Schüco is an ideal partner for Landmark Pinnacle in providing innovative, top quality solutions for application on this high rise residential tower. Let us tell you why. To start with, we have a history of excellence in building façade technology dating back to the mid-twentieth century, and a long history of successfully completed façade programs on the most challenging of buildings. If you are unfamiliar with the storied history of Schüco, we invite you to peruse the Organisational History section starting on page 8.

More significantly, the documentation contained in the Organisational History section evidences Schüco’s ability to harness the power of design. Schüco façade systems are built on a bedrock of German engineering. The design quality of our systems catalog is well known, widely acknowledged, and easily recognized in our product detailing. This results from decades of highly technical façade systems development, resulting in a unique capability for system design – one of Schüco’s core strengths. We deliver this capability to key clients in a novel process that marries emergent design-assist façade delivery strategies with our classic system development practices, a process we call Accelerated Design-Assist Product Development (ADAPD). This service is delivered through the Virtual Construction Lab of Schüco (VCL). The VCL and ADAPD are discussed in detail in the Virtual Construction Lab section starting on page 20.

In order to successfully deliver the façade systems for the Landmark Pinnacle, we propose using the ADAPD process. The process puts the VCL team side-by-side with the Landmark Pinnacle design team, developing the design while providing real-time feedback on such considerations as cost, schedule, constructability, and maintenance, while also creating an optimal decision-making environment; every decision made with the full understanding of relevant impacts. The result will be a customized modification of a Schüco standard system, thereby combining the benefits of established performance with a novel appearance. We have gathered the information provided to us by the Landmark Pinnacle team, and proceeded with preliminary conceptual design to demonstrate capability and a possible approach. This work is captured in this proposal, and includes design, engineering, installation methodology, and air and water infiltration performance.

In addition to our leading-edge systems and product development capabilities, Schüco also boasts a unique product delivery strategy that has evolved over decades of endless refinements. Schüco delivers more than mere façade systems to your building project requirements – we deliver a comprehensive supply chain that spans the building process from concept design through fabrication and installation, to lifecycle maintenance and, ultimately, renovation. The supply chain bears the Schüco stamp of approval in the form of a vendor/supplier certification program that qualifies the material supplier, fabricator, and/or installer as a Schüco supply chain partner. The supply chain services are discussed in detail in the Schüco Business Model section on page 12 of this volume.
The development process at Schüco does not end with the product design. Any customized modifications to a Schüco standard system as proposed herein are evaluated in the context of the existing supply chain to assure that the customization will be seamlessly handled throughout the entire delivery process. This evaluation includes existing component supply lines, fabrication processes, machinery and equipment, material workflows, installation procedures, QA assurance protocols, software tools, operation manuals, and training programs required to fully support the system from design application through final installation, lifecycle maintenance, and renovation.

The façade system for the Landmark Pinnacle project will be no exception. We will work at the direction of the Landmark Pinnacle team in developing the system and then fine tune the supply chain to assure delivery through our network of suppliers, fabricators, and installers, enterprises that have been certified by Schüco in their role with respect to this specific project, in providing the following:

- System design including structural calculations
- Inventory, material storage, quality management and material handling practices
- Fabrication and assembly procedures
- Fabrication QA systems, procedures, and reporting requirements
- Installation and maintenance procedures

If this proposal is viewed favorable by Landmark Pinnacle, the proposed next step is to enter a contractual design development phase using a mutually acceptable derivation of the ADAPD process. Schüco proposes to contribute the following resources to the Landmark Pinnacle/Schüco development team:

**Schüco Germany**

- Executive Direction: Thomas Schlenker
- Project Manager: Ulf-Karsten Strack

**Virtual Construction Lab of Schüco**

- Strategic Oversight: Mic Patterson, LEED AP BD+C
- Principal Designer & Executive Manager: TJ DeGanyar Ph.D., PE
- Design Manager: Katie Gould
- Visualization Manager: Chris Chin

Few, if any, firms are so uniquely positioned to provide such a comprehensive and robust service offering, and we extend it only to a select few. It would be our great pleasure to build the façade systems for Landmark Pinnacle, and to build a productive and mutually rewarding ongoing client relationship in the process.
Organisational History

1951 The birth of Schüco
Heinz Schürmann, a pioneer in the young Federal Republic of Germany, founds the company Heinz Schürmann & Co. in Porta Westfalica. In a small backyard with six employees, he produces shop windows, awnings and rolling grilles.

1954 A new home
During the West German economic miracle, innovative windows and façades become more and more important. Schüco supplies them. The company is at the forefront of progress using light and modern aluminium. By moving to Bielefeld, Schüco finds a new home.

1955-1963 Crossing borders
The rapid growth of Schüco requires new distribution channels. Commercial branches are established in Düsseldorf, Frankfurt, Stuttgart and Hamburg. License agreements and agency contracts enable new cooperation across Europe. In 1958, Schüco enters into a partnership with Alu König Stahl that still endures today.

1964 A strong connection that lasts to the present day
The sale of Schüco to technology company Otto Fuchs KG opens up new business and technological horizons. Schüco founder Heinz Schürmann hands over management of the company to Dr.-Ing. Ernst von Wedel.

1964-1969 Ascending together Schüco presses ahead with expansion internationally. In 1964, subsidiaries are set up in France, the Netherlands and Denmark. Schüco Design is established in Borgholzhausen in the same year.

1970s A system-based approach
Schüco develops into a system supplier for aluminium windows and doors. The company establishes new sites across Germany, continually expanding its sales network.

1970-1971 Ahead of the times
Aluminium windows, doors and façades, as well as large sliding systems with outstanding thermal insulation: Two years before the oil crisis, Schüco is already focusing on climate protection and conserving resources with innovative products.

1972 The customer is king
The topic of service becomes ever more important. Here too, Schüco is a pioneer. Schüco Service GmbH is founded as a fully owned subsidiary with three employees. The company provides software to help its metal fabrication customers with calculations and construction.
1980s A global player with new material

Schüco is also becoming increasingly international with licenses in Europe.

1980 Right on track Since the mid-1970s, the Schüco Express has been rolling through West Germany. Inside the carriages, customers can marvel at the latest window and façade technology – a unique form of product presentation.

1982 One step ahead Schüco has been meeting noise protection and environmental protection requirements successfully for years. Now the company also sets standards for fire security with the first approved fire protection system.

Market launch Schüco presents the new ISKOTHERM aluminium window system. The thermally insulated profiles are used for residential buildings and renovation projects in particular.

1990s A turning point

After the fall of the Berlin wall, building renovation with ecofriendly building materials in East Germany and Eastern Europe presents a major challenge. Schüco seizes this opportunity and expands its international business further. At the same time, the company enters the solar market and targets large commercial projects.

1990 An historic result Thanks to the construction boom in the east, Schüco turnover crosses the magical one billion D-mark threshold for the first time.

1992 Aiming high A new high-rise cassette warehouse in Bielefeld provides 22,000 storage areas across 81,000 m².

Inexhaustible source of energy Schüco adds a third business division with solar thermal and photovoltaic products, taking responsibility for sustainable development.

Strong cooperation A combined steel company for Germany and Switzerland forms under the name Schüco Jansen Steel Systems.
2000s Growing together and conserving resources

Schüco identifies opportunities for globalization and extends its business into the USA, South America and China. With its divisions – Metal and Solar – the company is a specialist for the entire building envelope.

2005 Ultra-high performance

The Schüco Technology Center is accredited as an independent and certified test institute for the building envelope.

Aluminium innovation

The Schüco AWS / ADS window and door system sets new standards and replaces the renowned Royal S system.

2009 Temperature control

Schüco presents the 2° Concept for the building envelope at BAU 2009. With pioneering, energy-efficient technology, the company makes an important contribution to restricting global warming to 2 degrees Celsius.

2011 Intelligent networking

At BAU 2011, Schüco thrills visitors with the energy self-sufficient Schüco Energy3 Building. By networking windows, doors and façades, it produces more energy than it consumes.


This is the Schüco slogan at BAU 2013. Four topic studios make the Schüco content interactive and an emotional experience. At the world’s leading exhibition for architecture, materials and systems in Munich, the company records 11,000 contacts – a record number of visitors.

A good investment

A new production hall measuring 6,300 m² is built in Weißenfels with 11 highly automated laminating lines for foiling and foil lamination of colored PVC-U profiles.

2014 Strong together

The successful union between Otto Fuchs KG and Schüco International KG has now been in place for 50 years.

Technology you can touch

The Schüco Showroom opens in Bielefeld, an interactive exhibition of metal construction products. Spread across 800 m², Schüco presents fascinating technologies and impressive systems using aluminium.

2015 Under the motto “Home. Work. Life”

Schüco exhibited many innovative and stylish system solutions in Munich featuring ideal home, living and working environments. With approximately 13,000 registered guests Schüco set a new visitor record.
Historical Timeline

1951
**Founded, Germany**
Heinz Schürmann founds Schüco and Company in Porta Westfalica, specialising in aluminium shop windows.

1960
**Window System Launched**

1970
**National Expansion, Germany**
Founding of sites across Germany and development of the sales network. Schüco becomes a systems provider.

1980
**European Expansion**
Internationalisation within Europe and entry into the PVC-U business.

1990
**Global Distribution**
Worldwide expansion and entry into the solar business.

2003
**United States Market**
Schüco is the specialist for sustainable solutions for the entire building envelope.
Market-Leading Building Façade Technology with a Focus on Supply Chain Management

Schüco combines best-in-market high-performance façade system products with a powerful design-to-site delivery strategy powered by a deep supply chain of multiple Schüco certified fabricators and installers.

Discerning Design Teams Choose Schüco

Schüco façade products are built on a bedrock of German engineering.

The standard-setting quality of Schüco systems is widely recognized, with design quality you can see. You don’t need a specification sheet, test report, or even a gage or measuring device; you can see it, easily, with your own eyes. Just look at the mitred-corner framing detail of a Schüco unitised window or curtainwall system, and try to find its equal in the marketplace.

We also make our unique façade product development capabilities available to clients and our supply chain partners. This includes a form of design-assist product development for both one-off project applications, or for the development of new systems exclusive to our client. These latter would include retail chains, for example, desirous of novel entry or lobby systems available as part of an exclusive brand. These services are discussed in detail in the following section on the Schüco Virtual Construction Lab (VCL).

Discerning Building Teams Choose Schüco

Many in the building industry are familiar with Schüco’s innovative high-performance façade systems. Most are less familiar with our equally innovative façade program delivery strategy, the process by which the requirements of the most demanding building façade programs are realized, with comprehensive services ranging from design through fabrication, assembly, installation, and even ongoing system maintenance if required. This strategy involves a sophisticated international supply chain of fabrication/installation partners capable of providing you with virtually unlimited capacity, consistent quality, competitive pricing, and timely delivery, most often from local or regional providers.

As a global façade system supplier, Schüco has over 12,000 trained and prequalified fabrication/installation partners in 78 countries. Each supply chain partner is supported by a regional Schüco organization, all of which have full access to central services provided by the headquarters in Bielefeld, Germany. These services include:

- Pre-construction services; preliminary estimating, product consult
- Design-assist services; real time estimating, scheduling, constructability review (through the Virtual Construction Lab of Schüco, see following section)
- Product development
- Design-assist product development; development of exclusive systems for key clients through Virtual Construction Lab of Schüco (ADAPD process), see following section
- Material supply
- Warehousing
- Machinery design and supply
- Software development and support
- Testing and certification
- Fabrication training
- Installation training
Schüco leaves the fabrication and installation responsibilities to this highly trained network of service providers, which allows us to focus on further enabling this network with:

- Next-generation systems development and management practices
- Advanced digital fabrication processes, machinery, and know-how
- Intensive training programs
- A range of novel software tools to expedite fabrication, installation and management processes

We provide the fuel to our supply chain in the form of optimal product designs, digital fabrication processes, machinery to optimize workflows, and training programs that deliver know-how necessary to implement this advanced technology. A variety of special tools, punches, jigs and presses are made available to ensure optimal quality while reducing fabrication time. The proprietary software package SchüCal creates a digital platform that facilitates an efficient flow of data from design through fabrication. The machinery developed and provided to fabricators by Schüco can read and process the SchüCal data and drive fabrication processes, enabling file-to-fabrication workflows at speed.

The attributes of our strategic supply chain are many, and are reviewed following.

