Facade Tectonics

PROPOSAL
CREDIT FOR ASSESSING CONDENSATION RESISTANCE

Background

Indoor air quality has been established as a key requirement for occupant health, well-being and productivity. Condensation as a result of poor performing windows and thermal bridging across façade attachments and interfaces can cause condensation which can create breeding grounds for mold and bacteria on walls, carpets, ceiling tiles etc. which can negatively impact indoor air quality. Thermal bridging within the wall systems in particular can cause condensation and then mold growth within walls which cannot be seen, resulting in indoor air quality issues the root cause of which can go undetected for many years. Canada has already implemented a requirement in their building code which requires designers to make best efforts to minimize condensation, understanding the negative consequences of thermal bridging to this and to overall energy performance. In addition, energy codes and standards such as ASHRAE Standard 90.1 and IECC do not effectively address and allow designers to ignore major thermal bridges in the envelope. As a result, energy modeling results will underestimate building energy use and can result in an under-performing building. Requiring a condensation analysis and minimum requirement will not only reduce the likelihood of condensation and the IAQ impacts, but will also result in higher performing envelope – or at least one that meets the performance expected and which was modeled. A good summary and resource can be found in British Columbia's Building Envelope Thermal Bridging Guide, prepared by recognized envelope performance experts Morrison and Hershfield. Note that the suggestion below could also be placed in the Energy and Atmosphere section as it will result in a better building energy performance too.

Recommendation:

A pilot credit in the IEQ credit area to reward project teams who make their best efforts to design against condensation occurring inside the wall and on the fenestration.

Suggested language:

Meet the following condensation resistance requirements for fenestration and opaque façade elements:

- **Fenestration**

Select fenestration with Condensation Resistance as defined by NFRC 500 so that the interior temperature of the fenestration is above the dew point temperature of the interior space when the exterior temperature is the mean winter low temperature for the coldest month. Procedure:

1. Calculate dew point of interior space conditions (humidity, ambient temperature). For example, a building at 68^oF with a 40% relative humidity would have a dew point of 43^oF (6^oC). The interior surface temperature of the fenestration therefore needs to be above 6^oC (T_{fen} in the equation below).
2. Use the following equation to estimate the fenestration Condensation Resistance required.

   Condensation Resistance estimate = $(T_{fen} – T_{ex})/T_{int}-T_{ex})$ *100
   Where:
   T_{fen} = Coldest allowable temperature on the inside surface of the fenestration before condensation can occur (6^oC in the above example)
   T_{ex} = The mean low ambient exterior air temperature of the coldest month. Calculated by taking the mean of the daily low temperatures of the coldest month where the building is located as reported by NOAA.

T_{in} = Ambient interior warm air temperature
For the example above, where the mean low exterior temperature is -13°C, the Condensation Resistance estimate is (6 – -13)/(21 – -13)*100 = 19/34 *100 = 56

3. Select fenestration with a Condensation Resistance according to NFRC 500 of greater than 56.

Note that the Condensation Resistance according to NFRC 500, uses an average of low temperatures on the fenestration, rather than one single low point temperature. However, since Condensation Resistance is one of the most generally available performance values for fenestration, it seems to be the best performance value to have architectural teams design around.

- **Opaque wall elements**

Use the methodology outlined in ASHRAE report 1365 and the Building Envelope Thermal Bridging Guide to determine the condensation resistance of the opaque wall assembly including all thermal bridges such as attachment mechanisms (Temperature Index). ASHRAE report 1365 provides the thermal performance data for 40 common building envelope details for mid- and high-rise construction. The Building Envelope Thermal Bridging Guide offer several hundreds more. If the performance of the opaque system cannot be derived from these resources, use 3D thermal analysis to determine the Temperature Index. The Temperature Index of the wall assembly (including attachments) must be greater than the dew point of the interior space condition based on the mean low exterior temperature of the coldest month. The mean low exterior temperature is calculated by taking the average of the lowest daily temperature in each of the days of the coldest month as reported by NOAA.

