

# Creative Solutions for Challenging Curtain Wall Conditions

By Joshua B. Kivela, PE  
and Derek B. McCowan, PE



## INTRODUCTION

Aluminum-framed curtain walls are highly engineered, popular, attractive wall systems that are often used for feature areas of buildings as well as for entire building façades. While the manufacturer's standard details and performance tests address typical field-of-wall conditions and performance issues, the desire to improve performance of atypical details often requires forethought and creativity.

The authors have experience designing various types of curtain wall systems, investigating problems with existing systems, and observing curtain wall construction—both in the factory and in the field. This article will present some solutions developed to help design and installation teams to overcome project challenges and meet aesthetic design objectives for common and unusual detail conditions encountered on recent aluminum-framed curtain wall projects.

## ANCHORAGE

### Unitized Curtain Wall Anchors

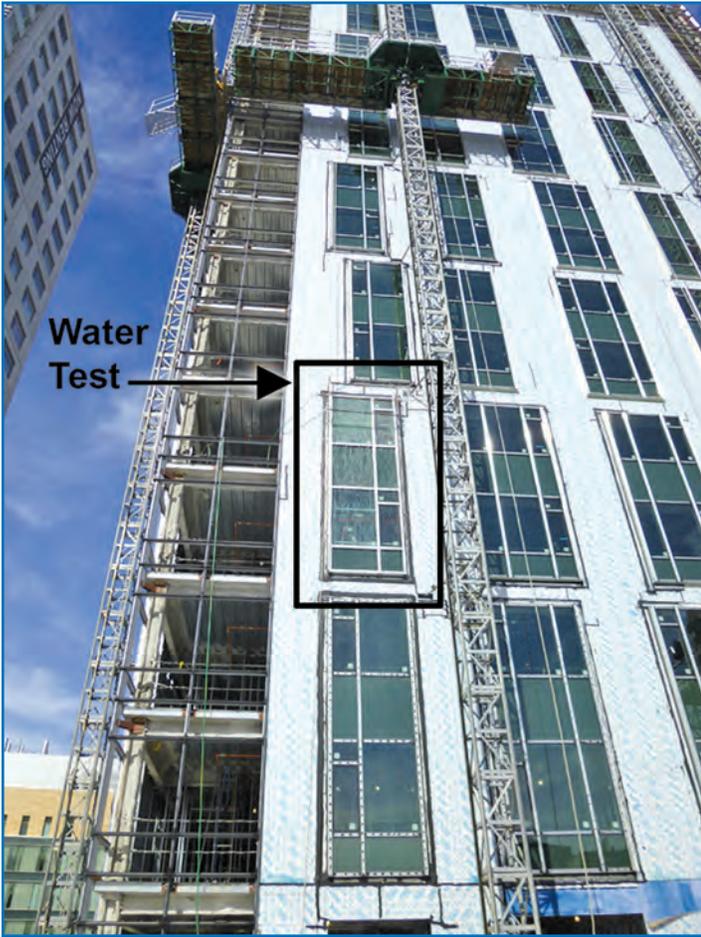
Anchor plates for multistory unitized curtain walls are often recessed into the top surfaces of concrete floor slabs (*Photo 1*). Providing recessed anchor conditions has a number of benefits, with the primary one being that interior flooring is not interrupted at each curtain wall anchor. The recessed areas are typically grouted solid after installation and final adjustment of the completed curtain wall anchor assemblies.

These slab cutouts should be considered during the original design of the building structure; adequate thickness and reinforcing is needed at the slabs, and pour stops or other edge metal (if present) must be interrupted. If the cutouts are not reviewed until the curtain wall subcontractor becomes involved and the structural design (and perhaps some structural work) is already complete, the slab edge conditions may not be adequate to accept the cutouts. This could wreak havoc on the design intent for the interior floor and wall finishes and/or require installation of more-complicated and costly slab edge anchor assemblies.

It may be tempting to eliminate these cutouts at roof levels (where flooring is not present) in order to save cost, though doing so may have unforeseen consequences. Roof membranes may be located several inches above the curtain wall anchors, though roof vapor barriers are normally located down on the top surface of the structural deck. Experience from past projects has shown



*Photo 1 – Unitized curtain wall anchor.*



*Photo 2 – Multistory modular curtain wall units installed with glazing pocket anchors.*

that installation of roof vapor barriers at curtain wall anchors is extremely challenging and often poorly executed. Anchors may need to be “boxed out” with plywood or sheet metal to allow a reliable membrane wrapping, and the added cost of the boxes may offset the savings discussed above.

