Façade Access & Maintenance for High-Rise Buildings

An output of the CTBUH Façade Access Working Group

Council on Tall Buildings and Urban Habitat

Peter Weismantle, Kevin Thompson & Emily Torem

CTBUH Technical Guides

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The content of this Technical Guide was also greatly enhanced by CoxGomyl, who as the designer, supplier and manufacturer of many of the systems profiled in this book, generously provided significant resource material. CoxGomyl is the leading manufacturer worldwide of Building Maintenance Units, with over 50 years experience of providing innovative and complete façade access solutions.

About CTBUH Working Groups

CTBUH Working Groups report on specific aspects of the planning, design, construction, and management of tall buildings. They are not standing committees, but groups that form for a period of time, specifically around a need or important topic in the industry, with the aim of disseminating their findings through the publication of a technical guide.

See more on other CTBUH working groups at: workinggroups.ctbuh.org

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Preface

As tall buildings have continued to realize new heights and forms, the complexity of the technologies required to access and maintain their façades has evolved in kind. The integration of these systems into contemporary skyscrapers represents a major design challenge, one that requires extensive forethought among all project stakeholders. This Technical Guide thus represents a desktop reference for designers, builders, developers, owners, and others involved with tall buildings to promote a better overall understanding of the needs and requirements for façade access. It provides best practice information and illustrates the limitations and possibilities of various building maintenance system (BMS) types.

This Technical Guide starts with a short historical overview introducing the solutions that have been devised over time. A primer on currently available system types and their general applications illustrates the components that have come about as responses to the various challenges posed by the tall building typology.

To understand these solutions, several case studies have been presented in detail to convey a comprehensive understanding of complex access issues. Following the case studies are a series of design considerations that present the key factors influencing a successful access strategy from design to implementation, underscoring the advantages of determining an access system throughout the design process, rather than treating it as an afterthought. Woven throughout are a collection of one-off, unique solutions to specific conditions addressing a diverse range of configurations. In reviewing these considerations, the aim is to instill a comprehension of the wide range of configurations available to the designer when approaching a BMS, in addition to the approach for choosing the most appropriate solutions.

A glossary provides a comprehensive list of basic terminology that tall building stakeholders may find useful as they navigate their own process of designing a cost-effective, safe and efficient façade access approach for their high-rise projects. Content for this Technical Guide was provided by a diverse assortment of professionals currently working in the field.

1.0 Introduction and Systems Overview

As tall buildings have evolved not only in height but in diversity of form and function, maintaining their exteriors has never been more necessary – or more challenging. Climatic and safety issues can be compounded hundreds of meters in the air, as can the cost of hosting and securing a permanent façade maintenance system. Though still very much a developing discipline, it is important to comprehend the implications of considering a façade access system during the design process from the outset, but in order to do so, all project stakeholders must first become familiar with basic system types and their functions. The following chapter details systems as they grow in complexity to match the heights and elaborate geometries of the buildings of today and tomorrow. A combination of several systems is often applied to a single project to optimize efficiency, as you will see throughout the case studies contained in this guide.

1.1 Historical Overview of Façade Access Systems

The need for façade access started with the more prevalent use of glass as a large-scale building material. While it was simple enough to wash windows for single story buildings by hand, as buildings grew vertically, the challenge of accessing their windows and exterior surfaces became more difficult. The first solution was to employ a ladder, but as advancements in steel construction and building technology during the 19th and 20th centuries allowed for continually growing heights, direct access quickly became more viable. Most windows in these buildings were operable and allowed access for cleaning through them. Workers wore safety belts and were harnessed to the building to prevent falls while reaching out of the building to clean its windows. At that time, however, not all buildings had safety belt terminals installed and many workers fell to their deaths without regulations on this equipment. In 1928, over 2,500 window washers protested in New York City for building owners to install safety belt terminals on all their buildings.

Some buildings (typically low-rise) still use direct access from the interior as a means of window washing. Many buildings do not employ this method because the façades are sealed to create an airtight envelope, or are too tall to safely access this way.

