# Transitions: How to Design Facade Interfaces

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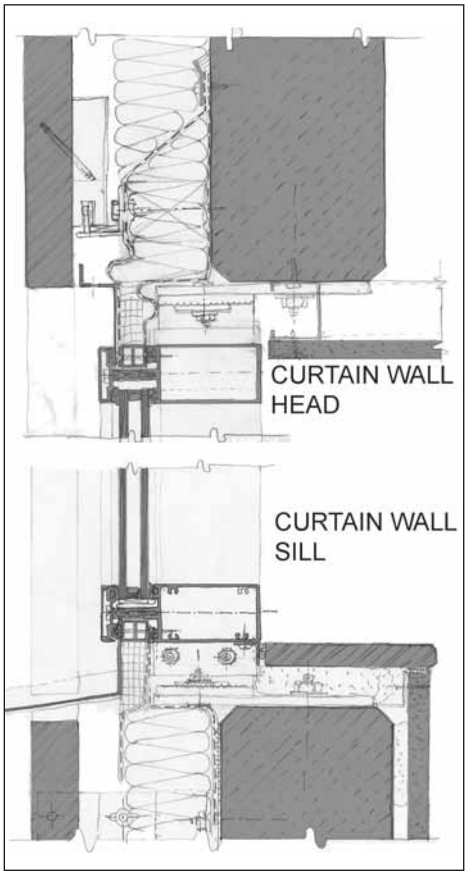


*Figure 1. Details to be analyzed.*

THE WALL PERFORMS A number of functions. The elements responsible for performing these functions must be continuous throughout an enclosure, particularly at the transitions (for example, at the interfaces of fenestration with adjacent assemblies). A discontinuity almost always causes a functional weakness or outright failure. In my practice I use a system of layering that helps me accomplish the principles of facade engineering. I visualize layers for waterproofing, thermal insulation, vapor retarder, air barrier, etc. The goal is to keep all layers continuous, no matter what part of vertical or horizontal section of building envelope is analyzed.

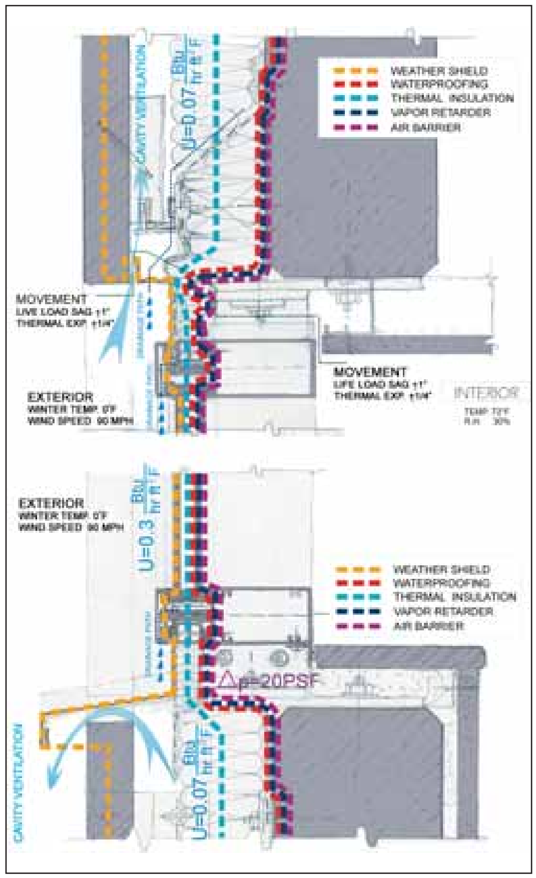


*Figure 2. Analysis of details.*

**Figure 1 and Figure 2** are an example of an analysis performed on curtain wall details. The building enclosure's layers are represented with colored, dashed lines. In this example, not only are all the major layers kept continuous, but also no sealant is used to perform any essential facade function. This type of rainscreen detail is seldom seen in the U.S. The rain screen wall is unfamiliar to many contractors and comes with a greater initial cost for owners.

The typical layers include: weather screen, insect or bird screen, vapor-permeable waterproofing, vapor-impermeable waterproofing, thermal insulation, acoustical insulation, fire isolation, smoke isolation, vapor barrier and air seal. Special layers may include blast resistance, burglar resistance and bullet resistance.