Most anchorage components consist of carefully engineered and machined aluminum parts. It is good practice to use anodized or painted aluminum for these components to provide a barrier between the aluminum and the cementitious grout used to fill the cutouts. If bare (mill) aluminum is used, a field-installed coating, such as a spray- or brush-applied bituminous product, can be used after installation.

### **Glazing Pocket Flange Anchors**

Unitized curtain walls are often a viable alternative to field-built systems. Although most commonly used for continuous cladding on large building façades, these pre-manufactured systems are gaining popularity for use in multistory punched openings (*Photo 2*). When these large, modular cur-

tain wall units are fitted with perimeter glazing pocket flange anchors, the installation is often faster and the construction of higher quality compared to stick-built systems. This construction includes the interface with the walls that form the rough opening.

A glazing pocket flange anchor is an extruded aluminum section that consists of two main components: 1) A flange (similar to a nailing flange on a vinyl window), and 2) an adapter that fits into the glazing pocket. The adapter is commonly square-, U-, or F-shaped. The adapter must be designed to fit securely within the glazing pocket, and it must be mechan-

ically attached and sealed to the curtain wall framing. The dead load of the curtain wall is initially transferred to the building structure through the glazing pocket flange anchor, so an analysis must be conducted to confirm that the flange anchors and the attachments to the curtain wall and the structure are adequate. If the curtain wall spans multiple floors, the corners of the glazing pocket flange anchors can be fully welded to improve strength and weather-tightness.

Installation of these modular units is similar to installing a flanged window. The curtain wall is hoisted into place, it is attached to the structure by fastening through the flange to the structure, and the flange is stripped in with flashing membrane. Depending on the size of the openings and the design loads on the walls (including the self weight of the curtain wall), supplemental dead-load and wind-load anchors may be required at floor lines. Slab deflection and thermal movement must be taken into account—e.g., by including slotted holes in the flanges and



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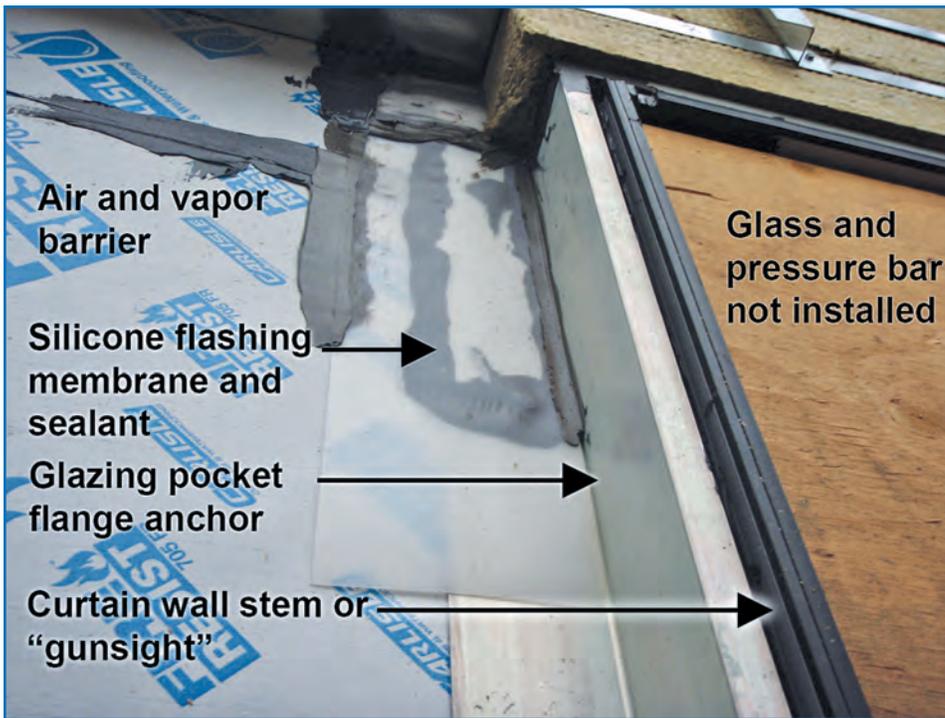


Photo 3 – Glazing pocket flange anchor sealed with silicone membrane.

by stripping in the flanges with a flexible membrane product such as an extruded silicone sheet membrane (Photo 3) or EPDM membrane. Typically, self-adhering rubberized asphalt “peel-and-stick” membrane cannot handle the shear forces present in the flashing membrane.