In addition to directly accessing façades, the water-fed pole system was created as an alternative. In 1945, Irv Tucker founded the Tucker Manufacturing Company, which made the original "Tucker Pole" or water-fed pole system. This system includes a telescoping pole with a water line and a brush at the end which allows the user to reach and clean windows above them from a safe level (see Figure 1.1).

▲ Figure 1.1: Tucker Poles use a telescoping water line and brush to safely clean façades from several floors below.
© GerardM (cc by-sa)

Once buildings reached heights that could not be easily or safely accessed from the ground, mounted suspension systems became necessary. The first systems were abseils, which involve the window washer being suspended from a single support line attached to the roof and essentially climbing down the face of the building to access its façades. Boatswain's chairs or Bosun's chairs were then invented, which involved suspending a chair or seating platform from the roof upon which a worker could sit and clean. Today these systems are limited by the International Window Cleaner's Association to 91 meters for safety (Standard I–14).

In today's building market, there are many options for providing cleaning and access to tall buildings, and the design of these systems in conjunction with a building can be a complex process. If a building maintenance system is properly planned for, however, nearly any building material, geometry, and height can be accommodated.

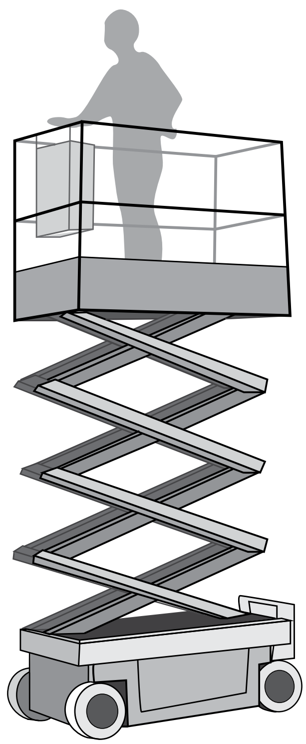
1.2 Building Maintenance Systems Overview

Aerial Work Platforms

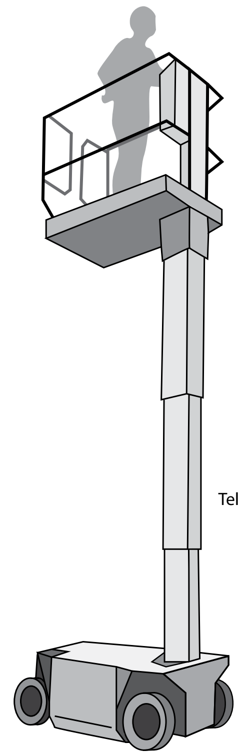
Aerial work platforms (AWPs) are transportable ground-based platforms that provide access to buildings for maintenance or construction. The range of AWP equipment that is currently available is wide, meeting a variety of needs. There are several different types of AWPs, each with its own mechanical means of positioning the work platform.

Some AWPs may be propelled on wheels, while others may be on tracks. AWPs are frequently used for indoor applications as well, as it is possible to use compact models that fit through building doors, are easy to store, and are lightweight so as not to damage floors. Electrically-powered models are available to avoid emissions.

All AWPs must be paired with a personal fall protection system for workers, no matter its vertical or horizontal reach, and operation of the equipment must be halted under extreme wind conditions, as dictated by applicable codes. Most AWP equipment can be loaded with between 227–454 kilograms. The main requirement for using an AWP is that there is an adequate area for the equipment to be set up and stabilized as required during operation.



▲ **Figure 1.2: Typical scissor lift.** © CTBUH



▲ **Figure 1.3: Typical vertical mast lift.** © CTBUH

Scissor Lifts

A scissor lift is a type of AWP that uses a scissor mechanism to propel a working platform in the vertical direction to reach a particular height. Scissor lifts are typically used for heights up to 18 meters and do not have the capability to make any horizontal reach, so are limited to the vertical plane of the vehicle (see Figure 1.2).