Most of these functions can also be tagged with the required unit and value, for example *fire rating min 1hr, vapor retarder max 1 perm (57 ng/s• m²• Pa), air barrier min 45 psf (2,155Pa),* etc. This is particularly useful where the values change, for example where horizontally positioned R20 (RSI-3.10) insulation transitions into vertical R10 (RSI- 1.76) insulation.

*Bird screen interrupted at each mullion of a stepped curtain wall.*

*Figure 3.*

*Figure 4.*

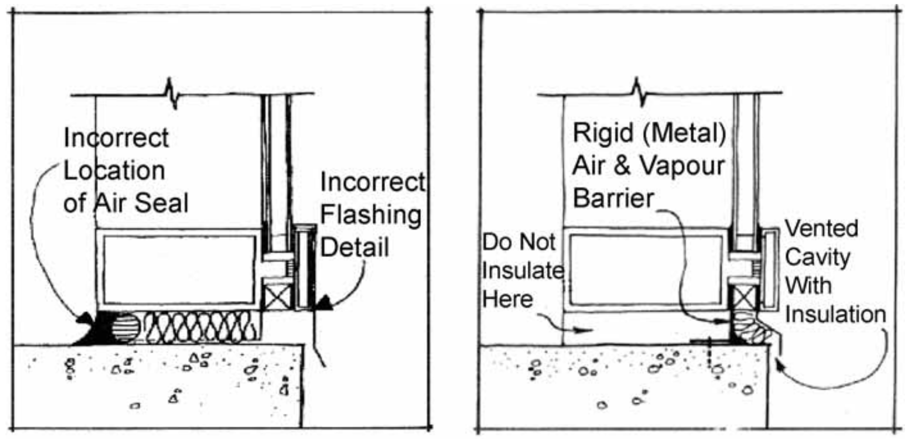


*Figure 5. Source: R.L. Quirouette, "Glass and Metal Curtain Wall Systems".*

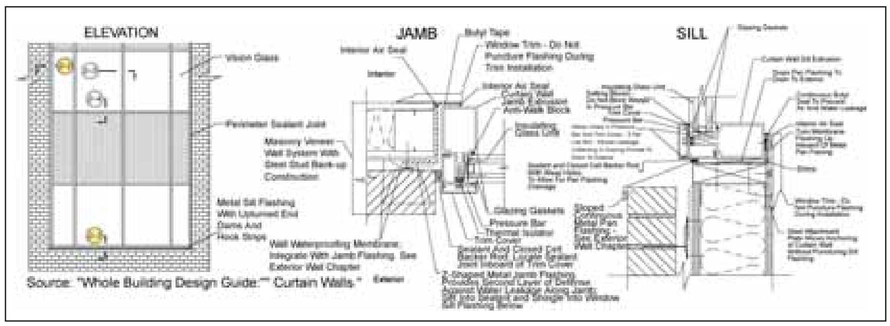


*Figure 6.*

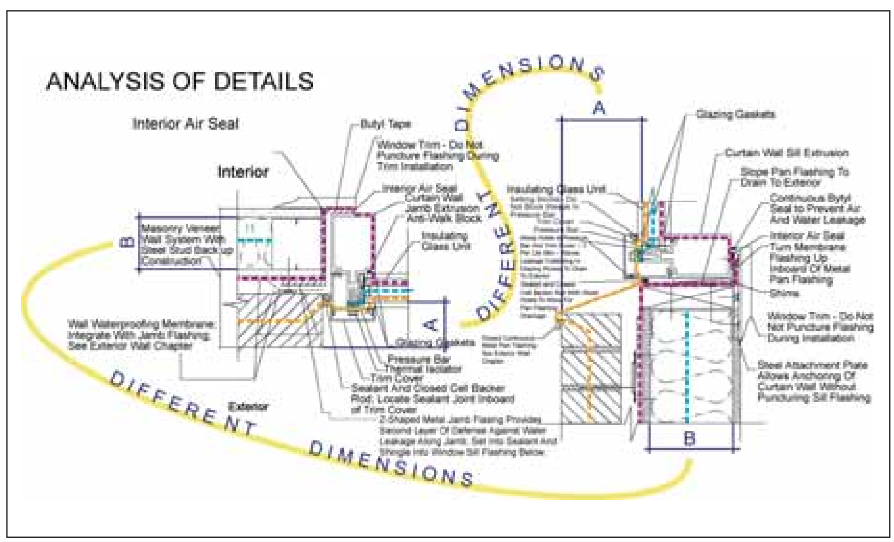


*Figure 7.*

Some materials perform more than one function. The most demanding applications will require particular focus on the choice of the proper material and connections. In this example, the perimeter membrane acts as the waterproofing membrane, the vapor retarder, and the air barrier all in one. In this case the most demanding function is the air barrier because a membrane material has to resist perhaps 20psf (958Pa) positive and negative pressure differential or more, and transfer the load to the assembly. Design wind pressure establishes the performance criteria and describes the in-service need for physical durability of the layer, as opposed to the 1.57psf (75Pa) air permeance testing pressure listed in ASTM E2178 which merely establishes acceptability as an air barrier material.

In **Figure 1 and Figure 2**, one would specify a thick, puncture-and-tear-resistant elastomeric membrane, mechanically clamped at its terminations. A metal flashing would be inappropriate because of the vertical movement the flashing has to accommodate at the head.