Why Schüco: Standard or Customized Systems, Your Choice

As a system supplier with an unparalleled line of existing products, coupled with deep product development capabilities, Schüco can deliver a standard or customized façade program that can be supplied, fabricated, installed and serviced in 78 countries by prequalified and trained local and regional fabrication/installation partners. This strategy enables our clients to control the supply chain on their projects, optimizing cost, quality, lead time, and system solution.

Managing an Adaptive Delivery Process, Your Options

Upon development of a system design, we provide clients with two pathways to procurement:

- Contract directly with local Schüco partners for complete supply, fabrication, and installation services, or
- Contract directly with local Schüco partners for fabrication and installation services only. Procure product material kits directly from Schüco for delivery to the select Schüco partner.

For mission-critical facilities, or as desired to support delivery and emergency response times, a predetermined quantity of materials can be inventoried at strategically located Schüco or Schüco partner facilities internationally to expedite installation, repair, or replacement.
Consistent Quality, Optimal Economy

Schüco has a long history of façade product development yielding a catalog of standardized systems unequaled in quality and performance. Moreover, we’ve developed a product delivery supply chain of extensively vetted and highly qualified fabrication and erection service providers. This international supply chain has successfully delivered thousands of challenging façade programs with consistent and predictable results as measured by schedule, quality, and economy. For its part, Schüco manages a stock of 44,000 pre-engineered components for delivery to its supply chain partners. These partners also benefit from the tools we provide them to seamlessly manage their processes from estimating through project close out, tools including our proprietary estimating and fabrication software, SchüCal.

This extensive, internationally distributed network of fabrication/installation partners provides significant advantages.

- Advantageous market labor rates can be leveraged.
- Multiple fabrication and installation service providers assure competitive pricing and delivery scheduling.
- Even the highest capacity product requirements can be met through the employment of multiple service providers.
- Travel and shipping costs can be minimized.
- Consistent top quality resulting from the intimate familiarity with system requirements by Schüco licensed fabrication/installation partners.
- Top level technical support provided to all licensed fabrication/installation partners by Schüco.
Design & Delivery Services

Schüco employs 2,500 engineers worldwide:

- developing and applying standard systems,
- providing customized solutions for bespoke building projects,
- and performing client-driven product development for key clients employing our novel ADAPD (Accelerated Design-Assist Product Development) process. (See the following Virtual Construction Lab section for more detail.)

An application design team is assigned to project applications, and typically includes the technical department of a Schüco facility of local country organization, the central design department at Schüco headquarters in Bielefeld, Germany, and the technical personnel of the select fabrication/installation partner(s).

The fabrication/installation partners typically carry the construction contract, servicing the Owner or General Contractor as required, while the local or regional Schüco office provides technical support. The technical groups at the Schüco regional facilities have deep familiarity with all of Schüco’s product catalog, and are also familiar with local codes and regulations pertaining to the building façade. The central technical department at headquarters in Germany reviews the work of the regional teams and interfaces with Schüco’s supply chain partners as required to ensure optimal design, constructability, scheduling, and economy.

In addition to the usual spectrum of design and engineering services, Schüco staff provide die drawings, technical support to fabrication/installation partners, develop tools, training programs, and assembly, fabrication, and installation manuals for the application of all Schüco products.
Strategic Partners: Supply Chain Fabrication and Installation Service Providers and Certification

As a central element of the Schüco delivery strategy, we undertake the training and certification of qualified fabricators/installers to contract the supply, fabrication, installation and maintenance services required for the delivery of our products. The training includes:

- Designing with the systems, including structural calculations, code considerations, etc.
- Material storage, quality management, and material handling, plant organization and workflow
- Intensive hands-on fabrication, assembly, and installation workshops

The qualification process also involves the review and approval of key vendor metrics including financial reports, QA/QC systems, facilities organization, machinery, reference projects, workforce skill and training, and health and safety planning.

Managing the Process

A delivery team is assigned for each Schüco project. The team makeup will vary as a function of project size, location, and the systems involved, but the core team is generally comprised of:

- Schüco project manager (from local/regional office)
- VCL team manager (if the Virtual Construction Lab is involved)
- Schüco HQ design manager
- Installation/fabrication manager(s) (certified Schüco service providers)

The fabrication/installation service providers carry full contractual responsibility for the provision of their services, and are solely responsible for the management and execution of their work. Schüco local/regional organizations in conjunction with Schüco headquarters support the fabrication and installation processes through the provision of materials and technical support.
Schüco
- Architectural Advertising
- Technical Support
- Design Department
- Customer Service
- Quality Assurance
- Training

Fabricators
- Fabrication
- Project Engineering
- Mockups

Installers
- Logistics
- Install Labor
- Bid Submittals
Supply Chain Coordination

Schüco is flexible in working with clients and our supply chain partners. We will work with certified Schüco fabricators/installers to prepare a proposal in response to specific project requirements, either in a lead or supporting role. Or we will nominate to the building team the certified service providers we think are most appropriate for the project, leaving the vendor qualification, design and procurement entirely to the building team and service providers. We can also provide coordination services from early on in the design process through the entire façade delivery process to final installation.

Procurement Planning

Each project provides a unique context. Schüco can manage the procurement of all materials and components required for a façade program, coordinating just-in-time delivery directly to select certified fabricators or to certified installers at the building site. Schüco manages the global inventory and warehousing of some 44,000 components in support of its products, minimizing lead time and greatly expediting the order-delivery process. Our deep supply chain comprised of multiple partners for all key components assures the fastest possible delivery regardless of project size.

Prefabricated Systems

All Schüco façade systems are based on prefabricated design strategies. Components come together at a certified Schüco fabricator on a just-in-time basis for assembly under qualified factory controlled conditions and under approved QA/QC procedures, with integrated reporting transparency. Prefabricated units are carefully packed and shipped to the building site ready for installation with minimal site work required.

Unit Assembly

As part of its façade product development practices, Schüco designs the machines and processes for product fabrication. The machines and know-how are then made available to our supply-chain partners. It is this digital fabrication technology that enables the quality product detailing, like mitred corner connections, at competitive pricing.
Quality Assurance

The QA and QC systems and practices of all certified fabricators/installers are subject to review as part of the certification process, with the prerequisite to certification that they meet demanding Schüco standards. These practices are well established with the catalog of Schüco products. New product development at Schüco includes the development of the systems and practices required to assure the determined standard of quality for that product. These systems and practices are then systematically transferred to the fabricators and installers as part of the product technology transfer.

Just-in-time Delivery and Site Logistics

Schüco certified fabricators and installers are trained to coordinate just-in-time site deliveries as required to support site logistics and planning. Storage and staging areas are often limited, especially on dense urban building sites, and organization and coordination of deliveries can be vital in maintaining installation progress and minimizing impact to adjacent trades. In particularly demanding situations, offsite storage can be arranged to optimize material deliveries to site.

Visual and Performance Mockups

Schüco standard products have all been subject to some level of performance testing, but local requirements may vary. Schüco will coordinate with the select fabricator and installer service providers to accommodate both visual and performance mockup and testing programs.

Closeout Documents and Final Site Inspection

Schüco is available to review closeout documents and provide a final site inspection of installed products.

Ongoing Maintenance Services

In addition to fabrication and installation services, Schüco supply chain partners are also available to provide ongoing maintenance services as required for a given installation.

The following section explores the capabilities and services of the Virtual Construction Lab of Schüco (VCL).
The Virtual Construction Lab (VCL) is a powerful resource to Schüco clients. The Lab is based on a conceptual model that was initially developed to facilitate project delivery strategies structured to meet the challenges of novel and highly complex building façade projects. These strategies—often referenced under the umbrella term of design-assist—were highly collaborative, characteristically involving key design and delivery providers very early in the design process. Design-assist project delivery strategies quickly proved to be effective in delivering innovative solutions to complex building problems, while mitigating the risk that accompanies innovation in the building construction market. VCL is an adaptation of this model to the nuanced requirements of product development as opposed to the one-off nature of building design.
Product versus project

The Lab has developed a work process called Accelerated Design-Assist Product Delivery or ADAPD. There are substantive differences between products and projects, and successful development processes are shaped by these differences; ADAPD is a process carefully attuned to the particular challenges of product development in the AEC (Architecture, Engineering, and Construction) industry. ADAPD is a strategic product development framework that transcends the limited boundary of product design to consider the full context of the product lifecycle from initial market research and concept development through post launch performance monitoring and evaluation. With a prospective client’s involvement, the ADAPD framework is customized to the specific requirements of each individual product development project.

VCL amplifies innovation in product development through the application of strategic design principles. While there are goals common to both product and project development, such as general considerations of economy, optimal product development demands special consideration of the following:

- Strategic product development that considers the full contextual environment of the product development life cycle.
- Product and production design to provide efficient fabrication and assembly at the projected scale of unit production.
- Product design for ease of installation across the range of applications.
- Robust supply chain development, matching projected program requirements with supply chain capacity, quality, inventory and delivery scheduling, geographic distribution, and installation, across the spectrum of site conditions.
Organization and Service Offerings

VCL is comprised of a small multi-disciplinary team of designers from disciplines ranging from architecture to product design, from building physics to parametric modeling. The concept embodied in VCL is unique in focusing on new product and technology development in the AEC market and has proven a powerful asset in developing niche product solutions as well as highly adaptive product technologies capable of wide variations in application. The ADAPD work process employed by the VCL includes a variety of strategies and techniques including sophisticated rapid visualization processes that speed conceptual design development, combined with progressive budgeting, scheduling, and constructability services that provide an optimized environment for early decision-making by a collaborative design team comprised of representative stakeholders.

The Lab is structured as an independent business unit of Schüco acting as a specialty consultant to multiple clients, but is also capable of adopting a specialty team role while embedded within a partner organization. The Lab model, combined with the unique technical depth of the VCL team, is easily tuned to the specific requirements of a wide variety of research and product development initiatives. The following are among the services offered by the VCL as part of a collaborative product development program.
Services

1. Product design
2. Value-engineering of new and value-analysis of existing products and systems
3. Parametric design
4. Complex geometry and geometric optimization
5. Rapid visualization: 3D modeling, rendering, animation, digital printing
6. Performance analysis: thermal, acoustical, structural, durability, environmental life cycle assessment and analysis, supported by various simulation and analytical techniques
7. Finite element and CFD modeling
8. Façade physics optimization: thermal, acoustical, moisture
9. Code checking
10. LEED, Energy Star, Green Globes, and other rating system facilitation
11. Rapid prototyping and visual mockup services
12. Digital fabrication and automation assistance
13. Manufacturing capacity analysis, production planning and monitoring
14. Constructability analysis, site operations planning and logistics
15. Maintenance programs, planning and training
16. Product commissioning through post-occupancy
17. Personnel training programs
18. Visual mockup construction and management
19. Performance mockup
20. Quality control program development and monitoring
21. Sales and presentation tools: proposal development, graphics, slideshows, animations, mockups
22. Product packaging design
23. Print and web promotional services
24. Event planning and production (conferences, workshops, etc.)
25. Branding, strategic planning, communication, infographics

Your project may require few or many of these capabilities. VCL will provide a proposal custom tailored to your project’s needs, drawn from the ADAPD framework.
Preplanning and the Basis of Design

VCL commences a product development project by working with the client to establish a clear set of goals and objectives for the product, which are documented in the Basis of Design (BOD). The BOD then becomes the reference for decision-making as the project moves forward, and its contents become the predominant criteria for evaluating progress. Ultimately, the success of the product will be determined by the extent to which the goals embedded in the BOD are met or exceeded. The BOD is a living document hosted by VCL but shared between VCL and the client, and subject to ongoing revision as the development process unfolds.

The BOD is finely tuned to the product development program, but generally includes definitions regarding the following:

- Market research and analysis requirements
- The standard of quality
- Scheduling milestones
- Market program: Budgets, price points, financial models, branding and identity, test marketing, promotion, sales
- Technical program: Performance requirements, engineering, analysis, production and facilities design, installation, service life, maintenance, supply chain development
- The user experience
- Program specific goals
- Testing and prototyping requirements
- Implementation: Plant and production, product management
- Environmental considerations: Green product certification, embodied energy profile, operational energy consumption, materials red list, recycling or reuse requirements
- Post-launch monitoring and evaluation
Designing the User Experience

The VCL team understands the importance of end-user considerations to guide the product development process. VCL works with the client and representative user groups as required to assure understanding of the user experience and the client’s goals for the user experience. This information can either be provided as an input to the VCL development process, or VCL can manage the acquisition and evaluation of this information. The user experience can be considered from pre-purchase market exposure through the use cycle and end-of-life disposal.

