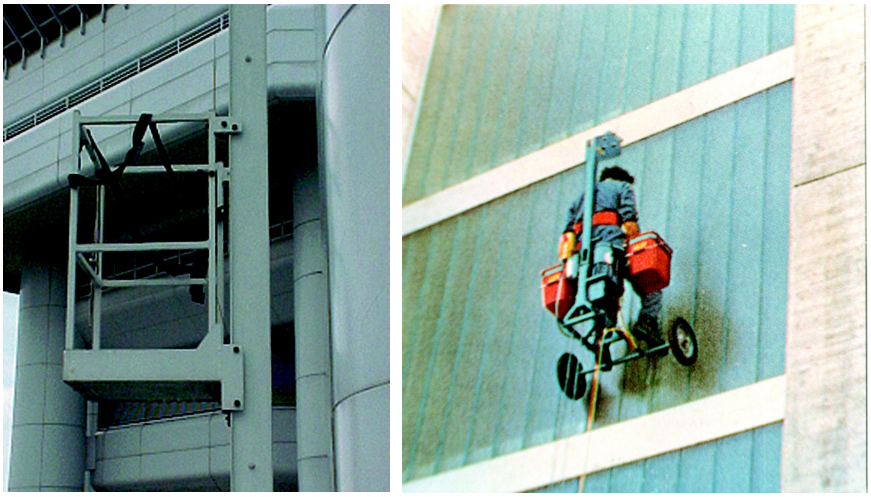


(a) (b)

**Figure 5.14.** (a) A personal unit anchored on a ladder for vertical cleaning and (b) A one-man working seat.

### *5.5.1.4. Personal Unit*

Personal units are access systems that allow access to the facade for only one man. They are usually used when the area to be cleaned is relatively small, or for minor cleaning and repair jobs such as window cleaning (Fig. 5.14).

### *5.5.1.5. Fixed Davit*

Fixed davits can be mounted on the roof slab or parapet wall. The manner of mounting will determine the ease by which the cradle can be moved from one section to another to reach the different areas of the building's facade. The davits can be rotated 180° to launch it off the roof onto the facade (Fig. 5.15).

### *5.5.1.6. Powered Travelling Davit*

The difference between the powered travelling davit and the fixed davit

(a) (b)

**Figure 5.15.** Platform suspended from fixed davits.

is that the travelling davit is mounted on rails fixed to the parapet (Fig. 5.16). This allows the davit to move from one working position to another easily. This system is especially useful when the roof is particularly crowded with services.

#### *5.5.1.7. Travelling Ladders and Platforms*

These are vertically mounted or sloped, guided along rails and designed to blend in with the shape and colour of the background of the building (Figure 5.17 and 5.18). It is particularly useful for facades or building envelopes that are odd in shape and not able to take loadings.

### *5.5.2. Temporary Access*

Temporary access systems can be classified as follows (Table 5.10) [32–35]:

#### *5.5.2.1. Temporary Installed Gondolas*

Temporary installed gondolas are temporarily fixed on a building or structure for carrying out a specific task. It consists of a platform and a suspension rig which are assembled prior to use on a work site. They are dismantled and removed from the site on completion of the work.

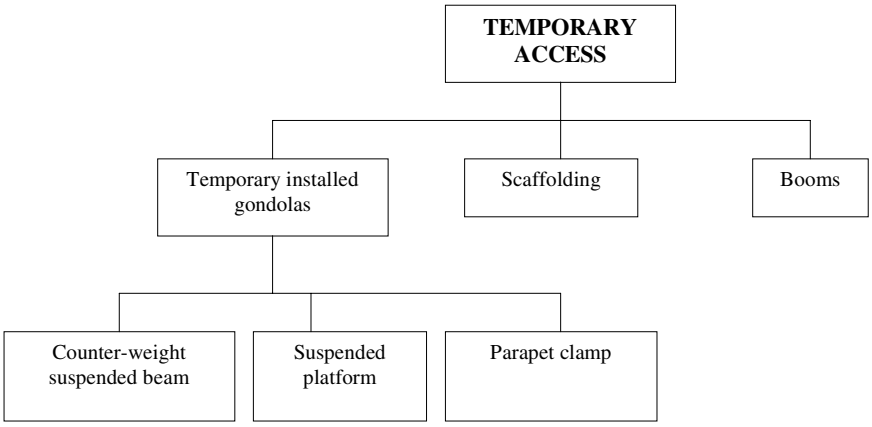
(a) (b)

**Figure 5.16.** Powered travelling davit running on rails fixed on parapet wall.

**Figure 5.17.** Traversing ladder with fixed guardrails for cleaning the exterior of a glazed roof.

**Figure 5.18.** Traversing ladder for cleaning the inside of a glazed roof.

**Table 5.10.** Classification of temporary access systems.




It is usually used by operators for external wall repairs, painting, maintenance and inspection works.