Once one determines exactly what function is performed by the particular material, one is more likely to avoid common mistakes. One common mistake in this example is the placement of insulation below the bottom mullion and above the top mullion. As a result of this action, condensation forms on the interior side of the vapor barrier in cold climates. Once one realizes where the vapor barrier is located, this mistake should not happen. See **Figure 5**, reprinted from "Glass and Metal Curtain Wall Systems" (R. L. Quirouette, http://irc.nrc-cnrc.gc.ca/pubs/bsi/82-3_e.html).

All sections of the enclosure opening have to be designed in one process: jamb, head, spandrel, sill, etc. The layers pictured at each section must be located at the same respective wall depth and position around a perimeter of an opening. Otherwise, a wall would be non-constructible, or gaps in the corners would be created. A common error of this kind is demonstrated by the two details reproduced below which belong to the same, straight masonry opening, according to the elevation.

Note in **Figure 6** how the distance between the face of the curtain wall and the brick veneer varies. The analysis of the weather shield continuity allows for an early detection of such an error. The analysis of the details above reveals also some other problems. We encourage the reader to analyze these details in context (available at www.wbdg.org/design) and compare with the logic presented in this discussion.

The major facade layers are penetrated at the anchors. The support function should be decoupled from the need for sealing; these two functions are typically done by different trades and specified separately. See **Figure 7**. The thermal insulation is discontinuous, bridged by conducting elements and the vapor retarder is placed on its outer side, suggesting the details are unsuitable for a cold or mixed climate. Note the incorrect placement of

Figure 8. Examples of transom discontinuity.

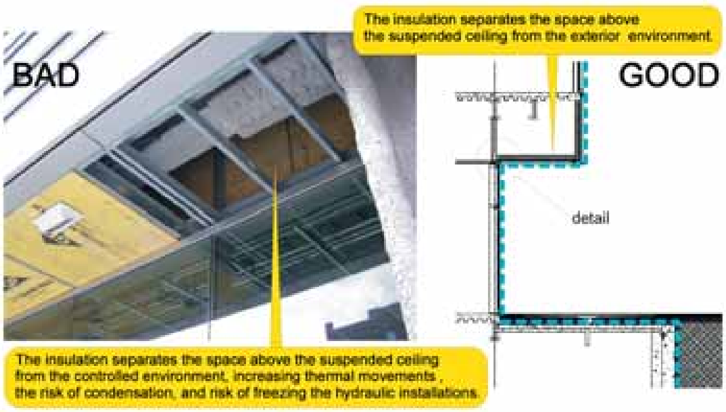


Figure 9.

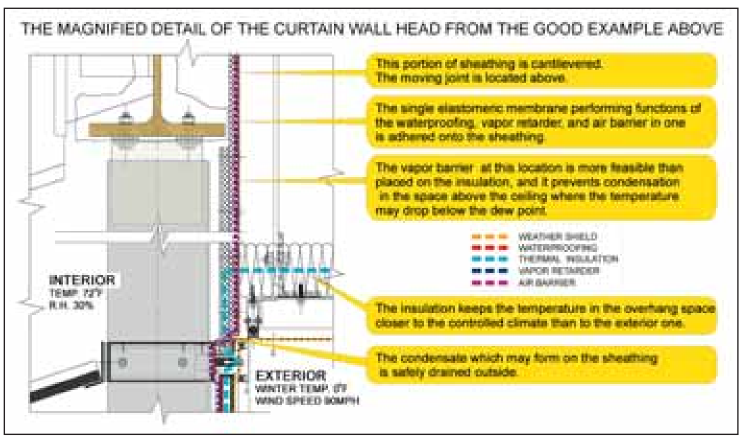


Figure 10.