Design, Engineering, and Analysis: Implementing Innovative Building Technology

The core strength of VCL is a deep technical capability supporting creative problem-solving processes that consistently yield innovative solutions that are both practical and economical. Moreover, our work processes are purposefully designed to mitigate the risk associated with product innovations, yielding novel product solutions stripped of the risk and uncertainty that may accompany innovation in the challenging context of the built environment. Using a wide assortment of powerful tools, VCL in-house analytical capabilities include:

- Design development in various scales and materials
- Structural engineering
- Mechanical engineering
- Thermal and condensation analysis
- Acoustical analysis
- Kinetics and control systems
- Durability analysis
- Security assessment and analysis

The VCL works with a spectrum of design and analysis tools, including some self-developed software tools proprietary to Schüco that can be shared with clients as appropriate. Modeling tools such as Revit can be used by VCL to develop custom tailored BIM systems in support of new product developments. These models can be handed off to the client as part of the VCL service offering.
Rapid Multimedia Visualization

VCL’s design and technical capability is amplified by 3D visualization techniques embedded throughout the Lab’s digital workflows. These include 3D renderings in 2D media, including video animations, but quickly progresses to full scale mockups and prototypes with the goal of getting into physical 3D as quickly as possible. Digital printing and other model-making techniques are a key output of the product development process. Video animations are often used to demonstrate function, supply chain design, and means-and-methods of assembly and installation.

Collaborative Digital Workflows

VCL work processes are steeped in collaboration. We stand shoulder-to-shoulder with our clients through the product development process, enabling decision-making by informing them in real time of the impacts of design decisions as they are made. Consequently, design progresses in the context of known impacts to the BOD, including such critical factors as cost, deployment, and maintenance.
Cost Management (CM), Value Engineering (VE), and Continuous Cost Modeling (CCM)

Cost is invariably a key metric in a product development program, and CM is the process by which that metric is controlled. A cost model is typically built for a VCL product development program and used as the basis for continuous budgeting throughout the design development process, thereby integrating cost management with ADAPD workflows. VE is also integrated into ADAPD as a means to optimize value outcomes as the design progresses. The process brings supply chain development forward and into design development by formally engaging key materials suppliers, vendors, fabricators, and specialty contractors to participate in the development of innovative and economical solutions that satisfy the product design intent.

Continuous cost modeling is a VCL management practice involving the definition of the basic elements and cost structure of the development program in detail. Budget targets along with VE opportunities are identified, prioritized, scheduled and incorporated into the model. The cost model provides a real-time picture of the program budget as it evolves through design development and VE, thus facilitating accurate budget review throughout ADAPD process. The model helps to define areas where VE exercises may be most productive, and the results of the various VE exercises can easily be dropped into the cost model to evaluate impact.

Supply Chain Development

The engine of the ADAPD process is supply chain development. This begins with the involvement of key material and process providers early in design development, and continues right through to product launch, at which time the task of supply chain management can be handed off either to the client, or to Schüco as a value-added service. Supply chain development will drive the product delivery strategy, and must consider the entire product lifecycle from concept development through the operation and maintenance phase, and finally to end-of-life strategies of reuse, recycling, or disposal. The supply chain is critical to the development process, as it will ultimately play the dominant role in determining product quality, service life, lifecycle cost, the user experience, and environmental impacts.
Mockups and Prototypes

Mockups and prototypes play an integral role in the ADAPD process, varying in scale, material, and quality based on their role in the design development process. Sketch mockups may be relatively crude of cardboard; visual mockups are likely to be full scale and built from production materials. Digital printing is often used in the assembly of full-scale façade product mockups.

Testing

Façade systems and products typically require testing, and performance mockups are often constructed for this purpose. Whether actual production products or mockups are tested, VCL can develop and execute the testing program in conformance with specification and/or relevant code requirements. Durability testing is another common testing protocol. Tests can be scheduled at a client’s facility, at the facility of an independent third-party certified testing laboratory, or at Schüco’s Technology Center in Bielefeld, Germany.
Durability Analysis, Maintenance Requirements and Lifecycle Planning

Lifecycle considerations of new product development begin early in the ADAPD process, starting with the definition of the design service life for the product in the BOD document. The new product or system is subject to durability analysis, and maintenance strategies are explored as a strategy to extend service life. This often involves testing in various forms as discussed above. Operable elements, for example, will be subject to repetitive cycling testing of a defined magnitude. Maintenance requirements can then be defined and published as part of the product offering. VCL can even develop personnel training programs to support operations and maintenance procedures, including print and digital manuals, videos, webinars, and workshops. A program of value assessments of defined frequency during the operational phase of a product can monitor the effectiveness of maintenance practices and evaluate the approach of obsolescence.

Environmental Impacts and Sustainability Considerations

Sustainability considerations are gradually shifting from voluntary standards to codified requirements, while concerned enterprises are increasingly layering on their own program goals for environmental performance. Materials red lists are becoming more common. Resilience has become a predominant buzzword in the discussion of urban habitat. New product rating systems such as Green Globes and C2C have emerged with certification protocols. Environmental Product Declarations (EPDs) and their variant cousins are becoming a common requirement on building projects. VCL can evaluate a product and determine the most appropriate scheme and perform the required analysis or otherwise facilitate a program to achieve certification, or simply to assure a targeted level of environmental performance.

VCL as a Flexible and Adaptive Product Development Partner

Perhaps the most valuable components of the VCL–ADAPD equation is the flexibility of VCL team and the broad range of adaptability of the ADAPD process to the myriad nuances that comprise a product development program. It’s the technical depth and range of experience of the VCL team that makes this possible. As a Schüco client, you may be able to bring the VCL onboard as part of your product development team. A specific proposal to accomplish just this — tuned to your program requirements — is either included in or accompanies this document, or is otherwise available on request.
Strategic Partners

Strategic Fabrication Partners

Strategic fabrication partners for the Landmark Pinnacle project will meet the following requirements:

- Demonstrable experience fabricating Schüco systems.
- Possession of the machinery, equipment, and training to fabricate the system according to K drawings.
- Completion of a certification program specifically tailored to the Landmark Pinnacle project.
Certification Program

Fabrication partners will be required to attend and satisfactorily complete a training program at the Schüco headquarters in Germany. Only select companies will be invited to participate. The program is intended to ensure that these fabrication partners can consistently meet the required standard of quality.

The fabrication partners will be trained in:

- Understanding shop drawings and the specifics of the system.
- Cutting and assembly of the profiles and fittings.
- QA/QC procedures for all fabrication processes.
- Packaging and crating for shipment.

Global partner network

Schüco’s global fabrication/installation partners number in the thousands, easily accommodating the global chain required for the project program. Our regional managers on every continent will be involved in the selection of qualified fabrication/installation partners in their local or regional territory.
This section outlines the proposal of the façade design for the Landmark Pinnacle in London, UK, through drawings, renders, and diagrams. The system implemented in this project is based on the standard Schüco UCC 65 SG (Unitised Customizable Construction), tailoring the aluminium-framed units into four distinct typologies to serve different needs of the architecture’s schema. UCC 65 SG is a structurally glazed system that provides a sleek, modern appearance with a relatively easy installation process and unparalleled quality control. The units designed for this project include a Clear Glazed model, a Non-Vision Panel, and a Pop and Slide Door double-width unit. An additional Alternate Clear unit helps integrate the Pop and Slide Door into the façade array but is otherwise identical to the Clear Glazed unit to help preserve a unified exterior design.

The units are anchored to the building structure at their base, with standard Schüco coupling gaskets creating an air-tight seal between adjacent units on all sides. The unit design incorporates a spandrel at the sill of each unit, covered with an opaque panel, and an HVAC vent at the top of each unit, which will connect into a larger system to be installed within the ceiling cavity. The HVAC vent is covered with a grill that when taken alongside the opaque panel of the spandrel above it, provides crisp latitudinal lines up the façade of the skyscraper.

The Clear Glazed unit provides floor-height views of the majestic Thames and surrounding Canary Wharf, while the Non-Vision Panel obscures interior shear and partition walls with an opaque shadowbox installed behind its double-pane glass. The Pop and Slide Door unit adapts the Schüco PASK Tilt/Slide from a standard entry system into a Juliet balcony by reimagining the standard form as a structurally glazed element, with a security balustrade installed behind it on the interior. As a unit, it is double the width of the units around it, a difference that has been tactfully minimized so that from the exterior one can scarcely tell it apart, maintaining the unity of the façade. Behind the Pop and Slide Doors is fitted a small winter garden, providing each apartment in the new high-rise a pleasant, refreshing oasis. The design of the Pop and Slide Door necessitates the Alternate Clear Glazed unit, which has an offset vertical aluminium profile to accommodate the double-width unit.

Taken together, the unified unitised façade proposed in this book lends the Landmark Pinnacle a bold face to match its audacious plan to become the tallest residential tower in all of Europe. But no matter the size of the project, Schüco takes pride in furthering the science behind its façade systems, down to the smallest detail.
- Clear Glazed Panel
- Insulated Opaque Back Panel
- Pop and Slide Doors
- Glass Balustrade
- Bottom Hung Projected in Opening
Elevation & Overall Plan
Units Types & Details

Unit 1
Clear Glazed

Unit 2
Non-Vision Panel

Unit 3
Pop and Slide Door

Unit 4
Alternate Clear Glazed
Unit 1

Clear Glazed
Legend

1. Vertical Aluminium Profile
2. Horizontal Aluminium Profile
3. Insulated Glass Unit
4. Spandrel
5. HVAC Vent
6. Vertical Coupling Gasket
7. Horizontal Coupling Gasket
8. Anchor
9. Bracket
10. Intermediate Aluminium Profile
11. Sliding Door Profile
12. Insulated Non-Vision Panel
13. Glass Balustrade
14. Balustrade Bracket
15. Steel Reinforcement
Legend

1. Vertical Aluminium Profile
2. Horizontal Aluminium Profile
3. Insulated Glass Unit
4. Spandrel
5. HVAC Vent
6. Vertical Coupling Gasket
7. Horizontal Coupling Gasket
8. Anchor
9. Bracket
10. Intermediate Aluminium Profile
11. Sliding Door Profile
12. Insulated Non-Vision Panel
13. Glass Balustrade
14. Balustrade Bracket
15. Steel Reinforcement
Unit 2

Non-Vision Panel
Legend

1. Vertical Aluminium Profile
2. Horizontal Aluminium Profile
3. Insulated Glass Unit
4. Spandrel
5. HVAC Vent
6. Vertical Coupling Gasket
7. Horizontal Coupling Gasket
8. Anchor
9. Bracket
10. Intermediate Aluminium Profile
11. Sliding Door Profile
12. Insulated Non-Vision Panel
13. Glass Balustrade
14. Balustrade Bracket
15. Steel Reinforcement
Unit 2

DH4

Legend

1. Vertical Aluminium Profile
2. Horizontal Aluminium Profile
3. Insulated Glass Unit
4. Spandrel
5. HVAC Vent
6. Vertical Coupling Gasket
7. Horizontal Coupling Gasket
8. Anchor
9. Bracket
10. Intermediate Aluminium Profile
11. Sliding Door Profile
12. Insulated Non-Vision Panel
13. Glass Balustrade
14. Balustrade Bracket
15. Steel Reinforcement
Unit 3

Pop & Slide Door
As a vent, tilted open.