PROPOSAL

ENSURING APPROPRIATE ENVELOPE PERFORMANCE

Background

Currently, design teams can specify a relatively poor performing envelope, and less than the local prescriptive code might allow, by trading off with a high performing HVAC, lighting and other internal systems in the Energy and Atmosphere credit area. According to Curtain Wall Design Consulting (CDC), this trade-off is happening throughout the US. In Washington DC, for example, the envelope performance of new buildings is mediocre in some cases even when LEED certified, and does not consistently rise to the level one might expect given the goal of increasing building performance. In fact, CDC frequently sees fenestration (fixed vertical fenestration values) U-factors of 0.40 to 0.42 btu/$_o$f.hr.ft$_2$ in submittals when the minimum prescriptive code requirement is 0.38 btu/$_o$f.hr.ft$_2$. This results in a poor thermally performing envelope which will likely result in an uncomfortable perimeter zone.

While it is inappropriate for us to identify specific buildings here, if the review team would like to get more information on this, Vicente Montes-Amoros (vmontes@cdc-usa.com) from CDC (a member of the Façade Tectonics Institute) in Washington DC would be available to discuss in more detail. Since project teams are allowed to choose which credits they use, they are not compelled to choose the IEQ credits that may address visual comfort and thermal comfort near the building envelope and compel the use of higher performing envelopes.

The easiest solution to this problem would be to require that the fenestration and wall assemblies meet the minimum prescriptive requirements for U-factor and solar heat gain coefficient. However, we recognize that this removes the flexibility in design that USGBC may want to provide. In this case, the flexibility is given to design to a single performance metric – building energy – rather than a range of performance metrics including occupant comfort.

If teams had an incentive to improve both the energy performance of the building *and* the comfort next to the façade, whole building energy performance targets could be achieved without compromising envelope performance and occupant comfort.

An added benefit to this would be the delivery of improved building resilience related to power outages during extreme weather events (as addressed by the pilot "passive survivability credit" option 1 in LEEDv4). Given that the building envelope performance is key to keeping interior temperatures reasonable during the high heat of summer or the lows of winter cold, ensuring that the envelope meets a higher level of thermal performance with help deliver on this performance metric too.

We recommend considering the following options:

(i) EA Pre-requisite: Minimum Energy Performance:

Require fenestration and opaque wall components at a minimum meet the U-factor and SHGC prescriptive requirements of the baseline building. Give an exception for cases where design teams are achieving the same or better façade performance through other methods e.g. A project might have glass with higher SHGC than code allows, and then have exterior shading which more than compensates that which maybe be good strategy for maximizing daylight and transparency. This will allow for innovation in façade design, while still ensuring a minimum level of façade performance.

"*For projects using Normative Appendix G or Section 11 Energy Cost Budget Method, the performance of fenestration and opaque wall elements shall at a minimum meet the U-factor and*

SHGC requirements of the prescriptive path. Exception: Where an engineering analysis shows that the façade design achieves the equivalent performance as the façade in the prescriptive path."

(ii) EA Credit: Optimize Energy Performance

Require fenestration and opaque wall components which at a minimum meet the U-factor and SHGC prescriptive requirements of the baseline building, before points can be gained from energy performance over the baseline building for option 1: Energy Performance Compliance. Give an exception as above to allow for innovative designs that deliver the same or better façade performance.

Option 1: Energy Performance Compliance

Insert at the end of the first paragraph: *"The performance of fenestration and opaque wall elements shall at a minimum meet the U-factor and SHGC requirements of the prescriptive path of ASHRAE Standard 901-2016*. *Exception: Where an engineering analysis shows that the façade design achieves the equivalent performance as the façade in the prescriptive path."*

(iii) Credit Bundling 1 :

Award 1-2 additional points to projects which have fenestration that at least meets the prescriptive U-factor and SHGC requirements while either (1) achieving a point from the thermal comfort in the IEQ credit area (where teams have demonstrated thermal comfort has been achieved in the perimeter zone) or (2) Option 1 of the pilot passive survivability credit (LEEDv4) or (3) meeting the requirements of a condensation resistance credit (see new proposal).

(iv) Credit Bundling 2:

Do not allow points to be achieved in the EA: Optimize Energy Performance credit area to be achieved without achieving (1) thermal comfort credit (with performance measured in the perimeter zone) or (2) achieving condensation resistance performance (see new proposal) or (3) achieving the pilot passive survivability credit option 1 (LEEDv4).

There are improvements that we would recommend (and which are referenced above) be implemented in the IEQ credit area (see other improvement suggestions from the Façade Tectonics Institute) to better manage thermal comfort near fenestration and indoor air quality that could provide a more effective way to ensure that the envelope is designed in a way that delivers good indoor environmental quality in the perimeter zone. In this way the LEED program would be guarding against the achievement of whole building energy performance improvements at the expense of human comfort and well-being in the perimeter zone.