Mast Lifts

Mast lifts are another type of AWP appropriate for shorter height needs. There are two families of mast lifts: vertical mast lifts and mast boom lifts. The first group is very similar to scissor lifts in that they only rise in the vertical direction, and are therefore only able to service faces directly parallel to the equipment (see Figure 1.3).

Mast boom lifts use the same configuration as a vertical mast lift, but they have the added component of a boom arm which allows for horizontal outreach, increasing the flexibility of the equipment. Vertical mast lifts can usually service a height of up to 18 meters, while a mast boom can only service heights up to 10 meters and provide an outreach of up to 4.4 meters. Some models of mast lifts may also have a slewing (rotating the boom in the horizontal plane) capability in the base of the lift to allow for rotation of the platform up to 360 degrees.

Boom Lifts

Boom lifts generally allow access to much larger vertical heights, making them a viable solution for taller buildings needing a straightforward solution for façade access. There are two types of boom lifts: articulating and telescoping. A telescoping boom simply allows a boom to expand during use and contract for storage, while an articulating boom essentially includes single or multiple hinges in the boom to increase its positioning possibilities. Both types usually offer both luffing (raising or lowering the boom) and slewing motions.

Both telescoping and articulating booms currently have reaches of up to 46 meters for applications in buildings

Project Data:

Year of Completion
- 2010

Height
- 828 meters

Stories
- 163

Gross Floor Area of Tower
- 309,473 square meters

Building Function
- Office / Residential / Hotel

Structural Material
- Steel/Concrete

Total Façade Area Requiring Access
- 129,535 square meters

Usable Roof Area
- 6,670 square meters

BMS Overview:

System Types
- Building Maintenance Unit (BMU)
- Outriggers/Davits

Platform Types
- Roof-rigged and -powered
- Self-powered

Number of Access Zones
- 15

Longest Single Platform Drop
- 382 meters

Maximum Projection of Equipment from Façade
- 21.5 meters

Average Façade Area Covered per Unit
- 9,500 square meters

Percent of Façade Accessed by Powered Machinery
- 99 percent

Stabilization Types
- Intermittent Stabilization Anchors (ISAs)

Codes Applied
- ASME A120.1
- BS EN 1808
- IWCA I-14.1
- OSHA 1910

Environmental Concerns
- Dust and sand
- High winds at upper levels

Façade Maintenance Cycle Time (FMCT)
- 4 months

Frequency of FMCT
- 3 cycles annually

Façade Maintenance Staff
- 36

Case Study 2.1

Burj Khalifa Dubai, UAE

Background

The Burj Khalifa changed the landscape of façade access because of the sheer scale of the building. Soaring 828 meters above downtown Dubai, no prior building approaches the height and complexity of this tower (see Figure 2.1.1). The Y-shaped floor plan maximizes views out to the Arabian Gulf, with three sculpted wings that buttress the central core. The tower form rises from a 160-meter base, with setbacks occurring in an upward spiral pattern that reaches skyward to a 2.1-meter-wide spire. The setbacks reduce the building mass as it rises, creating a series of roof terraces that diminish in size. The resulting tower has a truly unique geometry in terms of access for cleaning and maintenance operations.

As the world's tallest building as of the date of this publication, the Burj presents significant challenges in façade access beyond those of a typical building. Made up of over 26,000 glass panels and 204,000 square meters of curtain wall cladding, the area to be cleaned and maintained is extensive. In addition to the glazing system, there are polished stainless steel vertical fins attached at the exterior of the envelope to reduce solar gain in the extreme desert climate.

Design Challenges & Opportunities

The three tower wings create a helical pattern with their setbacks, decreasing wind loads at higher elevations and creating 27 roof terraces that provide desirable outdoor space. Consequently, the Burj lacks the continuous vertical surfaces of ordinary buildings that are easily accessed by a simple descending platform. The curving plan also required a unique solution that would allow the working platforms to remain close to the façade for safe and easy access.