As a door, slid open.
Unit 3

Pop and Slide Door
Unit 3

Legend

1. Vertical Aluminium Profile
2. Horizontal Aluminium Profile
3. Insulated Glass Unit
4. Spandrel
5. HVAC Vent
6. Vertical Coupling Gasket
7. Horizontal Coupling Gasket
8. Anchor
9. Bracket
10. Intermediate Aluminium Profile
11. Sliding Door Profile
12. Insulated Non-Vision Panel
13. Glass Balustrade
14. Balustrade Bracket
15. Steel Reinforcement
1. Vertical Aluminium Profile
2. Horizontal Aluminium Profile
3. Insulated Glass Unit
4. Spandrel
5. HVAC Vent
6. Vertical Coupling Gasket
7. Horizontal Coupling Gasket
8. Anchor
9. Bracket
10. Intermediate Aluminium Profile
11. Sliding Door Profile
12. Insulated Non-Vision Panel
13. Glass Balustrade
14. Balustrade Bracket
15. Steel Reinforcement
Unit 4

Alternate Clear Glazed
Unit 4

DH2

Legend

1. Vertical Aluminium Profile
2. Horizontal Aluminium Profile
3. Insulated Glass Unit
4. Spandrel
5. HVAC Vent
6. Vertical Coupling Gasket
7. Horizontal Coupling Gasket
8. Anchor
9. Bracket
10. Intermediate Aluminium Profile
11. Sliding Door Profile
12. Insulated Non-Vision Panel
13. Glass Balustrade
14. Balustrade Bracket
15. Steel Reinforcement
Legend

1. Vertical Aluminium Profile
2. Horizontal Aluminium Profile
3. Insulated Glass Unit
4. Spandrel
5. HVAC Vent
6. Vertical Coupling Gasket
7. Horizontal Coupling Gasket
8. Anchor
9. Bracket
10. Intermediate Aluminium Profile
11. Sliding Door Profile
12. Insulated Non-Vision Panel
13. Glass Balustrade
14. Balustrade Bracket
15. Steel Reinforcement
Gasket Compression
Typical Anchor Detail

Legend

1. Vertical Aluminium Profile
2. Horizontal Aluminium Profile
3. Insulated Glass Unit
4. Spandrel
5. HVAC Vent
6. Vertical Coupling Gasket
7. Horizontal Coupling Gasket
8. Anchor
9. Bracket
10. Intermediate Aluminium Profile
11. Sliding Door Profile
12. Insulated Non-Vision Panel
13. Glass Balustrade
14. Balustrade Bracket
15. Steel Reinforcement
Anchor Installation Sequence

1. Install and assemble anchor into cast-in channel.

2. Align anchor to allow for structural tolerances.

3. Once positioning is confirmed drill and fix with tapered pin.

4. As unit is lowered into anchor at base of unit temporary fixings are used at the top.
As the top of each unit is secured by the unit above the temporary fixing below can be removed.

Once unit is secured by temporary fixing adjust unit height with leveling screws at base anchor.

Next row of units are installed as per steps 4 - 6.

Only once an entire level of units are in place, then the continuous horizontal gasket is installed.
The system employed in this project is a customization of the standard Schüco UCC 65 SG unitised system. Schüco UCC 65 SG (Unitised Customized Construction) combines the high-quality look of a structural glazing façade with the standardized project processing of a high-performance and flexible modular system while providing individual design options.

The units are 2950mm tall with a typical width of 1235mm. The double width Pop and Slide Door unit have a width of 2470mm, seamlessly integrated into the array of the façade in a planar pattern. Each unit is divided into three main sections; A spandrel at the base, a floor-height vision panel in the middle, and an HVAC vent at the top of the unit. The Non-Vision Panel unit has an opaque shadow box in lieu of its vision panel (to hide interior shear and partition walls) and the Pop, and Slide Door unit has an intermediate vertical aluminium profile, which frames the operable door built into each unit. Each unit’s frame is composed of horizontal and vertical aluminium profiles, which are mitre cut at their corners and joined via corner cleats. Intermediate horizontal and vertical aluminium profiles are attached to this frame via screw raceways.

Unlike a standard UCC 65 SG construction, the units for this project are supported at the sill, interlocked to the unit above via a set of aluminium lifting logs (which are also used when installing the unit in place). Due to it being a standing system, the units are fitted with temporary fixings at the head to keep them upright in anticipation of the next floor of units. Once they are interlocked at the head, the temporary fixings are removed to be reused further up in the façade’s installation.

The self-weight is assumed to be carried by two bottom anchors, and the lateral loads are resisted by all four anchors (including those at the unit’s head). The anchors are shared by two adjacent units, and each anchor carries the total weight of two units. The anchors have a ± 36mm of tolerance moving left/right parallel to the edge of the slab, ± 12mm of tolerance moving in/out from the slab, and ± 16mm of tolerance moving up/down.

Wind loads are dictated by wind tunnel tests and load cases; combinations comply with ASCE 7-10 standards. Dead loads are computed based on individual compost weights. The lateral load transfer both through vertical spanning members to the attachment at anchors and connection logs.

The following sections present typical unit calculations for various components of the system, including framing, glass, hardware, and anchorage system. These calculations are for typical unit dimensions and configurations. More detailed analysis and calculations will be required for the final design.
S2.1 Design Criteria

Sizes:

Maximum Glass Thickness: \( G_t = 34 \text{ mm} = 1.34 \text{ in} \)

Safety Factors:

- Tensile Rupture: \( \Omega_{\text{rupture}} = 1.95 \)
- Tensile Yielding: \( \Omega_{\text{yield}} = 1.65 \)
- Compression: \( \Omega_c = 1.65 \)
- Flexure Rupture: \( \Omega_{\text{rupture}} = 1.95 \)
- Flexural Other: \( \Omega_{\text{other}} = 1.65 \)
- Shear Rupture: \( \Omega_{\text{rupture}} = 1.95 \)
- Shear Other: \( \Omega_{\text{other}} = 1.65 \)
- Toration Rupture: \( \Omega_{\text{rupture}} = 1.95 \)
- Toration other: \( \Omega_{\text{other}} = 1.65 \)

Material Property \( I = 101 \)

\[
\begin{align*}
\text{Alloy} &= F(I, 1) = 6005 \\
\text{Temper} &= F(I, 2) = "T5" \\
E &= 10100 \text{ ksi} \\
F_{\text{tu}} &= F(I, 6) \cdot 1 \text{ ksi} = 38 \text{ ksi} \\
F_{\text{ty}} &= F(I, 7) \cdot 1 \text{ ksi} = 35 \text{ ksi} \\
F_{\text{tyw}} &= F(I, 8) \cdot 1 \text{ ksi} = 24 \text{ ksi} \\
F_{\text{syw}} &= F(I, 9) \cdot 1 \text{ ksi} = 13 \text{ ksi} \\
F_{\text{su}} &= 0.6 \cdot F_{\text{tu}} = 22.8 \text{ ksi} \\
F_{\text{sy}} &= 0.6 \cdot F_{\text{ty}} = 21 \text{ ksi} \\
G &= 3800 \text{ ksi}
\end{align*}
\]
S2.2 Computer Model

A computerized analytical model created in the software program SpaceGASS represents the structural elements arranged according to the configuration in the following sketch. The section and material properties, deformation characteristics, and connectivity of the members are considered.

The left window (with DV1 as the following figure) is calculated due to its most critical section. The glass panel is pinned at the center of the structure as the grey plates in the following figure. The corner of the glass is constrained so that no rotation is allowed.

The unitized frame is modeled as aluminum beams, with the cross section described in section S2.3. The top horizontal beam of the glass panel employs section 1 while the bottom horizontal one for the glass panel uses section 2. The vertical member is made of the cross section 3 except member 7 and 4 which use section 4 to connect the two windows. The section properties are extracted from the software program IES ShapeBuilder and assigned to the Finite Element Model in the SpaceGASS.

The dead load of the glass panel is added to the frame as point load at stiffner and the bottom of the frame, as well as the moment induced by the eccentricity of the glass panel. The wind load is extracted from the ‘1502419 RWDI-City Pride - Cladding Wind Load Study - Draft’. The 1.5 kPa wind pressure is considered for the glass panel as most positive wind load, while -1.75 kPa for the most negative wind load.
S2.3 Section Properties

Section 1. The cross section of the top horizontal beam for the glass panel.

Section 2. The cross section of the top horizontal beam for the glass panel.
Section 3. The cross section of the vertical beam.

Section 4. The cross section of the pinnacle beam (member 4 and member 7).
S2.4 Load Cases and Combinations

<table>
<thead>
<tr>
<th>Load Case</th>
<th>Description</th>
<th>Direction</th>
<th>Value</th>
<th>Unit</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Self Weight</td>
<td>-y</td>
<td>32.17</td>
<td>kN/m</td>
<td>9.8</td>
<td>kN/s</td>
</tr>
<tr>
<td>2</td>
<td>Positive Wind Load</td>
<td>-z</td>
<td>31</td>
<td>kN/m</td>
<td>1.5</td>
<td>kPa</td>
</tr>
<tr>
<td>3</td>
<td>Negative Wind Load</td>
<td>z</td>
<td>37</td>
<td>kN/m</td>
<td>1.75</td>
<td>kPa</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Load Combination</th>
<th>LC 1</th>
<th>LC 2</th>
<th>LC 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>101</td>
<td>1.0</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>102</td>
<td>1.0</td>
<td></td>
<td>1.0</td>
</tr>
</tbody>
</table>

S2.5 Reactions

<table>
<thead>
<tr>
<th>Support</th>
<th>Load Case</th>
<th>X-Axis Force (kN)</th>
<th>Y-Axis Force (kN)</th>
<th>Z-Axis Force (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Left</td>
<td>101</td>
<td>-0.34</td>
<td>0.68</td>
<td>1.16</td>
</tr>
<tr>
<td></td>
<td>102</td>
<td>-0.34</td>
<td>0.68</td>
<td>-1.36</td>
</tr>
<tr>
<td>Upper Right</td>
<td>101</td>
<td>-0.34</td>
<td>0.68</td>
<td>1.16</td>
</tr>
<tr>
<td></td>
<td>102</td>
<td>-0.34</td>
<td>0.68</td>
<td>-1.36</td>
</tr>
<tr>
<td>Lower Left</td>
<td>101</td>
<td>0.34</td>
<td>0.69</td>
<td>1.49</td>
</tr>
<tr>
<td></td>
<td>102</td>
<td>0.34</td>
<td>0.69</td>
<td>-1.74</td>
</tr>
<tr>
<td>Lower Right</td>
<td>101</td>
<td>0.34</td>
<td>0.69</td>
<td>1.49</td>
</tr>
<tr>
<td></td>
<td>102</td>
<td>0.34</td>
<td>0.69</td>
<td>-1.74</td>
</tr>
</tbody>
</table>
S2.6 Deflection Check

Load Case 101: 1.0 Dead Load + 1.0 Positive Wind Load on Glass Panel

Maximum deflection for horizontal beam
\[ \delta_y = 0.0004 \text{ in} \left( 3.333 \times 10^{-5} \right) \text{ ft} \]

Member length
\[ L = 47.48 \text{ in} = 3.957 \text{ ft} \]

Allowable deflection
\[ \delta_c = \min \left( \frac{3.957}{175} \right) = 0.023 \text{ ft} \]

\[ \delta_y \leq \delta_c, \text{ Yes} \]

Maximum deflection for vertical beam
\[ \delta_y = 0.001 \text{ in} \left( 8.333 \times 10^{-5} \right) \text{ ft} \]

Member length
\[ L = 91.18 \text{ in} = 7.598 \text{ ft} \]

Allowable deflection
\[ \delta_c = \min \left( \frac{7.598}{175} \right) = 0.043 \text{ ft} \]

\[ \delta_y \leq \delta_c, \text{ Yes} \]

Maximum deflection for pinnacle beam (member 4, 7)
\[ \delta_y = 0.00001 \text{ in} \left( 8.333 \times 10^{-7} \right) \text{ ft} \]

Member length
\[ L = 15.748 \text{ in} = 1.312 \text{ ft} \]

Allowable deflection
\[ \delta_c = \min \left( \frac{1.312}{175} \right) = 0.007 \text{ ft} \]

\[ \delta_y \leq \delta_c, \text{ Yes} \]
Load Case 102: 1.0 Dead Load + 1.0 Negative Wind Load on Glass Panel

Maximum deflection for horizontal beam
\[ \delta_y = 0.0006 \text{ in} = \left(5 \cdot 10^{-5}\right) \text{ ft} \]

Member length
\[ L = 47.48 \text{ in} = 3.957 \text{ ft} \]

Allowable deflection
\[ \delta_c := \min \left(3.957 \cdot \frac{3}{4} \text{ ft} = 0.023 \text{ ft} \right) \]
\[ \delta_y < \delta_c = 1 \]

Yes

Maximum deflection for vertical beam
\[ \delta_y = 0.0013 \text{ in} = \left(1.083 \cdot 10^{-4}\right) \text{ ft} \]

Member length
\[ L = 91.18 \text{ in} = 7.598 \text{ ft} \]