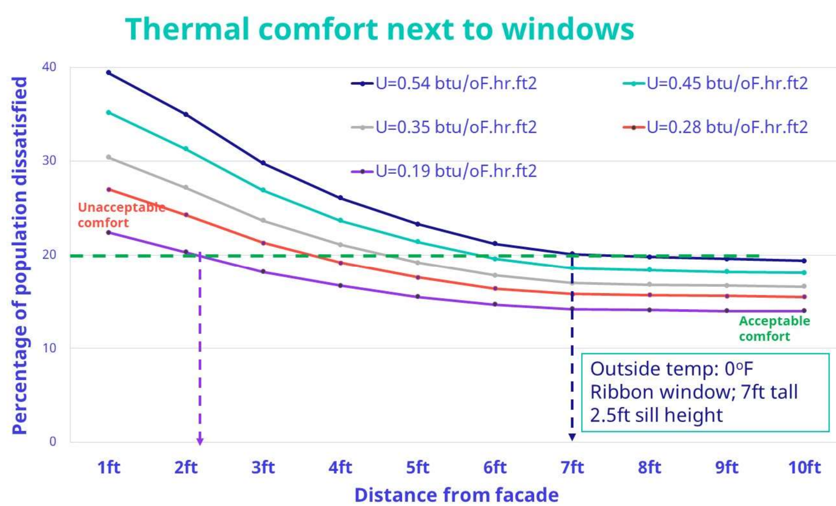
PROPOSAL

IMPROVE DELIVERY OF THERMAL COMFORT NEAR FACADES

Background

The façade can significantly impact the mean radiant temperature of the perimeter space of a building due to long wavelength radiation from hot or cold glass and metal window surfaces and from short wavelength direct solar impingement through the glass. Thermal comfort next to a façade remains a significant problem because of uneven radiant temperatures, convective drafts next to cold windows and direct solar impingement coupled with the challenges with managing this through HVAC design.

To demonstrate the impact of fenestration on perimeter zone comfort, below is some data generated based on ASHRAE 55 for comfort next to a façade with ribbon windows extending from desk height to ceiling with a variety of thermal performance for an outside temperature of 0°F, in the absence of perimeter heat and including the impact of downdrafts (https://www.payette.com/glazing-and-winter-comfort-tool/). The LEEDv4.1 EA baseline requirements are based on ASHRAE 90.1-2016. As an example, the U-factor requirement for 90.1-2016 in zone 6 (Minneapolis) is 0.36 btu/°f.hr.ft^2, which in this example would require occupants to sit almost 5 ft away from the façade to achieve comfort.



LEEDv4.1 has been updated to include the latest version of ASHRAE Standard 55 (2017) which includes methods to address the significant impact of solar radiation and other improved calculation methodologies. Effective thermal comfort design according to ASHRAE 55 requires a realistic mean radiant temperature (MRT) to be inputted into the calculation method, and for uneven MRT, downdraft and direct solar radiation impingement at the façade to be adequately considered. To ensure that projects are adequately evaluating and addressing these issues, we recommend that documentation be provided to demonstrate robust compliance and that appropriate analysis has been done, especially around the building perimeter.

Also, the current option 2 in this credit area which allows for use of the ISO standard does not account for envelope effects such as direct solar impingement. According to the thermal comfort experts at UC Berkeley's Center for the Built Environment (CBE), the standard is outdated compared to ASHRAE Standard 55 and should not be used for effective comfort design (Dr. Ed Arens, CBE). We recommend removing the option for using ISO/CEN methods for determining comfort.

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Recommendation

IEQ: Thermal Comfort

Option 1. ASHRAE Standard 55-2017

Insert the following text: *Submit documentation to demonstrate that the design team has accounted for the following aspects of thermal comfort in their compliance with ASHRAE standard 55:*

- *Mean radiant temperature (long wavelength infrared) asymmetry at the façade*
- *Mean radiant temperature*
- *Direct solar transmission (short wavelength infrared radiation) at the façade*
- *Downdraft at the façade*
- *Operative temperature*

For spaces where the design team expects solar impingement, the SolarCal portion of the CBE/ASHRAE 55 thermal comfort tool must be completed or the relevant Standard 55 prescriptive approach table submitted as documentation.

Option 2: ISO Standards

Recommend removing this option