Field air and water testing (Photo 2) on

these units prove that high-water and air-resistant penetration levels can be achieved despite the fast installation. On a recent project in the northeast U.S., the curtain wall contractor installed 28 8-ft.-wide by 8-ft., 3-in.-tall weathertight curtain wall units in a single day. This advanced the construction schedule by allowing the inte-



Photo 4 – Membrane flashing installed in the glazing pocket around the perimeter of a curtain wall.

rior fit-out work to start much sooner than if the curtain walls had been stick-built in the field.

## PERIMETER FLASHING

### Sill Flashing

Perimeter conditions—and, in particular, sills—are common problem areas for curtain wall systems. Often perimeter conditions consist of only single or dual sealant joints, though use of a membrane or metal sill flashing will improve the durability and the performance of the interface. Two general approaches for flashing curtain wall sills are 1) extending membrane or metal sill flashing under the wall system (similar to window pan flashings) and 2) sealing and clamping a flashing member into the glazing pocket.

Sill anchorage is an important consideration when designing sill flashing conditions. Stick-built curtain wall systems are often supported by T-shaped or F-shaped anchors that bear directly on the top of a concrete slab or curb at the sill. Unitized systems normally include a continuous starter sill at the base of the wall. Both T/F anchors and starter sills include anchor bolts into the substrate below. Modification of standard anchorage details to simplify flashing work may be an option for some window systems, though it is typically not feasible for curtain wall systems (with the exception of the glazing pocket flange anchorage options discussed above).

When sill flashing pans are used, all anchor penetrations through the flashing should be sealed. These seals must be particularly reliable, because substrates for the anchors and flashing are typically not sloped toward the exterior. Water may pond around anchor penetrations on level or slightly depressed surfaces. To improve durability of seals, consider enhancing liquid adhesive seals with gasket-type seals between T/F anchors and flashing, or require membrane flashing covering the base of the T/F anchor. Though this traditional through-wall flashing method has been used successfully on all types of glazed systems, other flashing methods exist that take advantage of the mullion geometry and zoned drainage common to many stick-built curtain wall systems.

For stick-built pressure-glazed systems, where glazing pockets are accessible during installation, extending membrane flashing into the glazing pocket offers a good alternative to through-wall flashing. Since the

horizontal and vertical mullions are of similar shape, one flashing method can typically be used around the full perimeter of the curtain wall (Photo 5). Membrane flashing can be adhered to the outer face of the mullion “tube” and clamped securely into place using the pressure plate.

The design of the membrane flashing (sometimes called a transition membrane) should consider a variety of topics, such as:

- Spanning the gap between the curtain wall and the rough opening
- Accommodating deflections between the curtain wall and the building structure (as well as out-of-plane deflections)
- Compatibility with adjacent construction, including air barrier materials, curtain wall frame seals, etc.
- Build-up of materials in the glazing pocket
- Remaining airtight and watertight under design wind loads



Photo 5 – EPDM membrane flashing installed in the glazing pocket of a curtain wall.

This membrane flashing also provides added bond surface (when compared to traditional sealant joints) and can be particularly helpful in dealing with the hollow ends of vertical mullion extrusions, which can be extremely difficult to bond to reliably with sealant alone.

Several large manufacturers of building enclosure products (including at least one roofing company and several sealant manufacturers) now offer transition membranes designed specifically for these applications. These membranes are made of either uncured EPDM roofing or cured

extruded silicone membrane, two proven workhorse materials in the building enclosure industry.

### Corners

Inside and outside corner conditions are present in almost every curtain wall job, though project requirements at corners vary significantly by project. Many manufacturers offer a variety of “standard” options. One common option includes a single extrusion installed on an angle. Another common option consists of using two independent extrusions and a metal

closure panel installed in between (sometimes glazed into the glazing pocket of each of the two mullions).