The materiality of the building did not have a significant impact on the access systems, aside from the vertical fin protrusions that prevent direct contact between working platforms and the curtain wall. However, the dusty and corrosive environment increases the need for maintaining the cleanliness of the building, requiring careful consideration for the façade maintenance cycle time.

The building setbacks at the upper portions of the tower created opportunities for roof-mounted BMU storage, in lieu of an actual roof. For the lower portions of the building where the roof terraces are in use by the building tenants, alternative storage solutions were needed to keep the BMU equipment hidden from view.

The top levels of the building are unique because they are the highest man-made, accessible points on earth, but are also difficult to access because of the slenderness of the spire geometry. Without large roof areas to locate BMUs, other solutions were required.

BMS Configurations

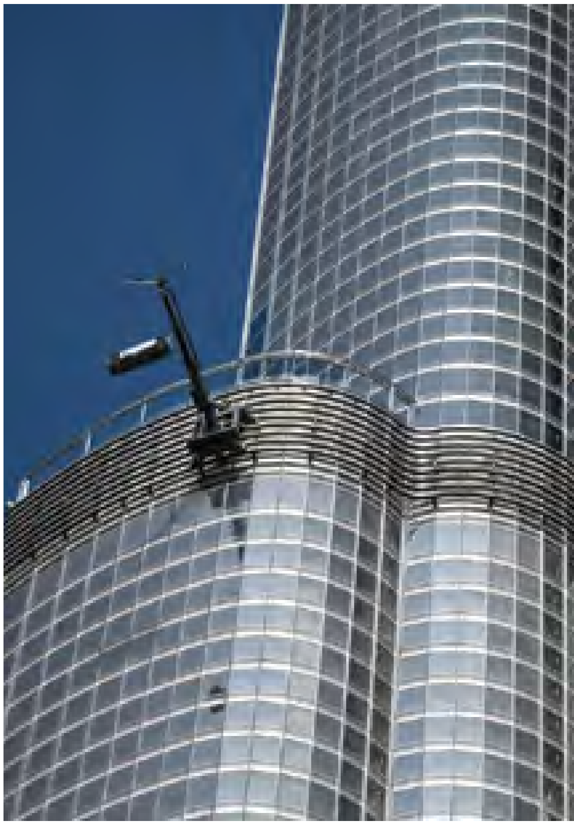
Zones 1–3
For the lower 109 floors of the building, large BMUs traverse the perimeter of the tower horizontally on tubular rails (see Figure 2.1.2). There are a total of three of these systems, at levels 40, 73,

Façade Impacting Features:

Cladding Materials
- Glass
- Stainless steel

Geometries
- Setbacks
- Curved exterior walls
- Spire

Other Features
- Vertical fins



▲ Figure 2.1.2: Large BMUs traverse the perimeter of the tower on tubular rails. © CoxGomyl

◀ Figure 2.1.1: Dubai's record-breaking Burj Khalifa soars over the city with 27 roof terraces and a 160-meter base. © Nick Merrick / Hedrich Blessing

3.0 Design Considerations and Best Practices

The design criteria outlined in this section sets out principles to be used as a reference while developing and evaluating potential façade access solutions for tall buildings. Each performance parameter has been defined in terms of its relevance to the design process, and has been gleaned from common approaches, stipulations and solutions presented in this guide as case studies.

Throughout, there are references to unique façade conditions, with brief descriptions on the access solutions that were developed in response. These snapshots provide insight into how façade access solutions can not only respond to, but enable, in other buildings beyond the case studies covered in depth in this guide, innovative enclosures and building types. The concluding section considers future access solutions and technologies, acknowledging that rapidly changing skylines will require equally adaptable solutions in the discipline of façade maintenance.

3.1 Operational Considerations

It is essential to outline all the types of operations that will be required of façade access equipment prior to its design. Both interior and exterior operations need to be considered, although equipment may differ significantly between these two contexts. Operations that necessitate access to the building envelope may include cleaning, caulking, metal polishing, glass or other façade material replacement; and general light maintenance (see Figure 3.1). These operations will affect the sizing, location, and usage of the overall building maintenance system. The higher the number of distinct operations required on a building, the more complex a maintenance system must be.