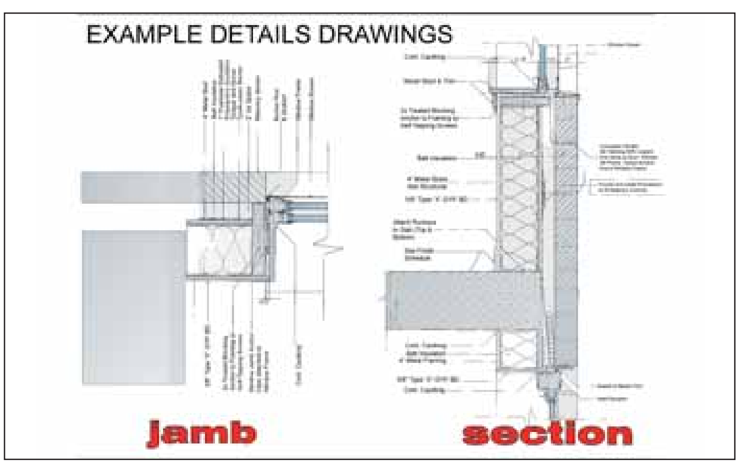


Figure 11.

air barrier, sealed to the non-continuous bottom transom. This error is particularly evident at the corners of a curtain wall. This is also a potential problem when a designer decides to use a transom different than a mullion, either for economy or aesthetics—see **Figure 8** showing a corner of a curtain wall sill.

The principle of continuity holds true no matter what scale is considered. In the scale of the whole building, a designer has to determine where the layers are located with regard to all rooms and partitions. Typically, the forgotten spaces are those above suspended ceilings of overhangs, resulting in bursting, frozen plumbing in cold climates. According to ASHRAE statistics, frozen sprinkler pipes are the biggest single cause of mold in New York City.

See **Figure 9** showing the properly conditioned overhang space and the photograph showing the unconditioned space separated thermally from the building by the insulated wall. See **Figure 10** for magnified detail of the curtain wall head from the good example above.

A different, but equally important example is a frequent violation of fire and smoke compartmentalization in cavity walls. Typically a rated slab is bypassed by an exterior wall cavity, which in turn opens to the building interior at deflection joints, and is not sealed by rated materials at the fenestration openings' perimeters above and below.

Fire and smoke transmission among compartments is further assured by stack or chimney effect. See **Figure 11** for detailed drawings of a masonry wall with a loose lintel in a high-rise building and the photographs taken in **Figure 13 and Figure 14**, in the field. In this example, the outer sheathing of the backup wall is made of combustible plastic foam. The distance between the loose lintels and the slabs varies from floor to floor; the resulting gap effectively connects compartments. The designer not only forgot about the fire code, the building is located in a cold climate zone too. As a result, the risk of condensation is increased because the thermal insulation layer is interrupted, and is unprotected by a vapor retarder; thermal bridging is effected by concrete, metal, and wood elements. The spacing of brick veneer ties do not meet code, but this problem is irrelevant to the current discussion. See **Figure 12**.

The photos in **Figure 13** were taken when the brick veneer was already being erected, after the substrate had been accepted by the masons. The joints around wall panels remained unsealed; an observer can see through the crack. Moisture problems are likely to develop due to the condensation induced by an unpredictable pattern of air leakage and discontinuity of the drainage plane. The mechanical system may negatively pressurize the interior walls and suck the humid outside air inside in summer; a positive pressure in the apartments would blow the moist interior air to the outside in winter. The interruptions of both the lintel and the thru-wall flashing ensure chimney effect in the wall