Allowable deflection
\[ \delta_c := \min \left(7.598 \cdot \frac{3}{4} \text{ ft} = 0.043 \text{ ft} \right) \]
\[ \delta_y < \delta_c = 1 \]

Yes

Maximum deflection for pinnacle beam (member 4, 7)
\[ \delta_y = 0.00001 \text{ in} = \left(8.333 \cdot 10^{-7}\right) \text{ ft} \]

Member length
\[ L = 15.748 \text{ in} = 1.312 \text{ ft} \]

Allowable deflection
\[ \delta_c := \min \left(1.312 \cdot \frac{3}{4} \text{ ft} = 0.007 \text{ ft} \right) \]
\[ \delta_y < \delta_c = 1 \]

Yes
2.7 The Top Horizontal Beam Check --- Member Number 2

Section Properties

\[ A_{y} := S(5, 1) \text{ in}^2 = 4.34 \text{ in}^2 \]
\[ d := S(1, 1) \text{ in} = 8.818 \text{ in} \]
\[ I_{xx} := S(6, 1) \text{ in}^4 = 35.52 \text{ in}^4 \]
\[ I_{yy} := S(7, 1) \text{ in}^4 = 32.2 \text{ in}^4 \]
\[ S_{y} := S(11, 1) \text{ in}^3 = 7.83 \text{ in}^3 \]
\[ S_{y} := S(13, 1) \text{ in}^3 = 6.325 \text{ in}^3 \]
\[ J := S(48, 1) \text{ in}^3 = 20.24 \text{ in}^3 \]
\[ x_{y} := S(45, 1) \text{ in} = 3.217 \text{ in} \]
\[ C_{y} := S(47, 1) \text{ in}^5 = 45.51 \text{ in}^5 \]
\[ Z_{y} := S(31, 1) \text{ in}^3 = 9.992 \text{ in}^3 \]
\[ \beta_{y} := S(49, 1) \text{ in} = 1.467 \text{ in} \]
\[ \lambda_{y} := S(46, 1) \text{ in} = 2.372 \text{ in} \]
\[ \beta_{y} := S(32, 1) \text{ in}^3 = 9.155 \text{ in}^3 \]
\[ w_{y} := A_{y} \cdot 170 \text{ pcf = 5.124 lbf ft} \]
\[ r_{xx} := \sqrt{\frac{I_{xx}}{A_{y}}} = 2.861 \text{ in} \]
\[ r_{yy} := \sqrt{\frac{I_{yy}}{A_{y}}} = 2.724 \text{ in} \]
\[ S_{y} := S(14, 1) \text{ in}^3 = 10.2 \text{ in}^3 \]
\[ S_{y} := S(12, 1) \text{ in}^3 = 8.295 \text{ in}^3 \]

Member Forces

<table>
<thead>
<tr>
<th>Member</th>
<th>Case</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top Horizontal</td>
<td>101</td>
</tr>
<tr>
<td>Max. Sh.</td>
<td>0.000</td>
</tr>
<tr>
<td>Max. Mom.</td>
<td>0.000</td>
</tr>
<tr>
<td>Max. Sh.</td>
<td>0.000</td>
</tr>
<tr>
<td>Max. Mom.</td>
<td>0.000</td>
</tr>
</tbody>
</table>

| Top Horizontal | 102   |
| Max. Sh. | 0.000 |
| Max. Mom. | 0.000 |
Check Compression

There is no axial force. The check for compression is satisfied.

Check Flexure

There is no moment in Y-Axis, so one only need to check the flexure in X-Axis

\[
M_{nx} = \min \left( \frac{M_{reg \cdot yield X}}{\Omega_{other}}, \frac{M_{reg \cdot rupture X}}{\Omega_{rupture}} \right) = 12.981 \text{ kip-ft}
\]

\[
\frac{M_1}{M_{nx}} = 3.852 \cdot 10^{-4}, \quad \frac{M_2}{M_{nx}} = 4.622 \cdot 10^{-4}
\]

Check Shear

There is no shear in X-Axis, so one only need to check the flexure in Y-Axis

\[
\text{Type} = 0 \quad 1 \text{ stands for the support on both edges, while 0 stands for the support on one edge.}
\]

\[b_s = 8.25 \text{ in}, \quad t_s = 0.17 \text{ in}, \quad d_s = 8.82 \text{ in}\]

The available shear strength is

\[
V_y = \min \left( \frac{V_{rup}}{\Omega_{rupture}}, \frac{V_{yield}}{\Omega_{other}} \right) = 3.997 \text{ kip}
\]

\[
\frac{V_1}{V_y} = 7.505 \cdot 10^{-4}, \quad \frac{V_2}{V_y} = 0
\]

\[
\left( \frac{M_1}{M_{nx}} \right)^2 + \left( \frac{V_1}{V_y} \right)^2 = 7.116 \cdot 10^{-7}, \quad \left( \frac{M_2}{M_{nx}} \right)^2 + \left( \frac{V_2}{V_y} \right)^2 = 2.136 \cdot 10^{-7}
\]

OK
S2.8 The Bottom Horizontal Beam - Member Number 15

Section Properties

\[ A_s := S(5, 1) \text{ in}^2 = 3.47 \text{ in}^2 \]
\[ d := S(1, 1) \text{ in} = 5.904 \text{ in} \]
\[ I_{xx} := S(6, 1) \text{ in}^4 = 14.99 \text{ in}^4 \]
\[ I_{yy} := S(7, 1) \text{ in}^4 = 19.09 \text{ in}^4 \]
\[ S_{xx} := S(11, 1) \text{ in}^3 = 6.616 \text{ in}^3 \]
\[ S_{yy} := S(13, 1) \text{ in}^3 = 3.442 \text{ in}^3 \]
\[ J := S(48, 1) \text{ in}^3 = 1.863 \text{ in}^3 \]
\[ x_s := S(45, 1) \text{ in} = 1.614 \text{ in} \]
\[ Z_x := S(31, 1) \text{ in}^3 = 6.391 \text{ in}^3 \]
\[ \beta_x := S(49, 1) \cdot \text{ in} = 1.093 \text{ in} \]
\[ S_{m} := S(14, 1) \text{ in}^3 = 7.067 \text{ in}^3 \]
\[ S_{m} := S(12, 1) \text{ in}^3 = 4.12 \text{ in}^3 \]
\[ C_w := S(47, 1) \text{ in}^3 = 11.87 \text{ in}^3 \]

\[ w_x := A_s \cdot 170 \text{ pcf} = 4.097 \frac{\text{lbf}}{\text{ft}} \]
\[ r_{xx} := \frac{I_{xx}}{A_s} = 2.078 \text{ in} \]
\[ r_{yy} := \frac{I_{yy}}{A_s} = 2.346 \text{ in} \]
\[ Z_y := S(32, 1) \text{ in}^3 = 5.972 \text{ in}^3 \]
\[ y_s := S(46, 1) \text{ in} = 5.39 \text{ in} \]

Member Forces
Check Compression

Member Buckling

\[ L_x := 47.48 \text{ in} \quad L_y := L_x \quad L_z := L_x \]

The member buckling strength \( P_{\text{ncl M}} = 115.253 \text{ kip} \)

Local Buckling

\[ F_{\text{ncl}} = 33.551 \text{ ksi} \quad P_{\text{ncl}} = 119.455 \text{ kip} \]

The member and local buckling interaction

\[
P_{\text{ncl}} = \left( \frac{0.85 \cdot \pi^2 \cdot E}{b_{\text{inter}} \cdot t_{\text{inter}}^2} \right)^{\frac{1}{3}} \cdot F_{\text{stiffner}} \cdot A_g = 308.497 \text{ kip}
\]

The governing load is: \( P_{\text{ncl govern}} = \min \left( P_{\text{ncl}}, P_{\text{ncl L}}, P_{\text{ncl M}} \right) = 115.253 \text{ kip} \)

The available compression strength is

\[
P_{\text{nc}} = \frac{P_{\text{ncl govern}}}{\Omega_c} = 69.85 \text{ kip} \quad \frac{P_{\text{i}}}{P_{\text{nc}}} = 7.158 \times 10^{-5} \quad \text{OK}
\]
Check Flexure

\[ M_{npYieldX} = \min \left( Z_x, F_{cy}, 1.5 \cdot S_1, F_{ty}, 1.5 \cdot S_c, F_{cy} \right) = 18.025 \text{ kip \cdot ft} \]

\[ M_{npYieldY} = \min \left( Z_y, F_{cy}, 1.5 \cdot S_1, F_{ty}, 1.5 \cdot S_c, F_{cy} \right) = 17.418 \text{ kip \cdot ft} \]

Check Yielding

Check Rupture

\[ M_{npRupX} = Z_x \cdot \frac{F_{tu}}{k_t} = 16.191 \text{ kip \cdot ft} \]

\[ M_{npRupY} = Z_y \cdot \frac{F_{tu}}{k_t} = 15.129 \text{ kip \cdot ft} \]

Check Local Buckling - Flexure

\[ F_b = 47.352 \text{ ksi} \]

\[ F_c = F_{cut} = 33.551 \text{ ksi} \]

\[ M_{nlbx} = F_c \cdot \frac{l_t}{c_{ct}} + F_b \cdot \frac{l_w}{c_{cw}} = 62.471 \text{ kip \cdot ft} \]

\[ M_{nlby} = F_c \cdot \frac{l_t}{c_{ct}} + F_b \cdot \frac{l_w}{c_{cw}} = 5.951 \text{ kip \cdot ft} \]

Check Lateral Torsional Buckling

X Axis (Strong Axis)

\[ M_{nmbX} = 15.882 \text{ kip \cdot ft} \]

\[ k_2 = 2.27 \]

Y Axis (Weak Axis)

\[ M_{nmbY} = 15.216 \text{ kip \cdot ft} \]
Check Flexure

M_{nx} = \min \left( \frac{M_{n_{\text{rupture}}}}{\Omega_{\text{rupture}}}, \frac{M_{n_{\text{Yield}}}}{\Omega_{\text{Yield}}} \right) = 8.303 \text{ kip} \cdot \text{ft} \quad M_{nx} = 0.001 \text{ OK}

M_{ny} = \min \left( \frac{M_{n_{\text{rupture}}}}{\Omega_{\text{rupture}}}, \frac{M_{n_{\text{Yield}}}}{\Omega_{\text{Yield}}} \right) = 3.607 \text{ kip} \cdot \text{ft}

Check Yielding

Y Axis (Weak Axis)

Check Lateral Torsional Buckling

Check Local Buckling - Flexure

Check Rupture

M_{n_{\text{rupture}}} = \frac{C}{k_{t}} \cdot \frac{F_{n_{\text{Yield}}}}{\Omega_{\text{Yield}}} = \frac{16.657}{8.542} \text{ kip} \cdot \text{ft} \quad T_{n_{\text{Yield}}} = \frac{F_{n_{\text{Yield}}}}{\Omega_{\text{Yield}}} = \frac{19.178}{8.542} \text{ kip} \cdot \text{ft}

Check Shear

Check the Y direction Shear

\text{Type} = 0 \quad \text{1 stands for the support on both edges, while 0 stands for the support on one edge.}

b_{y} = 1.5 \text{ in} \quad t_{y} = 0.17 \text{ in} \quad d_{y} = 8.0625 \text{ in}

The available shear strength is

V_{y} = \min \left( \frac{V_{n_{\text{rupture}}}}{\Omega_{\text{rupture}}}, \frac{V_{n_{\text{Yield}}}}{\Omega_{\text{Yield}}} \right) = 3.245 \text{ kip} \quad \frac{V_{y}}{V_{y}} = 0 \text{ OK}

Check the X direction Shear

\text{Type} = 0 \quad \text{1 stands for the support on both edges, while 0 stands for the support on one edge.}

b_{x} = 1 \text{ in} \quad t_{x} = 0.125 \text{ in} \quad d_{x} = 1.75 \text{ in}

The available shear strength is

V_{x} = \min \left( \frac{V_{n_{\text{rupture}}}}{\Omega_{\text{rupture}}}, \frac{V_{n_{\text{Yield}}}}{\Omega_{\text{Yield}}} \right) = 1.591 \text{ kip} \quad \frac{V_{x}}{V_{x}} = -0.123 \text{ OK}