Special building elements that should be considered in the initial analysis may include: solar panels (see Figure 3.2), exterior lighting, signage, waterfalls, and green façades (see Special Condition: Oasia Hotel Downtown, p. 117), among others. All of these façade typologies may influence the types of systems used by complicating the required components. FKI Tower (see Case Study 2.9, p. 92), for example, features building maintenance units (BMUs) with telescoping rollers and a bottom trip bar in response to the PV paneling that makes up a majority of the façade on the building.

Façade Maintenance Cycle Time (FMCT) / Operation Capacity
The façade maintenance cycle time is the required amount of time to complete a full cleaning cycle of the façade elements of a building. This number is established by the designers and clients in the Basis of Design or early in the design process. The frequency of cleaning can depend on a number of factors including the climate,

▲ **Figure 3.1: Glass replacement is a common operation required of a façade access system.** Courtesy of Lerch Bates, Inc.

▲ **Figure 3.2: Special building elements, such as PV paneling, must be considered in the initial BMS design analysis.** © Adrian Smith + Gordon Gill occupancy, building classification, aesthetic preferences of the client/user, and inspection requirements.

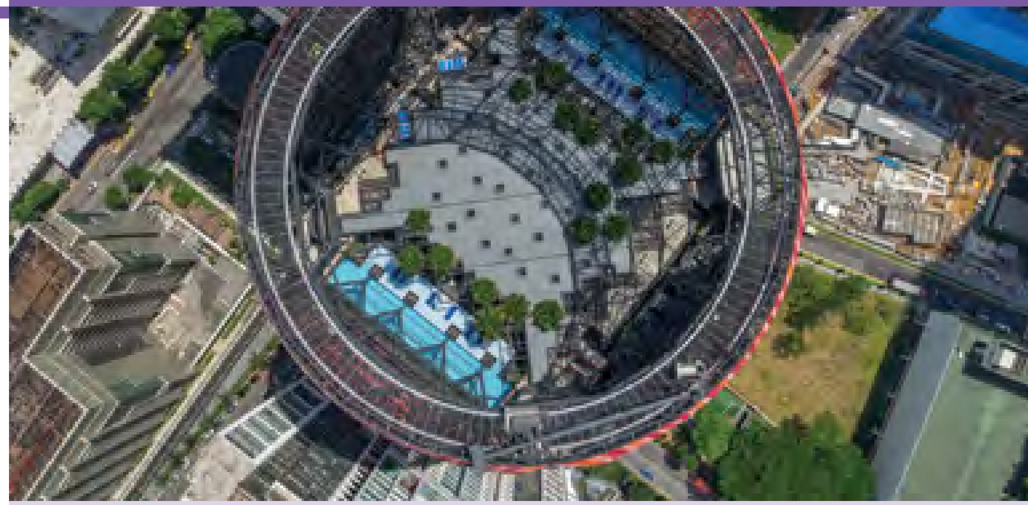
Often, the lower areas of the façade are cleaned more frequently as they are more easily viewed by building occupants and pedestrians. Similar considerations are taken for observation areas, where glass needs to be cleaned with greater frequency. At Shanghai World Financial Center (see Case Study 2.3, p. 44), the façade maintenance cycle time (FMCT) changes for each programmatic zone of the building, reflecting the varying glass transparency needed for each section; the observation deck is cleaned twice a month, while the hotel areas are cleaned monthly and the office floors are cleaned every three months.

It is generally recommended that the building maintenance system can accommodate the desired number of cleaning cycles plus at least one maintenance cycle annually. For instance, Shanghai Tower (see Case Study 2.2, p. 36), can be fully cleaned in as little as one month with all systems running simultaneously; however, the design brief calls for only two full cycles annually, leaving a large degree of flexibility in how the systems are operated.