### *5.5.2.2. Counterweighted Suspension Beam*

It consists of counterweight to stabilise the gondolas. The loading

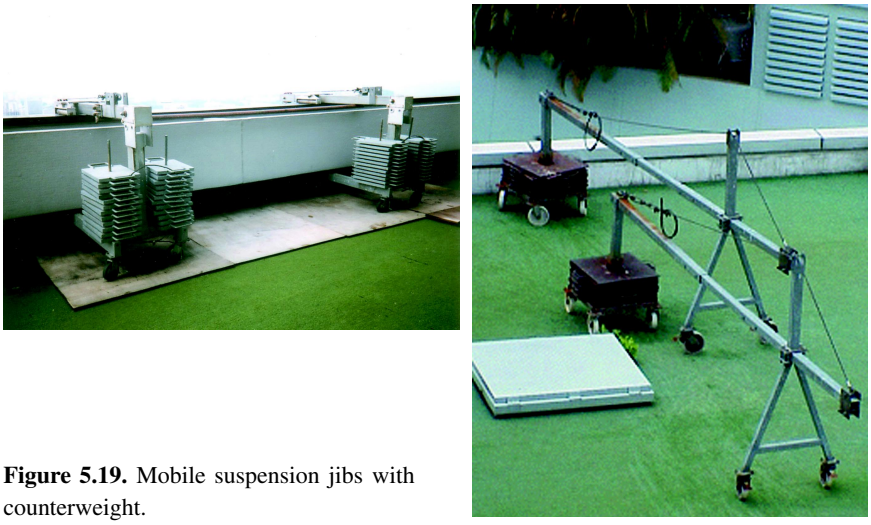


**Figure 5.19.** Mobile suspension jibs with counterweight.

allowed on the gondola will thus be determined by the counterweights used (Fig. 5.19).

#### *5.5.2.3. Suspended Platform*

Suspended platforms are platforms that are fixed temporarily on davits (jibs). They are normally used for maintenance work in residential building or new building constructions and can be moved from one place to the other. The platforms used can also be double-decked for increased efficiency and simultaneous work to different storey heights (Fig. 5.20).

#### *5.5.2.4. Parapet Clamp*

If a sufficiently solid and strong parapet (reinforced concrete or steel) is available, the parapet clamp may be used. The stability of the clamp is provided by the parapet itself. The parapet will thus need to be certified to take the loading required (Fig. 5.21).

(a) (b)

**Figure 5.20.** Temporary suspended platform on davits. (a) Single deck. (b) Double deck.

**Figure 5.21.** Parapet clamp as used on a parapet wall.

### *5.5.2.5. Scaffolding*

It is mobile and can be temporarily assembled along the perimeter of the buildings. Scaffolding has the advantage of being light-weight, easy, quick to erect and economical (Figs. 5.22 and 5.23). For these reasons, they are widely used in the region for new construction as well as for


(a) (b)

**Figure 5.22.** (a) Mobile scaffolding. (b) Overhanging scaffolding.

**Figure 5.23.** Bintagor scaffolding is very popular among developing countries due to its low cost and sturdy framing members.

refurbishment works. It is seldom used for cleaning and maintenance works due to its limited reach and its difficulty in traversing.

### *5.5.2.6. Boomlifts*

For low rise cleaning and maintenance works of up to 60 metres, boomlifts are most often used. They are extremely mobile and can be hired on contract basis. A strong foundation and unobstructed access path is required when using the boomlift (Fig. 5.24).

**Figure 5.24.** Articulated boomlifts for external facade's maintenance.

### *5.5.2.7. Facade-cleaning Robots*

The use of robotics technology can be used to overcome the dangerous and time consuming nature of cleaning work, especially that of facade cleaning (Fig. 5.25). Cleaning systems can be specially designed and built to tailor to the specific requirements, such as the surface and geometry of a facade [36, 37].