Use of a single, angled mullion extrusion results in true continuity of the glass and aluminum curtain wall system through the corner transition. Horizontal mullions continue around corners; and at the top and bottom of the corner, the mullions can be similar to those elsewhere in the wall system.

If two independent mullions are used (which is very common), the air, water, and thermal barriers of the glazed curtain wall

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Photo 6 – Curtain wall corner.

system may be discontinuous unless special provisions are added. Sometimes no seal of any kind is provided between the two vertical extrusions, leaving the closure panel as the only protection from the weather.

A more robust design includes continuous backup protection such as membrane underlayment or, as a minimum, a sealed sheet metal pan at these “open-corner” conditions. It is best to consider these areas as wall perimeters or jamb conditions (i.e., interruptions of the curtain wall) where perimeter flashing is needed.

Silicone sheet and sealant (Photo 6) may be a good choice for the membrane/flashing because it would likely be compatible with the curtain wall frame seals already present. Other membrane options are available, such as EPDM and peel-and-stick rubberized-asphalt membrane, though compatibility and adhesion with the associated frame sealants must be addressed. Membrane flashing should either extend into the vertical glazing pocket at each mullion (as noted above for perimeter flashing) or, as a minimum, should extend to the outer edge of the vertical extrusion.

Confirm that all frame joints in the area, including vertical mullion splice joints, are fully sealed to avoid leaving any potential

pathways for air and water migration.

Occasionally, designers desire creative and unusual corner conditions at glass and aluminum curtain walls, such as “mullionless” corners. Attractive corners like these can sometimes be achieved through careful engineering and installation (at least for moderate glass sizes), including installation of welded steel mullion reinforcing, vertical tension rods, and other measures to ensure stability.

When considering unusual designs like this, conduct a full engineering assessment of all related loads and deflections, including review of deflections of glass and framing collectively (in combination).

#### CANOPIES AND SUNSHADES

Canopies and curtain walls are both attractive systems and can be very functional; as such, both are often present near building entrances. Canopies often include semitransparent glass, metal panels, roofing, or an open trellis-style system. Sunshades provide a similar appearance to open (discontinuous) canopies, though they are often smaller and may be located at multiple floor levels. Due to their size and horizontal orientation, canopies often must resist significant vertical loads (snow, wind, self-weight, etc.) and, therefore, typically require structural steel supports. Steel supports normally must anchor back to the base building structure. Sometimes the steel supports require a structural thermal break

where they penetrate the exterior walls to help avoid condensation and to improve thermal performance, though the design of the structural steel is outside the scope of this article. Attaching supports to aluminum curtain wall framing is often feasible for sunshades of moderate size, but this is typically not practical for large canopies.

Some designers elect to interrupt the vertical curtain wall at canopies, which is understandable, as the canopy seems like a natural interruption of a vertical wall system (Photo 7). If the wall areas above and below the canopy are intended to be in the same plane, however, it is often feasible to extend the curtain wall continuously past the canopy. Locations of steel canopy supports can be coordinated with aluminum mullion framing so that the curtain wall mullions are not interrupted by the steel. Horizontal mullions can be required several inches above and below the steel elements to “box out” the steel penetrations in openings of moderate size. Sheet metal back pans can also be provided to close the opening between the mullion framing and around the steel supports, and a combination of membrane flashing and sealant can be used to seal the steel penetrations and back pan perimeters (Photo 8). Deflection of the canopy supports should be accommodated and can often be accomplished using flexible membrane products. Treating canopy support conditions in this way allows designers to create continuous weathertight wall systems prior to installation of canopy cladding or roofing (where applicable). The result is redundant protection.

As noted earlier, sunshades are small-



Photo 7 – Canopy installed between curtain wall segments.



Photo 8 – Canopy installed through continuous curtain wall.

er and less disruptive to exterior curtain wall systems, though they can still prove to be a challenge to design and construct. Many manufacturers now offer standard attachment details that may be feasible for shades of small to moderate size. The standard brackets often attach to exterior mullion stems, which provide a variety of benefits, such as avoiding notching through tube mullions (which can be a structural and weatherproofing issue) and allowing some thermal separation. Pressure-glazed curtain wall systems are often more receptive to sunshade systems than structural silicone-glazed (SSG) systems because they include the stems/“gunsights.” SSG systems often require more creative and complex detailing for sunshade supports.