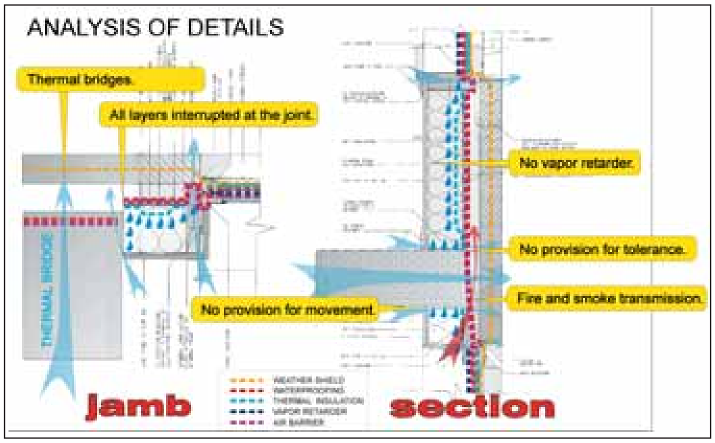


*Figure 12.*


*Figure 13.*


*Figure 14.*

cavity. A transfer of insects, odors and sound among apartments through the open cavity are among probable side effects.

The photos in **Figure 14** show the misalignment between the face of insulating sheathing and concrete. The tape reads over 2 in. (5 cm). In the above drawings, construction tolerances, particularly the cast-in place concrete tolerance is not anticipated. The air barrier was installed in a discontinuous fashion which creates problems.

Continuity must also be maintained through movement joints. An average curtain wall typically has several movement joints differing in direction and magnitude of designed movement. Typically the floor deflection joints are most vulnerable. Each layer has to be constructed in such a way as to accommodate the designed movement.

The process of design sometimes requires compromises. If you follow this method, you will soon discover that many popular design practices, materials and systems don't work, and no economical method may exist to solve the problem and keep the layers continuous. Remember, there are two price tags attached to each compromise: the long term cost and the initial cost. Many good solutions are available from countries employing sophisticated construction techniques, including Great Britain, Germany and Canada. My favorite example is thermally broken lintels and balcony slab systems produced by foreign manufacturers. See **Figure 15 and Figure 16**. There is an increasing demand for them in North America. ■

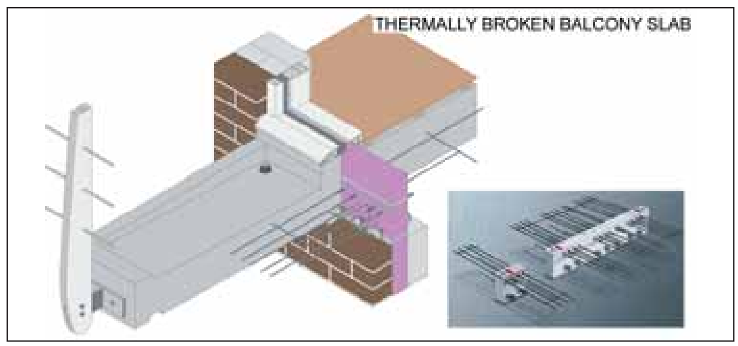


*Figure 15.*

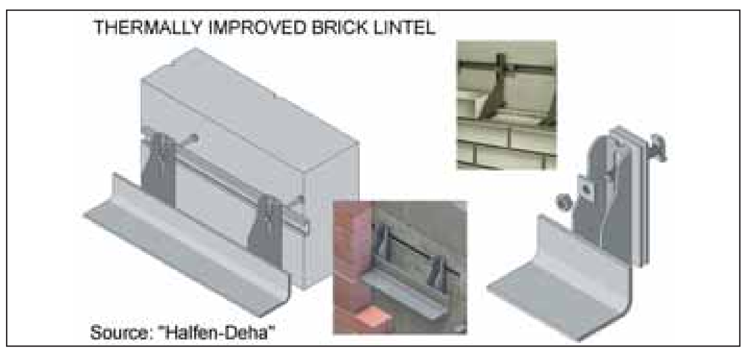


*Figure 16.*

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**SUGGESTED LITERATURE:**

American Society of Heating, Refrigerating, and Air-Conditioning Engineers, "Applications Handbook" Chapter 42 "Building Envelopes."

R.L. Quirouette, "Glass and Metal Curtain Wall Systems." NRC, 1982. http://irc.nrc-cnrc.gc.ca/pubs/bsi/82-3_e.html

Thomas Herzog, "Facade Construction Manual." Birkhauser, 2004.

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