On the other end of the spectrum, Burj Khalifa (see Case Study 2.1, p. 26), has a four-month FMCT with a frequency of three cycles per year, meaning the systems must be in operation year-round (see Figure 3.3). Although that doesn't follow best practice suggestions, Dubai's desert environment means that systems need to be run with greater frequency, thereby negating the possibility of any downtime. Therefore, it is necessary to consider not only the scope of the cleaning cycle, but also how often the job will need to be done when determining the number of BMUs to install.

Special Condition

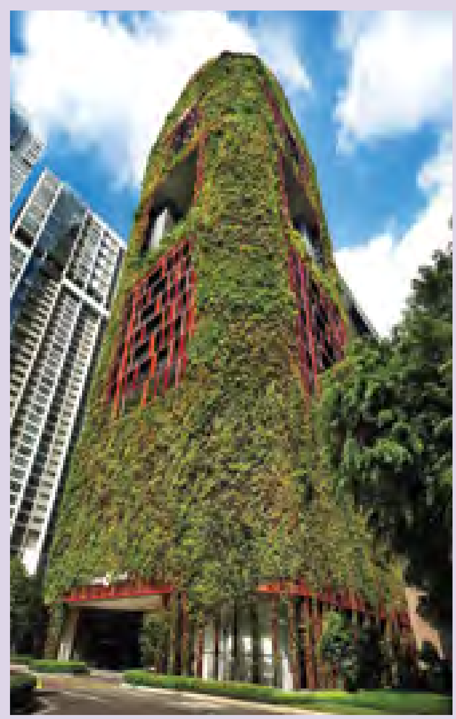
Living Green Walls: Oasia Hotel Downtown, Singapore



▲ Figure 3.1.1: A BMU is stored on the ring at the crown for when it is needed. © K. Kopter

Defined by their living vegetation (which requires continuous care and maintenance) green walls can present a number of potential challenges if they are not assessed early on in the façade maintenance plan.

The Oasia Hotel Downtown is a 27-story building in Singapore, notable for its open-air Sky Terraces at height, and "living" façade which supports vines and creeper plants. An auto-drip irrigation system that runs twice daily performs most of the upkeep to the green façade. By intentionally selecting native plants that are permitted to spread (as opposed to needing regular pruning), labor for maintenance is minimized. When necessary, maintenance access is incorporated as part of the façade design as an inner ring of steel catwalks and concrete ledges, alongside the planters on every story. The catwalks are accessed through the Sky Terraces on levels 6, 12, 21 and 27 with cat ladders connecting the stories so there is no need to traverse the exterior face in most cases. However should the need for the gondola access to the exterior arise, the topmost ring on the roof crown incorporates a BMU.



▲ Figure 3.1.2: The Oasia Hotel Downtown is covered in over 20 species of creeping plants, which create a unique challenge for façade access. © Patrick Bingham-Hall

KEY TAKEAWAYS

1. The consistently warm, humid temperatures and significant precipitation of Singapore's tropical climate complement the auto-drip irrigation system, reducing the need for daily maintenance. This approach will not work everywhere, depending on climate conditions and vegetation type.

2. Planning catwalks for access means there is no need for either storage or repeated installation and demobilization of temporary equipment.

As tall buildings have achieved greater heights and their designs have become more complex, the challenges of façade access and maintenance have grown exponentially, demanding new levels of efficiency, coordination and customization to effectively preserve a building's function and value to owners and tenants for years to come.

Through a series of detailed case studies – contextualized with supporting material on equipment types, spatial considerations, special façade typologies and more – this CTBUH Technical Guide attempts to illustrate the systems and components that are available to provide access solutions for the many and varied challenges inherent in the tall building typology. Key design considerations and best practices, distilled from the case studies and research within, aim to provide guidance for choosing the most appropriate solutions.

This desktop reference for designers, builders, developers, and owners is intended to promote a better overall understanding of the needs, requirements and options for façade access – conveying innovative solutions and in-depth analyses for this crucial element of skyscraper design.

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