EARLY TWENTIETH CENTURY TRANSITIONAL FACADES IN THE UNITED STATES: COMMON MALADIES

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SUMMARY

Early twentieth century transitional facades represent a technically problematic transition between earlier and later types of wall construction. As such, they are prone to problems uncommon in earlier or later buildings.

1. TYPICAL CONSTRUCTION

Many United States cities have a large stock of buildings with “transitional” facades that were frequently constructed in the U.S. from the 1890s until the mid 1900s. In their design and construction, these facades are a technical transition between the load-bearing mass-masonry barrier walls that preceded them and the modern curtain walls that succeeded them. With time and exposure to the elements, the inherent design shortcomings in these transitional facades are now evident. In many cases, fracture and loss of facade materials constitute a potential threat to public safety. Understanding how these facades are different from earlier or later walls is critical to understanding their particular problems and designing appropriate repairs.

The transitional facades were constructed with a structural “skeleton” frame of steel or, less commonly, reinforced concrete. Back-up masonry 20 cm (8 in.) thick consisting of brick or hollow clay tile, supported on the spandrel beam, fills the perimeter frame. The masonry and concrete floor slab encase the structural members in masonry. An outer wythe of masonry 10 cm (4 in.) thick consists of brick, stone, terra cotta, or cast stone, often in combination. A filled collar joint and headers or metal anchors bind the outer wythe to the back-up masonry, making the two composite. Figure 1, from a 1923 text, shows typical details in plan (below) and section (above). As shown in the Figure 1, secondary steel was used on some buildings to provide intermediate support for the outer wythe of masonry, while on others, the outer wythe was supported only at grade.

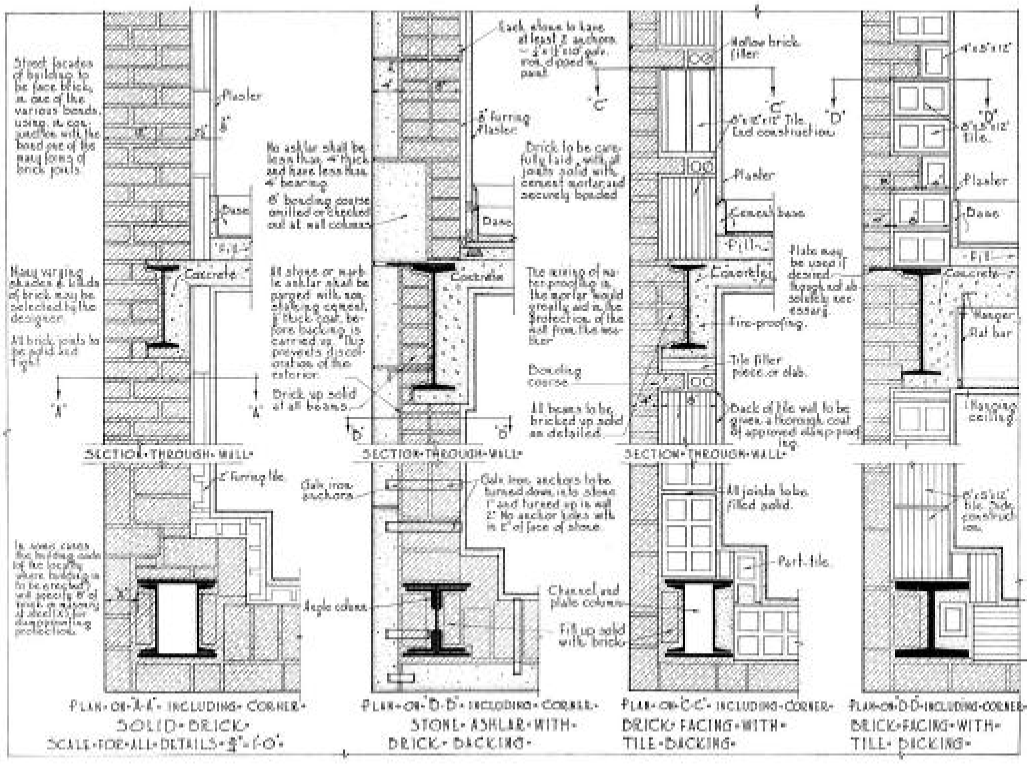
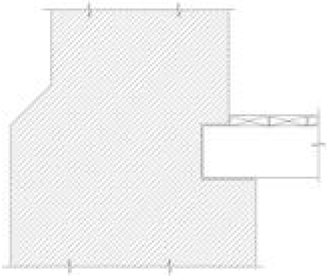


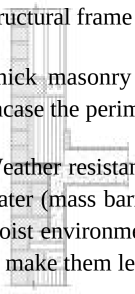
Figure 1 – “Curtain Walls” from *Good Practice in Construction*, by Philip Knobloch, 1923, Pencil Points Press (Reprinted with Permission).