The advantages of utilising cleaning robots for facades include:

- Complete system for automatic facade cleaning.
- Low operating costs with no personnel costs.
- Constant availability that enhances flexible cleaning cycles, cleaning of especially dirty facade areas or cleaning on demand.
- Usable on various types of facades.
- Secure movement without guide rails on the facade.
- Easy to operate.
- Efficient, economical and ecological cleaning if recycled water is used.
- Short cleaning times for large surfaces.


**Figures 5.25.** Cleaning robots on glass facades (Courtesy of: Fraunhofer Institute for Factory Operation and Automation IFF).

## 5.6 Building Forms

A building's overall form has a direct impact on the ease of cleaning of building facades. Buildings with simple and conventional tower forms are likely to incur lower cleaning costs since accessibility to the facade would be easier. On the other hand, access system of buildings with amorphous shapes may not allow workers full and safe access to the facade. It is common to find buildings whose access systems do not offer adequate coverage to its external wall areas but yet are expensive and dangerous to maintain and operate. Such systems are usually designed at later stages of the project where they are made to fit the form of the building.

In ensuring maximum and efficient coverage of external wall areas, the conceptualising of a building's overall form should be done with adequate consideration to the design, provision and future operation of its access systems [30–33]. Table 5.11 illustrates common building forms and their impacts on the provision of access systems [38].

**Table 5.11**. Common building forms that may affect the provision of access systems.

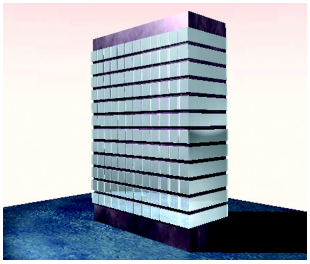
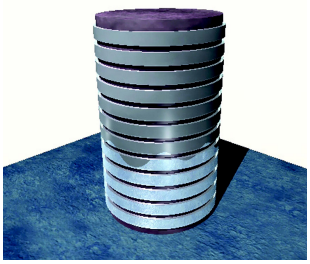
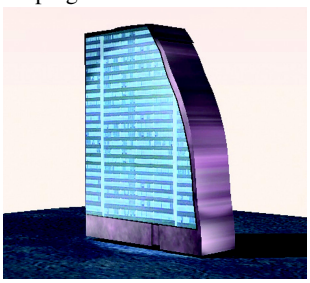
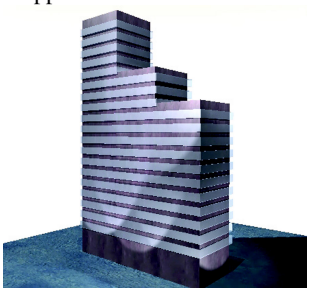
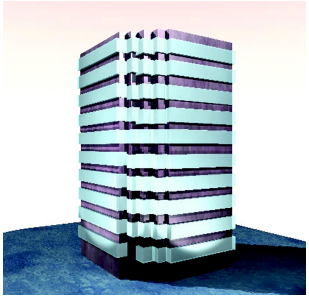
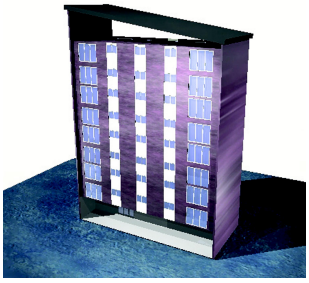
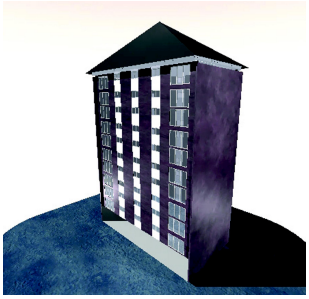
| Building Form | Impacts on Provision of Access System |
|---|---|
| Plain rectangular  | • Regular and plain form allows ease in the provision of access system.<br>• Roof services may be located in the centre of the roof, allowing tracks or rails for the access system to be laid along the perimeter.<br>• Minimum number of corners to turn.<br>• Maximum coverage with numerous types of access system. |
| Plain circular  | • Plain form allows ease in the provision of access system.<br>• No corners present. Access system can operate without need to be raised to turn corners. Maximum efficiency.<br>• Working platform should be contoured to the curvature of the building.<br>• Tracks can be laid along the circumference of the roof for the access system to run on. |
| Sloping face  | • Small roof space due to building form.<br>• The sloping face may be accessed with a jib that extends together with the outward sloping face as the working platform lowers.<br>• The extendable length of the jib should be able to cover the face when the face is at its largest width. |
| Stepped roof  | • Roof space for services and access system is reduced.<br>• Different access systems may need to be provided on each roof level in order to provide full coverage of facade.<br>• Intermediate roofs should have adequate roof space to operate the access system.<br>• Jibs that are located on the highest roof level and are able to extend to reach all areas of the facade will be efficient and cost effective. |