If the curtain wall is being installed in smaller punched openings or bays, consider attaching the sunshades to the adjacent opaque wall system, and avoid penetrating the curtain wall system altogether. Cavity wall systems at opaque wall areas often include membrane underlayment and liquid-applied membrane products that are well suited for flashing sunshade supports. While some of the preengineered sunshade brackets now available are designed well, often the most reliable approach to dealing with a penetration through a fenestration system is to avoid it altogether.

### PARAPETS AND RAILINGS

Many contemporary building designs incorporate glass and metal curtain walls that extend above rooflines to form guardrails and parapet walls. These design features present several technical challenges that must be resolved.

projecting balconies, terraces, or other forms of outdoor space on buildings, this guard height should be coordinated with waterproofing and paving to ensure that this minimum height requirement is met even after installation of components such as tapered concrete, insulation, waterproofing, pavers, or other forms of terrace walkways.

The projecting portion of the curtain wall and all attachments must be designed to resist code-required loads for a guardrail. The curtain wall design must provide sufficient capacity, rigidity, and reliability, while accommodating relative movement between the curtain wall and the building structure. Achieving these performance objectives requires mechanical attachment of the curtain wall to the building structure, often through placement of wind load anchors at the slab edge and often also requires reinforcing the mullions with steel.

Roofing and waterproofing assemblies on balconies and roofs must be integrated with the curtain wall system to provide continuous waterproofing protection. This integration can be particularly difficult if the inboard side of the curtain wall will be exposed. The interior sides of curtain walls

are not designed to be watertight, nor do they include the water management and drainage provisions that are present at the exterior side of the system. One concept for achieving this integration at balconies with glass and metal curtain wall railings is to break the curtain wall into two segments as shown in *Figure 1*.

When a curtain wall extends above a roof or balcony edge to form a guardrail, it must meet minimum height requirements to help protect building occupants. The International Building Code (IBC) requires that guards must extend a minimum distance above the walking surface. For projecting balconies, terraces, or other forms of outdoor space on buildings, this guard height should be coordinated with waterproofing and paving to ensure that this minimum height requirement is met even after installation of components such as tapered concrete, insulation, waterproofing, pavers, or other forms of terrace walkways.

The upper portion slides over structural tubes that extend up from the vertical mullions in the lower portion, and the lower segment is waterproofed with membrane flashing that connects with the balcony waterproofing. If the curtain wall will only be observed from the ground, such as at a high roof or parapet wall, a similar result can be achieved by using continuous vertical mullions and waterproofing the open curtain wall joints with membrane flashing (*Photo 9*). This design becomes even simpler if the interior side of the curtain wall is not exposed, because knee walls can be built on the roof side of the curtain walls and can be covered with roofing membrane. *Figure 2* shows a design concept with the roofing and coping clamping into the top mullion of the curtain wall and covering the top of the knee wall and curtain wall. For details such as this, where integration of work from multiple trades is required, it is important to clearly designate installation responsibility and establish ownership of materials.

Just like traditional glass guardrails,

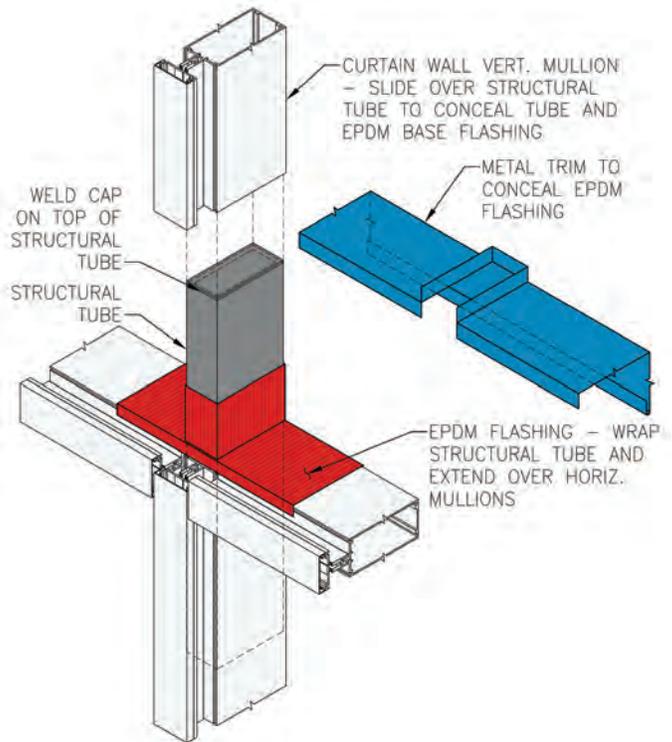


Figure 1 – Flashing concept for curtain wall guardrail.