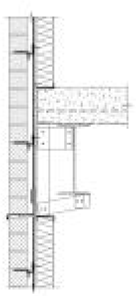
As outlined below in Table 1, the transitional facades employ a fundamentally different design approach than earlier or later walls.

Table 1 – Classification of Common Types of Masonry Wall Construction



Load-bearing mass masonry barrier walls ?? Common before 1890. ?? Thick, composite masonry walls support floor loads. ?? If the wall settles or moves, the floor framing “rides” with the wall. ?? Weather resistance: The massive masonry wall functions as a reservoir to absorb and evaporate water. In some cases, interior finishes are furred off the wall to make them less prone to moisture-related damage.	
Transitional hybrid walls ?? Common from the 1890s until WWII. ?? Floor loads and back-up masonry are intended to be carried by the structural frame (steel or concrete). ?? Thick masonry walls (not the intended primary gravity load support) encase the perimeter of the structural frame. ?? Weather resistance: Walls function as a reservoir to absorb and evaporate water (mass barrier wall) – Embedded structural framing is subjected to a moist environment. In some cases, interior finishes are furred off the wall to make them less prone to moisture-related damage. ?? The outer masonry, back-up masonry, and structural frame are NOT detailed to allow for differential movement.	





Modern curtain walls ?? Common after 1950 ?? Floor loads carried by structural frame (steel or concrete). ?? Thinner, lighter skin “rides” with frame. ?? Skin and frame detailed to accommodate differential movement. ?? Weather resistance: Thin skin cannot function as a reservoir; thus, skin employs a drainage plane or surface-sealed barrier approach. The structural frame is isolated from the “wet-zone” of the wall.	

2. PROBLEMS

Two distinct features of transitional facade construction cause many deterioration problems: the lack of detailing to accommodate differential movement, and a reliance on the exposed mass masonry wall to prevent water ingress and resultant corrosion of the embedded structural steel.

2.1 Differential movement

Over time, fired-clay masonry materials (e.g., terra cotta and brick) experience irreversible expansion as they gain moisture. Conversely, cementitious materials (e.g., reinforced concrete and cast stone) experience irreversible shrinkage. Structural frames may move due to gravity-load deflection, lateral sway, or foundation settlement.

In earlier load-bearing mass masonry walls, if brick walls moved upward from thermal or moisture-related expansion or moved downward due to settlement, the structural floor framing (wood beams) supported by the walls simply moved along with the wall.

In modern brick veneer walls, adjustable veneer ties and horizontal and vertical soft joints allow for differential vertical movement between the brick and the structural frame. For example, if the brick moves upward from moisture-related growth while the spandrel beam moves downward due to deflection, the veneer ties and the soft joints below shelf angles allow this differential movement to occur without creating additional stresses in the outer wythe of masonry.

The transitional facades are built in such a way that they often promote differential movement between the outer wythe of masonry and the structural frame. The outer wythe of masonry is often brick or terra cotta, which are prone to irreversible moisture-related expansion. However, the details are not designed to accommodate this movement. The outer wythe is built as composite with the back-up masonry without expansion joints, and the connections to the back-up masonry (such as headers) are rigid and do not allow for movement. Thus the outer wythe of masonry, the back-up masonry, the structural frame, and intermediate steel supports (shelf angles and/or loose lintels) are rigidly "bound together".

Figure 2: Buckling of terra cotta

If the outer wythe masonry expands but is restrained by the structure, it will eventually crack, spall, or buckle under the accumulated stresses. For example, in high-rise buildings clad with terra cotta, high stresses can accumulate in columns, causing buckling of the terra cotta masonry (Figure 2). At columns where the outer wythe of masonry is vertically continuous for the full height of the building, thermal and moisture-related expansion accumulates over the full building height (these buildings are often between six and thirty stories tall). If the structural frame is reinforced concrete, the columns will shorten over time, exacerbating the problem. Strain relief or flat-jack testing can be used to estimate the level of stress in the terra cotta. In situations where the terra cotta stresses are not excessive, repair often involves cutting expansion joints between the terra cotta block and the underside of steel shelf angles to relieve the stress, installing a compressible sealant joint to accommodate future movement without accumulating stresses, and then repairing the fractures in each terra cotta block.

