2021) for above-grade walls. To inform the proposed prescriptive requirements, various thermal bridging studies, detailing guides, and provisions developed domestically and internationally were reviewed [2-7].

Component performance alternative

In this section the linear and point thermal bridges (psi-, chi- factors) are included in the formula in a similar way to the existing U-, F- and C- factors. A table of psi- and chi-factors are provided to be used in this section, for the five prescriptive categories of thermal bridges. There are values proposed for thermal bridges compliant or non-compliant with the prescriptive path. The values provided for thermal bridges compliant with the prescriptive path are reflective of those details (which are not very stringent). The values provided for non-compliant are reflective of poorer interface details. The psi- and chi-factors of thermal bridges which exceed the prescriptive requirement are permitted to be determined by thermal analysis, testing or other approved sources.

Including values of thermal bridging in this section will ensure that any trade-offs in between envelope assemblies will account for thermal bridging.

Note that this section will need to be rationalized with CEPI-46 which addresses a problem with the current component performance alternative equation, if both are accepted by the committee.

Performance path

The performance path language ensures that the reference design accounts for thermal bridging rather than assuming no thermal bridges exist and that the interfaces are "perfect". This allows for good thermal bridging details in the proposed design to show improved energy performance.

The reference design uses the psi- and chi-factors from the component performance alternative section for those thermal bridges which are present in the proposed design. The proposed building uses psi- and chi- factors for thermal bridges calculated according to the methods allowed in the component performance alternative.

Bibliography: [1] https://en.wikipedia.org/wiki/Performance gap
[2] BC Housing, Thermal Bridging Guide, Version 1.5, 2020, https://www.bchousing.org/research-centre/library/residential-design-construction/building-envelope-thermal-bridging-guide

[3] Morrison Hershfield Ltd. (2011)

[4] ASHRAE 1365-RP Thermal Performance of Building Envelope Construction Details for Mid- and High-Rise Buildings. Atlanta, GA: American Society of Heating, Refrigeration and Air-Conditioning Engineers Inc

[5] ISO Standard 14683: 2007, Thermal Bridges in Building Construction – Linear thermal transmittance (simplified methods and default Chi-factors).

[6] AISC/SEI, Thermal Bridging Solutions: Minimizing Structural Steel's Impact on Building Envelope Energy Transfer, A Supplement to Modern Steel Construction, March 2012, American Institute for Steel Construction (AISC) & Structural Engineering Institute (SEI).

[7] USACE, "Development of Thermal Bridging Factors for Use in Energy Models," ERDC/CERL TR-15-10, June 2015, U.S. Army Corp of Engineers, Engineer Research and Development Center, Construction Engineering Research Laboratory.

Cost Impact: The code change proposal will increase the cost of construction.
The code change proposal will increase the cost of construction.

Perfect mitigation or no thermal bridging at interfaces is implied by code. However, current practice is to ignore them or provide no or little mitigation. So, any proposal to reduce thermal bridging will increase the cost of construction relative to current practices. This proposal provides a way of practical mitigation which does not require significant changes to current practices, setting a relatively low performance bar.

We could also consider there to be no change in construction cost (or even a reduction in cost) as this proposal enforces the intent of code and closes the gap between what is being built today and what code intends to be built. But, of course, perfect mitigation is not representative of current practices. By quantifying the impact of thermal bridges, we provide the option to address them, albeit not perfectly, in each compliance path.