Check Torque

t = 0.17 \text{ in}

C = \frac{J}{t} = 10.959 \text{ in}^3 \quad T_{\text{rupture}} := \frac{F_{su}}{k_{t}} \cdot C = 16.657 \text{ kip} \cdot \text{ft} \quad T_{\text{Yield}} := \frac{F_{n_{\text{Yield}}}}{\Omega_{\text{Yield}}} \cdot C = 19.178 \text{ kip} \cdot \text{ft}

T_{n} := \min \left( \frac{T_{n_{\text{rupture}}}}{\Omega_{\text{rupture}}}, \frac{T_{n_{\text{Yield}}}}{\Omega_{\text{Yield}}} \right) = 8.542 \text{ kip} \cdot \text{ft}

Safety := \frac{T_{n}}{T_{n}} = 0

Check the Combination of Loads

\frac{P_{1}}{P_{nc}} + \left( \frac{M_{nx}}{M_{nc}} \right)^{2} + \left( \frac{M_{ny}}{M_{nc}} \right)^{2} + \left( \frac{V_{x}}{V_{x}} \right)^{2} + \left( \frac{V_{y}}{V_{y}} \right)^{2} + \left( \frac{T_{n}}{T_{n}} \right)^{2} = 0.015 \text{ OK}
S2.10 The Vertical Mullions Check

Section Properties

\[
A_z := S(5, 1) \text{ in}^2 = 2.566 \text{ in}^2 \quad w_z := A_z \cdot 170 \text{ pcf} = 3.029 \frac{\text{lb} \text{ ft}}{\text{ft}}
\]

\[
d := S(1, 1) \text{ in} = 8.071 \text{ in} \quad \beta_z := S(49, 1) \cdot \text{ in} = 0.283 \text{ in}
\]

\[
l_{xx} := S(6, 1) \text{ in}^3 = 19.23 \text{ in}^4 \quad r_{xx} := \frac{I_{xx}}{A_z} = 2.738 \text{ in}
\]

\[
l_{yy} := S(7, 1) \text{ in}^3 = 0.737 \text{ in}^4 \quad r_{yy} := \frac{I_{yy}}{A_z} = 0.536 \text{ in}
\]

\[
S_{mp} := S(11, 1) \text{ in}^3 = 4.597 \text{ in}^3 \quad S_{mn} := S(12, 1) \text{ in}^3 = 4.597 \text{ in}^3
\]

\[
S_{mp} := S(13, 1) \text{ in}^3 = 4.597 \text{ in}^3 \quad S_{mn} := S(14, 1) \text{ in}^3 = 4.597 \text{ in}^3
\]

\[
J := S(48, 1) \text{ in}^3 = 0.68 \text{ in}^4 \quad C_w := S(47, 1) \text{ in}^3 = 5.455 \text{ in}^3
\]

\[
x_z := S(45, 1) \text{ in} = 1.854 \text{ in} \quad \gamma_z := S(46, 1) \text{ in} = 4.018 \text{ in}
\]

\[
Z_z := S(31, 1) \text{ in}^3 = 6.22 \text{ in}^3 \quad Z_{z'} := S(32, 1) \text{ in}^3 = 1.137 \text{ in}^3
\]

Member Forces

<table>
<thead>
<tr>
<th>Case</th>
<th>Member</th>
<th>Axial Force (k)</th>
<th>Y-Axis Shear (k)</th>
<th>Z-Axis Shear (k)</th>
<th>V_u (k)</th>
<th>Torsion (kft)</th>
<th>X-Axis Moment (kft)</th>
<th>Y-Axis Moment (kft)</th>
<th>M_z (kft)</th>
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</thead>
<tbody>
<tr>
<td>101</td>
<td>vertical</td>
<td>-0.005</td>
<td>0.000</td>
<td>0.052</td>
<td>0.052</td>
<td>0.000</td>
<td>0.000</td>
<td>0.010</td>
<td>0.010</td>
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<tr>
<td>102</td>
<td>vertical</td>
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<td>0.000</td>
<td>-0.016</td>
<td>0.016</td>
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</tbody>
</table>
Check Compression

Member Buckling

\[ L_x = 91.81 \text{ in} \quad L_y = L_x \quad L_z = L_x \]

The member buckling strength \( P_{ncM} = 7.406 \text{ kip} \)

Local Buckling

\[ P_{ncl} = 19.789 \text{ ksi} \quad P_{ncl} = 74.92 \text{ kip} \]

The member and local buckling interaction

\[ P_{ncI} = \frac{F_{ncI}}{E} \cdot \frac{b_{inter}^2}{d_{inter}} \cdot A_g = 55.424 \text{ kip} \]

The governing load is:

\[ P_{ncgovern} = \min \left( P_{ncl}, P_{ncI} \right) = 7.406 \text{ kip} \]

The available compression strength is

\[ \frac{P_{nc}}{\Omega_c} = 4.489 \text{ kip} \quad \frac{P_g}{P_{nc}} = -6.683 \times 10^{-4} \quad \text{OK} \]
Check Flexure

Check Yielding

\[ M_{npYieldX} = \min (Z_x, F_{cy}, 1.5 \cdot S_t \cdot F_{ty}, 1.5 \cdot S_c \cdot F_{cy}) = 18.142 \text{ kip} \cdot \text{ft} \]

\[ M_{npYieldY} = \min (Z_y, F_{cy}, 1.5 \cdot S_t \cdot F_{ty}, 1.5 \cdot S_c \cdot F_{cy}) = 3.316 \text{ kip} \cdot \text{ft} \]

Check Rupture

\[ M_{npRupX} = Z_x \cdot F_{tu} \cdot \frac{kt}{k_t} = 15.757 \text{ kip} \cdot \text{ft} \]

\[ M_{npRupY} = Z_y \cdot F_{tu} \cdot \frac{kt}{k_t} = 2.88 \text{ kip} \cdot \text{ft} \]

Check Local Buckling - Flexure

\[ F_p = 45.91 \text{ ksi} \]

\[ F_c = F_{act} = 19.789 \text{ ksi} \]

\[ M_{nlbx} = F_c \cdot \frac{l_p}{c_{ef}} + F_b \cdot \frac{l_w}{c_{cw}} = 60.523 \text{ kip} \cdot \text{ft} \]

\[ M_{nlby} = F_c \cdot \frac{l_p}{c_{ef}} + F_b \cdot \frac{l_w}{c_{cw}} = 5.767 \text{ kip} \cdot \text{ft} \]

Check Lateral Torsional Buckling

X Axis (Strong Axis)

\[ M_{nmbX} = 10.338 \text{ kip} \cdot \text{ft} \]

Y Axis (Weak Axis)

\[ M_{nmbY} = 5.41 \text{ kip} \cdot \text{ft} \]
$$M_{\text{ex}} = \min \left( \frac{M_{\text{npYieldX}}}{\Delta_{\text{other}}}, \frac{M_{\text{npRupX}}}{\Omega_{\text{rupture}}}, \frac{M_{\text{mbX}}}{\Delta_{\text{other}}}, \frac{M_{\text{nbX}}}{\Omega_{\text{other}}} \right) = 6.265 \text{ kip} \cdot \text{ft}$$

$$M_{\text{ey}} = \min \left( \frac{M_{\text{npYieldY}}}{\Delta_{\text{other}}}, \frac{M_{\text{npRupY}}}{\Omega_{\text{rupture}}}, \frac{M_{\text{mbY}}}{\Delta_{\text{other}}}, \frac{M_{\text{nbY}}}{\Omega_{\text{other}}} \right) = 1.477 \text{ kip} \cdot \text{ft}$$

Check Shear

Check the shear in Y-axis

$$\text{Type} = 0 \quad 1 \text{ stands for the support on both edges,} \quad \text{while } 0 \text{ stands for the support on one edge.}$$

$$b_s = 1.5 \text{ in} \quad t_s = 0.17 \text{ in} \quad d_s = 8.0625 \text{ in}$$

The available shear strength is

$$V_Y = \min \left( \frac{V_{\text{rupture}}}{\Omega_{\text{rupture}}}, \frac{V_{\text{yield}}}{\Omega_{\text{other}}} \right) = 3.245 \text{ kip} \quad \frac{V_{\text{sy}}}{V_Y} = 0$$

Check the shear in X-axis

$$\text{Type} = 0 \quad 1 \text{ stands for the support on both edges,} \quad \text{while } 0 \text{ stands for the support on one edge.}$$

$$b_s = 1 \text{ in} \quad t_s = 0.125 \text{ in} \quad d_s = 1.5 \text{ in}$$

The available shear strength is

$$V_X = \min \left( \frac{V_{\text{rupture}}}{\Omega_{\text{rupture}}}, \frac{V_{\text{yield}}}{\Omega_{\text{other}}} \right) = 1.591 \text{ kip} \quad \frac{V_{\text{sx}}}{V_X} = -0.038$$

Check the Combination of Loads

$$\frac{P_g}{P_{\text{nc}}} + \left( \frac{M_g}{M_{\text{ex}}} \right)^2 + \left( \frac{V_{sx}}{V_X} \right)^2 + \left( \frac{V_{sy}}{V_Y} \right)^2 = 8.084 \cdot 10^{-4} \quad \text{OK}$$
S2.10 The pinnacle (member 4, 7) Check

Section Properties

\[ A_s := S(5, 1) \text{ in}^2 = 2.093 \text{ in}^2 \]
\[ w_s := A_s \cdot 170 \text{ pcf} = 2.471 \text{ lbf ft} \]
\[ d := S(1, 1) \text{ in} = 3.543 \text{ in} \]
\[ l_{xx} := S(6, 1) \text{ in}^4 = 2.189 \text{ in}^4 \]
\[ l_{yy} := S(7, 1) \text{ in}^4 = 0.061 \text{ in}^4 \]
\[ r_{xx} := \sqrt{\frac{l_{xx}}{A_s}} = 1.023 \text{ in} \]
\[ S_{xx} := S(11, 1) \text{ in}^3 = 1.236 \text{ in}^3 \]
\[ S_{yy} := S(13, 1) \text{ in}^3 = 0.206 \text{ in}^3 \]
\[ J := S(48, 1) \text{ in}^3 = 0.225 \text{ in}^3 \]
\[ r_{yy} := \sqrt{\frac{l_{yy}}{A_s}} = 0.593 \text{ in} \]
\[ S_{xx} := S(12, 1) \text{ in}^3 = 1.236 \text{ in}^3 \]
\[ S_{yy} := S(14, 1) \text{ in}^3 = 0.206 \text{ in}^3 \]
\[ C_w := S(47, 1) \text{ in}^6 = 0.057 \text{ in}^6 \]
\[ y_s := S(46, 1) \text{ in} = (2 \cdot 10^{-4}) \text{ in} \]
\[ Z_y := S(32, 1) \text{ in}^3 = 0.309 \text{ in}^3 \]
\[ x_s := S(45, 1) \text{ in} = -2 \cdot 10^{-4} \text{ in} \]
\[ Z_x := S(31, 1) \text{ in}^3 = 1.854 \text{ in}^3 \]
\[ \beta_s := S(49, 1) \text{ in} = (5 \cdot 10^{-4}) \text{ in} \]

Member Forces

<table>
<thead>
<tr>
<th>Member</th>
<th>Case</th>
<th>Node</th>
<th>Axial Force (k)</th>
<th>Y-Axis Shear (k)</th>
<th>Z-Axis Shear (k)</th>
<th>V_x (k)</th>
<th>Torsion (kft)</th>
<th>Y-Axis Moment (kft)</th>
<th>Z-Axis Moment (kft)</th>
<th>M_x (kft)</th>
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<tr>
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<td>Max. Mem.</td>
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<td>0.000</td>
<td>0.141</td>
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<tr>
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<td></td>
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<tr>
<td></td>
<td></td>
<td>Max. Mem.</td>
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<td>0.000</td>
<td>-0.165</td>
<td>0.165</td>
<td>0.000</td>
<td>0.000</td>
<td>0.022</td>
<td>0.022</td>
</tr>
</tbody>
</table>

Project: Landmark Date: 11.07.2016
Subject: Structural Performance
Check Compression

Member Buckling

\[ L_x = 11.811 \text{ in} \quad L_y = L_x \quad L_z = L_x \]

The member buckling strength \( P_{ncM} = 71.668 \text{ kip} \)

Local Buckling

\[ F_{ncL} = 35 \text{ ksi} \quad P_{ncL} = 73.255 \text{ kip} \]