Often thermal and moisture-related expansion of an outer wythe of brick will cause the brick headers to shear at their juncture with the back-up masonry. Failed headers reduce the out-of-plane bending resistance of the wall because the inner and outer wythes cannot work in a composite manner in lateral bending. Failed headers also reduce the lateral restraint (out-of-plane) of the outer wythe by the back-up masonry and frequently contribute to bulges and deformation of the outer wythe (corrosion of embedded steel often causes bulging). Bulged masonry with sheared headers (lacking out-of-plane restraint) can be highly stressed and potentially unstable if long horizontal areas of the mortar joints are cut to install expansion joints or repoint masonry. In such cases, flat-jack testing and analysis may be used to estimate in-situ stresses in the outer wythe so that a safe means of repair can be established.

We observed an unusual and dramatic consequence of outer wythe expansion in a building with a reinforced concrete frame with an outer wythe of brick connected to the hollow clay tile back-up masonry by frequent headers. Shrinkage and creep of the concrete frame (moving downward) in combination with thermal- and moisture-related expansion of the brick (moving upward) caused the outer brick to lift the hollow clay tile back-up off its support at the spandrel beams at the upper floors of the building (Figure 3). In this case, our repair involved packing the joint between the concrete frame and the underside of the hollow clay tile to re-establish gravity support for the back-up.

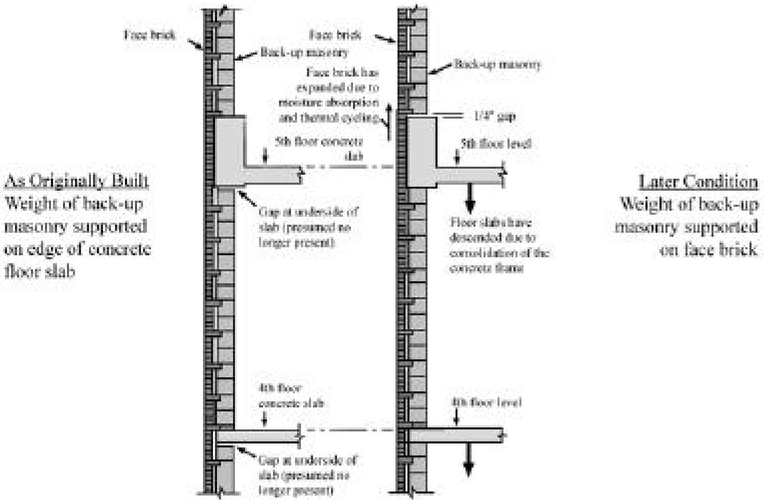


Figure 3: Expansion of brick outer wythe lifted back-up masonry off structure

2.2 Weather resistance

Earlier structures that rely on the mass of the masonry for weather resistance are different from the transitional facades in two critical ways: the earlier walls were typically thicker than the transitional facades, which are often about 12 in./30 cm thick, and the early masonry buildings did not have structural steel framing and steel secondary members embedded in the masonry.

Water penetration of masonry walls is inevitable. Water can penetrate into the wall of transitional facades through many avenues, including: mortar joints (particularly deteriorated or cracked joints); masonry units (particularly cracked or deteriorated units); windows (particularly at perimeters and frame corners); and through horizontal masonry surfaces (such as parapets, sills, and water tables). Without protection from impervious materials such as metal flashing, water lingers on these surfaces and is slowly absorbed into the core of the brick wall.

In transitional facades, a serious consequence of moisture within a wall is corrosion of embedded steel (secondary steel and structural frame). The first steel to corrode is usually the secondary steel found close to the surface of the facade such as lintels and shelf angles. As steel corrodes, it expands, exerting tremendous pressure on the surrounding masonry and causing cracking, spalling, and displacement (Figure 4). One of the most serious corrosion problems occurs when the corrosion reaches the structural steel frame. Often, an early sign is the appearance of bulges or vertical cracks in the masonry facade over the columns, particularly at the corners.

gure 4: Cracks in terra ta due to corrosion of derlying steel column.

While some relatively new methods of corrosion protection, such as cathodic protection and corrosion inhibitors, are being implemented on steel-framed transitional facades, these methods seek only to prevent further corrosion and *not* to remedy existing corrosion. To remediate a sectional loss of embedded steel members, the common method of repair is to expose the deteriorated member by removing masonry, supplement or replace the steel member, and reinstall the masonry. During structural repair, traditional techniques (cleaning, painting, and flashing) or newer methods (cathodic protection, corrosion inhibitors) can provide corrosion protection for the steel.

3. CONCLUSIONS

Early twentieth century transitional facades are fundamentally different than their predecessors and successors. As a result of inherent shortcomings in their original design, many now require extensive repair.