Photo 9 – Curtain wall forming a parapet with roofing/flashing work in progress.

if the curtain wall is intended to serve this purpose, it should include safety glass and incorporate features that will protect the glass from impact. For example, if precast concrete pavers will cover an adjacent balcony, the paving system should be separated from the glass with a retention element and/or a foam gasket to prevent paver-to-glass contact.

The thermal performance of all nonstandard curtain wall conditions should be assessed to limit thermal bridging and the potential for the formation of condensation on interior surfaces and to ensure compliance with applicable energy codes. This is particularly important for humidified buildings such as museums, hospitals, and natatoriums.

### CLOSING

Aluminum-framed curtain walls are complex fenestration systems that warrant careful consideration during the design and construction phases. Special focus is needed for attachments, penetrations, perimeter conditions, and other “detail” areas not fully described in the manufacturers’

standard detail packages to provide a cladding or fenestration that is fully integrated with the rest of the building envelope. These project-specific detail areas are often challenging to design and construct properly; and, not surprisingly, these are often the conditions that fail to perform. We encourage project teams to consider these condi-

tions carefully throughout the course of their projects, conduct performance testing whenever possible, and consider the suggestions presented herein. 

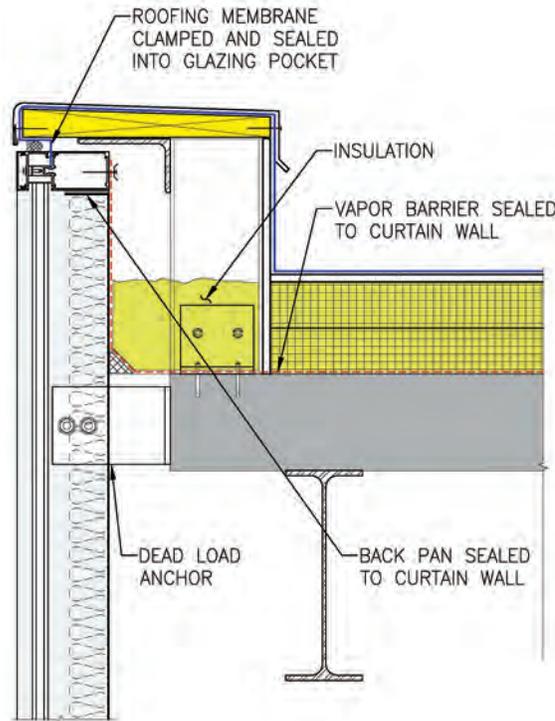


Figure 2 – Design concept of a curtain wall forming a parapet.

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Joshua B. Kivela, PE

*Joshua B. Kivela, PE, is a project manager at Simpson Gumpertz & Heger (SGH) with more than a dozen years of experience in design, investigation, evaluation, restoration, construction administration, and monitoring of historical and contemporary buildings. He specializes in waterproofing design of building envelope systems, including foundations; wall systems; curtain walls; windows/glazing; skylights; and flat, steep, and low-slope roofing. He has authored articles and presented lectures on the topic of building enclosures. Kivela is an active member in ASTM International, Committee D08 – Roofing and Waterproofing.*

*Derek B. McCowan, PE, serves as SGH’s project manager for large and complex projects, working directly with owners, architects, contractors, manufacturers, and other consultants. He has over 11 years of experience in the design and construction industry and specializes in glass and metal curtain wall systems, windows, skylights, cladding, and roofing. He also consults on waterproofing systems and historical masonry structures. He presents frequently on various building enclosure topics, has lectured at universities, and is a member of ASTM International, Committee C24 – Building Seals and Sealants.*



Derek B. McCowan, PE