The member and local buckling interaction

\[
P_{ncI} = \left( \frac{0.85 \cdot \pi^2 \cdot E}{\frac{L_{inter}^2}{t_{inter}}} \right)^{\frac{1}{3}} \cdot F_{ncL} \cdot \frac{2}{3} \cdot A_g = (3.034 \cdot 10^3) \text{ kip}
\]

The governing load is: \( P_{ncgovern} = \min \{ P_{ncI}, P_{ncL}, P_{ncM} \} = 71.668 \text{ kip} \)

The available compression strength is

\[
P_{nc} = \frac{P_{ncgovern}}{\Omega_c} = 43.435 \text{ kip}
\]
Check Flexure

Check Yielding

\[
M_{npYieldX} := \min \left( Z_x \cdot F_{cy}, 1.5 \cdot S_t \cdot F_{ty}, 1.5 \cdot S_z \cdot F_{cy} \right) = 5.408 \text{kip} \cdot \text{ft}
\]

\[
M_{npYieldY} := \min \left( Z_y \cdot F_{cy}, 1.5 \cdot S_t \cdot F_{ty}, 1.5 \cdot S_z \cdot F_{cy} \right) = 0.901 \text{kip} \cdot \text{ft}
\]

Check Rupture

\[
M_{npRupX} := Z_x \cdot \frac{F_{tu}}{k_t} = 4.697 \text{kip} \cdot \text{ft}
\]

\[
M_{npRupY} := Z_y \cdot \frac{F_{tu}}{k_t} = 0.783 \text{kip} \cdot \text{ft}
\]

Check Local Buckling - Flexure

\[F_b = 52.5 \text{ksi}\]

\[F_c := F_{ref} = 35 \text{ksi}\]

\[
M_{nlbx} := \frac{F_c}{c_{cf}} \cdot I_p + \frac{F_b}{c_{cw}} \cdot I_w = 24.712 \text{kip} \cdot \text{ft}
\]

\[
M_{nlby} := \frac{F_c}{c_{cf}} \cdot I_p + \frac{F_b}{c_{cw}} \cdot I_w = 14.273 \text{kip} \cdot \text{ft}
\]

Check Lateral Torsional Buckling

X Axis (Strong Axis)

\[M_{nlex} = 4.255 \text{kip} \cdot \text{ft}\]

Y Axis (Weak Axis)

\[M_{nley} = 0.869 \text{kip} \cdot \text{ft}\]
Check Flexure

Check Yielding

Y Axis (Weak Axis)

X Axis (Strong Axis)

Check Lateral Torsional Buckling

Check Local Buckling - Flexure

Check Rupture

\[
\frac{M_{101}}{M_{ny}} = 0.047 \quad \frac{M_{103}}{M_{ny}} = 0.055 \quad \text{OK}
\]

Check Shear

Check Shear in X direction

\[
Type = 0 \quad 1 \text{ stands for the support on both edges, while } 0 \text{ stands for the support on one edge.}
\]

\[
b_s = 3 \text{ in} \quad t_s = 0.125 \text{ in} \quad d_s = 8.0625 \text{ in}
\]

The available shear strength is

\[
V_X = 2 \cdot \min \left( \frac{V_{nsup}, V_{nother}}{V_{nsup}, V_{nother}} \right) = 7.752 \text{ kip} \quad \frac{V_{101X}}{V_X} = 0.018 \quad \frac{V_{103X}}{V_X} = -0.021
\]

Check Shear in Y direction

\[
Type = 0 \quad 1 \text{ stands for the support on both edges, while } 0 \text{ stands for the support on one edge.}
\]

\[
b_s = 8.0625 \text{ in} \quad t_s = 0.125 \text{ in} \quad d_s = 3 \text{ in}
\]

The available shear strength is

\[
V_X = 2 \cdot \min \left( \frac{V_{nsup}, V_{nother}}{V_{nsup}, V_{nother}} \right) = 3.252 \text{ kip} \quad \frac{V_{101Y}}{V_X} = 0 \quad \frac{V_{103Y}}{V_X} = 0
\]

Check the Combination of Loads

\[
\left( \frac{M_{101}}{M_{ny}} \right)^2 + \left( \frac{V_{101X}}{V_X} \right)^2 + \left( \frac{V_{101Y}}{V_Y} \right)^2 = 0.004 \quad \text{OK}
\]

\[
\left( \frac{M_{103}}{M_{ny}} \right)^2 + \left( \frac{V_{103X}}{V_X} \right)^2 + \left( \frac{V_{103Y}}{V_Y} \right)^2 = 0.006 \quad \text{OK}
\]
S11 Anchor Design

Maximum Anchor Loads (From Reactions)

\[ P_x = 2 \times 0.165 \text{kN} = 0.074 \text{kip} \]

\[ P_y = 2 \times 0.012 \text{kN} = 0.005 \text{kip} \]

\[ P_{\text{Fm}} = 1000 \text{lbf} = 1 \text{kip} \]

Material

Aluminum Extrusions (6061-T5 or 6005A-T61)

\[ F_{\text{br}} = 31 \text{ ksi} = 214 \text{ MPa} \quad F_s = 12 \text{ ksi} = 82.737 \text{ MPa} \]

\[ F_b = 28 \text{ ksi} = 193.053 \text{ MPa} \quad F_t = 19 \text{ ksi} = 131 \text{ MPa} \]

Minimum Wall Thickness \( t_m = 0.125 \text{ in} = 3.175 \text{ mm} \)

Bolts (Steel A325 or M5)

Diameter \( d_b = 0.625 \text{ in} = 16 \text{ mm} \)

Shear Capacity \( V_{bs} = 3.58 \text{ kip} = 15.925 \text{ kN} \)

Bearing Capacity \( V_{bb} = F_{\text{br}} \times d_b \times t_m = 2.422 \text{ kip} \quad V_{bb} = 10.773 \text{ kN} \)
Check the Anchor Bolt

Number of Bolts \( N = 2 \)

Number of Row \( Row = 1 \)

Eccentricities

\[
G_x := 78 \text{ mm} = 3.071 \text{ in} \\
G_y := 10 \text{ mm} = 0.394 \text{ in}
\]

Tolerance

\[
T_x := 1.5 \text{ in} \\
T_y := 2.0 \text{ in}
\]

Coordinates

\[
x := \begin{bmatrix}
0 \\
0 \\
-0.05
\end{bmatrix}
\quad y := \begin{bmatrix}
0 \\
B_y \\
B_x \\
0
\end{bmatrix}
\]

Group Centroid

\[
x_c := \frac{\sum x}{N} = 0 \text{ in}
\]

\[
y_c := \frac{\sum y}{N} = 2.362 \text{ in}
\]

Applied Moment at Centroid of Bolts

\[
M_{dl,aw} := P_y \cdot (G_x - x_c + T_x) + P_x \cdot (G_y + y_c + T_y) = 0.377 \text{ kip \cdot in}
\]

\[
M_{dl,m} := (P_y + P_y) \cdot (G_x - x_c + T_x) = 4.596 \text{ kip \cdot in}
\]

\[
M_{dl} := \max(M_{dl,m}, M_{dl,aw}) = 4.596 \text{ kip \cdot in}
\]

Torsion Constant:

\[
J := \sum (y - y_j)^2 + \sum (x - x_j)^2 = 11.16 \text{ in}^2
\]

Resultant Shear Force at Each Fastener:

\[
\nu := \sqrt{\left(\frac{P_x}{N} + \frac{M_{dl}}{J \cdot \sqrt{2}} \left(y - y_j\right)^2 + \left(x - x_j\right)^2 \right)^2 + \left(\frac{P_y}{N} + \frac{M_{dl}}{J \cdot \sqrt{2}} \left(y - y_j\right)^2 + \left(x - x_j\right)^2 \right)^2} = \begin{bmatrix}
1 \\
3.7 \cdot 10^{-2}
\end{bmatrix} \text{ kip}
\]

\[
V_{\text{max}} := \max(\nu) = 1.001 \text{ kip}
\]

\[
\frac{V_{\text{max}}}{\min(V_{bs}, V_{ab})} = 0.413 \ll 1.0 \text{ OK}
\]
Check Anchor Hook

\[ d_a = 20 \text{ mm} = (8 \cdot 10^{-3}) \text{ in} \]
\[ h = 18 \text{ mm} = 0.709 \text{ in} \]
\[ t_b = 0.625 \text{ in} = 15.875 \text{ mm} \]
\[ a_d = 5 \text{ mm} = 0.197 \text{ in} \]

**Location A**

**Shear**
\[ f_v = \frac{P_y}{t_h \cdot a_d} = 0.603 \text{ ksi} \]
\[ F_y = 12 \text{ ksi} \]
\[ \text{OK} \]

**Tension**
\[ f_t = \frac{P_y}{t_h \cdot a_d} = 0.044 \text{ ksi} \]
\[ F_t = 19 \text{ ksi} \]
\[ \text{OK} \]

**Bending**
\[ f_b = \frac{P_y \left( \frac{d_a}{2} \right)}{t_h \cdot a_d^2} \cdot 6 = 7.236 \text{ ksi} \]
\[ F_t = 19 \text{ ksi} \]
\[ \text{OK} \]

**Combined**
\[ \left( \frac{f_b}{F_b} \right)^2 + \left( \frac{f_t}{F_t} \right)^2 = 0.069 \]
\[ 1.0 \text{ OK} \]

**Point B**

**Shear**
\[ f_v = \frac{P_y}{t_h \cdot b} = 0.012 \text{ ksi} \]
\[ F_y = 12 \text{ ksi} \]
\[ \text{OK} \]

**Tension**
\[ f_t = \frac{P_y}{t_h \cdot h} = 0.167 \text{ ksi} \]
\[ F_t = 19 \text{ ksi} \]
\[ \text{OK} \]

**Bending**
\[ f_b = \frac{P_y \left( \frac{h}{2} + \frac{d_a}{2} \right)}{t_h \cdot h^2} \cdot 6 = 1.1 \text{ ksi} \]
\[ F_t = 19 \text{ ksi} \]
\[ \text{OK} \]

**Combined**
\[ \left( \frac{f_b}{F_b} \right)^2 + \left( \frac{f_t}{F_t} \right)^2 = 0.001 \]
\[ 1.0 \text{ OK} \]
\[ \frac{f_t}{F_t} + \frac{f_b}{F_b} = 0.047 \]
\[ 1.0 \text{ OK} \]

**Maintenance Load**

**Shear**
\[ f_v = \frac{P_y + P_{pmi}}{t_h \cdot h} = 2.27 \text{ ksi} \]
\[ F_y = 12 \text{ ksi} \]
\[ \text{OK} \]
Check Anchor

\[ w_s = 92 \text{ mm} = 3.622 \text{ in} \quad t_s = 12 \text{ mm} = 0.472 \text{ in} \]

\[ d_s = 20 \text{ mm} = 0.8 \text{ in} \quad d_p = 82 \text{ mm} = 3.2 \text{ in} \quad \text{TOL}_s = 0.5 \text{ in} = 12.7 \text{ mm} \]

Shear

\[ f_s = \frac{P_s}{t_s \cdot w_s} \quad (3.2 \cdot 10^{-3}) \text{ ksi} \quad \ll \quad F_s = 12 \text{ ksi} \quad \text{OK} \]

Bending

\[ f_b = \frac{P_s \cdot d_s + P_s \cdot (d_s + \text{TOL}_s)}{t_s^2 \cdot (w_s - 2 \cdot (1.0625 \text{ in}))} \quad 6 = 4.4 \text{ ksi} \quad \ll \quad F_b = 28 \text{ ksi} \quad \text{OK} \]

Combined

\[ \left( \frac{f_b}{F_b} \right)^2 + \left( \frac{f_s}{F_s} \right)^2 = 2.5 \cdot 10^{-2} \quad \ll \quad 1.0 \quad \text{OK} \]

Maintenace Load

Shear

\[ f_s = \frac{P_s + P_{ym}}{t_s \cdot w_s} = 0.6 \text{ ksi} \quad \ll \quad F_s = 12 \text{ ksi} \quad \text{OK} \]

Bending

\[ f_b = \frac{(P_s + P_{ym}) \cdot (d_s + \text{TOL}_s)}{t_s^2 \cdot (w_s - 2 \cdot (1.0625 \text{ in}))} \quad 6 = 23.2 \text{ ksi} \quad \ll \quad F_b = 28 \text{ ksi} \quad \text{OK} \]

High-Tensile T-Bolts

\[ \text{TOL}_2 = 1 \text{ in} = 25.4 \text{ mm} \quad \text{TOL}_s = 1 \text{ in} = 25.4 \text{ mm} \quad \text{TOL}_v = 1 \text{ in} = 25.4 \text{ mm} \]

\[ d_{TB} = 28 \text{ mm} = 1.102 \text{ in} \quad b_0 = 121 \text{ mm} = 4.764 \text{ in} \]

Allowable Loads

\[ V_{all} = 3.45 \text{ kip} \quad T_{all} = 5.2 \text{ kip} \]

\[ V_{TB} = P_s = 0.074 \text{ kip} \]

\[ t_{TB} = \frac{P_s \cdot d_s + P_s \cdot (d_s + \text{TOL}_s + 0.1 \cdot b_0)}{b_0} = 0.053 \text{ kip} \]

\[ \left( \frac{V_{TB}}{V_{all}} \right)^2 + \left( \frac{t_{TB}}{T_{all}} \right)^2 = 5.657 \cdot 10^{-4} \quad \ll \quad 1.0 \quad \text{OK} \]

Maintenace Load

\[ t_{TB} = \frac{(P_s + P_{ym}) \cdot (d_s + \text{TOL}_s + 0.1 \cdot b_0)}{0.9 \cdot b_0} = 0.531 \text{ kip} \quad \ll \quad T_{all} = 5.2 \text{ kip} \quad \text{OK} \]
Thermal Performance

Methodology

The report presents a thermal analysis by numerical simulation for Landmark Pinnacle. The models were created using THERM 7.4 and Window 7.4, specifically the latest version developed by Lawrence Berkley National Laboratory (LBNL). Finite Element Method (FEM) was implemented for simulation of combined steady state heat conduction and radiation. Where applicable and possible the simulation procedures outlined in the National Fenestration Ratings Council (NFRC) Simulation Manual were followed. Temperature distribution and dew point isotherms, which corresponds to the interior room temperature and relative humidity, are simulated by the NFRC certificated programs mentioned above. Condensation will form on surfaces below dew point temperature. All thermal transmittance calculations are based on the area weighted method as cited in EN 673 and BS EN ISO 10077 for determining the thermal transmittance of fenestration products.

Observed Environmental Conditions

External Conditions:
1. Air and Effective Sky Temperature 0ºC

Internal Conditions:
1. Room Temperature 20ºC
2. Air Movement - Natural Convection
3. Relative Humidity 50%
4. Dew Point 9.27ºC

Thermal Performance of Building Enclosure Systems

The building envelope systems proposed for Landmark Pinnacle were developed to achieve a level of thermal performance that surpassed traditional curtainwall systems installed in London.

Material Properties

<table>
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<th>Material</th>
<th>λ (W/MK)</th>
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Material Properties

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DV4-H
Color Contour Diagram of Material
Color Contour Diagram of Temperature

Isothermal Line of Dew Point Temperature
Landmark Pinnacle – Engineering Considerations

Virtual Construction Lab of Schüco

Project Subject: Landmark Pinnacle
Thermal Performance

Date: 11.07.2016

DH2
Color Contour Diagram of Temperature

DH2
Isothermal Line of Dew Point Temperature
DH3
Color Contour Diagram of Temperature

DH3
Isothermal Line of Dew Point Temperature
DH4
Color Contour Diagram of Temperature

DH4
Isothermal Line of Dew Point Temperature
Landmark Pinnacle – Engineering Considerations
DHS-R
Color Contour Diagram of Temperature

DH-R
Isothermal Line of Dew Point Temperature
Landmark Pinnacle – Engineering Considerations

Virtual Construction Lab of Schüco

Project
Subject
Date

Landmark Pinnacle
Thermal Performance
11.07.2016
DV1-S
Color Contour Diagram of Temperature

DV1-S
Isothermal Line of Dew Point Temperature
DV2-H
Color Contour Diagram of Temperature

DV2-H
Isothermal Line of Dew Point Temperature
DV2-S
Color Contour Diagram of Temperature

DV2-S
Isothermal Line of Dew Point Temperature
DV3-H
Color Contour Diagram of Temperature

DV3-H
Isothermal Line of Dew Point Temperature
DV4-S
Color Contour Diagram of Temperature

DV4-S
Isothermal Line of Dew Point Temperature
System U-Factor
Section of Elevation Evaluated
### Horizontal System Component U-Value

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### Vertical System Component U-Value

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<td>Total Area</td>
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</table>
The system proposed here is designed to accommodate the installation of the façade works for the Landmark Pinnacle London project. All materials and units will be delivered to production stage “just-in-time” to allow for the most efficient logistics throughout the installation process. Unitised façade units will be prefabricated before delivery, protected in canvas covered stillages designed specifically for the UK market. The following sequence of activity is recommended for the building installation:

1. **Unload units**: Using a crane and forklift, the units will be unloaded from the trucking onto pallets. An Alimak HEK TPM 3000T2 is recommended for hoisting materials and units. This model is large enough to accommodate single and twin span units, acting with dual functionality as a transport platform or material hoist. Eight single panel units or four double panel units can be hoisted per lift, but neither will exceed the three tonnes load capacity.
2. **Installation of unitised façade at floor slab:** An EMU glazing robot will be used to take the units from the crates to a tip table. From the tip table, the units will be attached to a spider crane from two floors above. The telescopic mechanism in the tip table will slide outwards with the unit during the installation.

3. **Alignment of façade elements:** Adjustments in the horizontal and vertical position are made as the unit is set. The temporary fixings supporting the unit to the anchor are removed after a unit is installed on top of the stack. The gaskets at the expansion joints are fixed, sealing the connection joints and edge connection.
4. **Shear Wall Installation:** A monorail will be used to install units at the shear wall. The units will be picked from a tip table, using the same installation methodology as before with the unitised panels. Anchors and fixings will be done through a punched hole from the installation floor.
5. **Amenity Wall Installation:** There are two options for the amenity wall installation. The first is to use a tower crane to lift the bunked crates from the truck to the roofing. A scaffold and balustrade will be erected as a working platform and space. From there, the units will be installed from the roof using the tower crane. The second option is to install the units directly from the truck. This method is not as efficient in utilizing the tower crane, as 75% more ground to roof lifts will be required. For the amenity units on floors 27 and 56, we recommend using Preston Platforms to get the panels to the floor. They provide a large enough working and landing platform to get the oversized units to the amenity floors. These drops can be done out of hours to accommodate and bring flexibility to the schedule.
Weathering performance of the curtainwall system is defined by an air and water primary line (plane) of demarcation between inside and out. Horizontally, this continuous barrier includes the exterior glass, its structural seal, the framing system, the framing internal seals, a horizontal primary gasket carried across unit joints and sealed at splices, and a silicone boot joining units and the primary gasket. Vertically, the barrier also includes glass, structural silicone, framing and seals, but the unit-to-unit seal is achieved through a vertical primary gasket sealed to the underside of the silicone boot and in contact with the primary horizontal seal gasket.

In the horizontal rainscreen, gaskets provide a first line of defense against water penetration by shielding the primary seal line and by creating a pressure equalized chamber in front of the primary seals.

This section diagrams the primary and secondary barrier lines of air and water infiltration for the key enclosure systems. Though only primary and secondary lines are shown, notice that a number of details have an additional third line of defense against the elements.

The concept of the split-mullion unitized curtainwall system is a standard in the construction of mid and high-rise buildings. The process involves the fabrication of aluminum extrusions that are then assembled into frames and glazed with glass or other material (typically aluminum) panels under factory-controlled conditions. The units are then shipped to the site, hoisted into position, and hung off the building structure, where the split-mullions interlock to form a weather seal. In this section, the following weathering characteristics of the unitized curtainwall are discussed:

1. **Water Penetration**

   Water penetration through a barrier is the result of the single or combined effect of three factors; an opening through the barrier; capillary action on the wall surface; a pressure difference across the barrier as the result of wind. Eliminating any one of these factors can prevent water penetration. Curtainwalls need to move, therefore it is not possible to close all openings. It is also very difficult to keep curtainwalls dry at all times. Controlling the third factor—pressure differential—has proven to be the most practical strategy. The concept of the rainscreen was introduced in the early 20th century and was adopted by the curtainwall industry in the 1960s as a primary means of preventing water penetration. The concept, generally referred to as pressure equalized rainscreen (PER) is illustrated in Figure 1 above.

   The PER concept is simple. If there is pressure equilibrium between the outside and the air chambers of the extrusions (Po=Ps), any water penetrating the rainscreen will be drained through the chambers to the outside.

2. **Stack Joint**

   The stack joint is the mating interface between upper and lower curtainwall units. It accommodates vertical movements imposed by structural live load deflections, temperature induced movements, and allowance for racking of the units during a seismic event. As a result the design of stack joint requires a high degree of articulation as well as the ability to maintain water and air seals. The concept of rainscreen is utilized in the design of the stack joint. A bulb gasket with positive continuous contact is placed in between the sill engagement groove and the head attachment gusset to insure a reliable air and water barrier. The outermost line of defense (in this case tertiary) is provided by creation of a pressure-equalized chamber in front of this air barrier using an exterior wiper gasket (see Figure 2). The pressure inside this chamber is equalized to the pressure outside through openings at quarter-points on the wiper flaps. This system will eliminate the migration of moisture due to pressure differential between the exterior wall and rainscreen cavity. In addition, the tertiary barrier is designed to prevent the movement of...
Figure 1 - Pressure Equalized Rainscreen (PER)

Figure 2 - Glazing Pocket
moisture due to capillary action, as well as providing protection against water penetration due to kinetic energy (driving rain) or other means of transport such as air stream or gravity.

**Vertical Mullions**

The diagram on page 132 represents the weathering system for the typical vertical split mullions. A two barrier system is also utilized here against water penetration. The primary water/air barrier is located at the back of the mullion, running along the outside face of glass and bridging the joint along the field-applied wet-seal. This is once again the result of the unique interior seal condition. For the secondary vertical, continuous contact is established at the gasket between aluminum components.

**Horizontal Mullions**

Horizontal mullions are factory sealed and designed with two lines of protection; the primary line of defense is the silicone caulk line factory applied at the glass joint. The secondary line of defense is the metal extrusion, which is mechanically fastened to the vertical mullions. All the joinery connections are sealed using silicone joinery pads or factory applied silicone.

**Glazing Pocket**

Glazing pockets are drained to the outside using drainage holes on quarter-points of the horizontal span, or the corner points (see Figure 2).

**Vapor Barrier Control**

Vapor diffusion through an exterior wall is sometimes the cause of cavity wall wetness or condensation in winter. However, because unitized curtainwalls have components that are resistant to vapor diffusion (aluminum extrusions, glass, sheet metal panels, and gaskets), cavity moisture due to diffusion is not a concern.

**Curtainwall Interface Details**

As a standard practice, all interface conditions provided by Schüco systems employ redundancy through a strategy of primary and secondary protection barriers.
Condensation Control

To be resistance to condensation the unitized aluminum curtainwall must incorporate various features, such as quality thermal breaks for the aluminum frames, double glazing for the vision area, and an insulated metal panel in spandrel areas. Connections and fasteners may also include thermal breaks or thermal separators. The condensation resistance of the curtainwall in winter is governed by the indoor conditions of temperature and relative humidity, and the outdoor temperature. In summer, the condensation resistance of the aluminum curtainwall is governed by the outdoor temperature, the outdoor relative humidity, and the indoor air-conditioned temperature. Condensation occurs on the glass or aluminum surfaces when the humidity of the surrounding air comes in contact with a cold surface and changes from a vapor to a liquid. Most of the unitized systems utilize thermal breaks to deal with the condensation issue. The Schüco system also provides a weep gutter at the stack joint. This feature offers an extra measure of protection against condensation. The weep-hole is only utilized in geographic regions of extreme climate or with facade specifications that require protection against humidity levels of 40% or more (see thermal performance report).

Air Infiltration

Air leakage at the glass/aluminum joint is minimized with either a wet silicone seal or a dry silicone gasket. In an unitized system, the mullions are split and therefore include an additional air barrier joint between the half mullions. Unitized systems perform well to common air infiltration standards (0.06 cfm psf at 6.24 psf pressure difference).
Unit 1

DV1

P Outside

P Outside