**Table 5.11.** (*Continued*)

| Building Form | Impacts on Provision of Access System |
|---|---|
| Staggered face  | • Numerous corners require the access system to change over at each turn of corner. This may slow down maintenance works and hence reduce efficiency.<br>• Each staggered face should be wide enough to accommodate the access system.<br>• The access system should be equipped with luffing jibs to enable ease when turning the corner. |
| Sloping roof  | • Minimal roof area for storage and operation of access system.<br>• The track or rail for the access system has to be inclined to the gradient of the roof slope.<br>• If roof is glazed, the access system must be light-weight and within the loading that the roof can withstand. |
| Pointed roof  | • Minimal roof area for storage and operation of access system.<br>• Access system may be anchored to facade or housed within the roof space that is provided with openings for operating the access system.<br>• Such building forms are usually provided with a flat area at a lower roof level, that runs around the perimeter.<br>• Access to the pointed roof area is possible with a traversing trolley or human rapellers. |

## References

[1] Smith D. [1988], "*Reliability and maintainability in perspectives*", Macmillan Education Ltd.

[2] A.C. Lemer and F. Moavenzadeh [1972], "*Performance concept in buildings*", edited by Secretary, National Bureau of Standards Special Publication 361, Vol 1, Joint symposium committee, Building Research Division, Institute for Applied Technology, NBS, Washington, D.C.20234.

[3] M.Y.L. Chew, Nayanthara De Silva, S.S. Tan (2003). Maintainability of buildings in the tropics, *International Workshop on Management of Durability in the BuildingProcess*, Politecnico di Milano, Italy, 25–26 June 2003.

[4] Bargh J. [1987], "*Increasing maintenance needs on limited budgets - a technique to assist the building manager in decision making*", in Building Maintenance Economics and management edited by Spedding, E & F.N. Spon publisher.

[5] Building Performance Group [1998], "*Technical audit of building and component durability*", London.

[6] M.Y.L. Chew, Nayanthara De Silva, P.P. Tan (2003). Maintainability of facades in the tropics, *Conference for Facade Design and Procurement*, Center for Window & Cladding Technology, University of Bath, UK.

[7] Flanagan Roger, Norman George, Meadows Justin, and Robinson Graham [1989], *"Life cycle costing, theory & practice*", BSP Professional Books, UK.

[8] Housing Association Property Manual (HAPM) [1997], "*Quality scores*", in Technical Notes April 1999 issue, London.

[9] John R. Meier and Jeffrey S. Russell [2000], "Model process for implementing maintainability", *Journal of Construction Engineering and Management*, November 2000.

[10] Knezevic J. [1993], "*Reliability, maintainability and supportability: a probabilistic approach*", McGraw-Hill.

[11] Venning Cyril [1995], *"External access systems"*, in Building Maintenance Technology in Tropical Climates edited by Cliff Briffet, Singapore University Press.

[12] Singapore Productivity and Standards Board (1997), Singapore Standard "CP 67 Code of practice for Cleaning and Surface Repair of Buildings, Part 1: Natural Stone, Cast stone and Clay Brick Masonry", Singapore.

[13] Grimm, C.T., "*Cleaning Masonry — A Review of the Literature*", Construction Research Center, University of Texas at Arlington, 1988.

[14] Mack, R.C., "*The Cleaning and Waterproof Coatings of Masonry Buildings*", *Preservation Briefs No. 1*, National Park Service, Washington, D.C., 1975.

[15] M. Marosszeky and M.Y.L. Chew, "Importance of workmanship on concrete durability", Concrete *Durability seminar, National Building Technology Center, Sydney, September 1987*.

[16] Singapore Productivity and Standards Board (1999), Singapore Standard "CP 67 Code of practice for Cleaning and Surface Repair of Buildings, Part 2: Concrete and concrete masonry", Singapore.

[17] "Cleaning Concrete Surfaces", REMR Technical Notes CS-MR-4.4, United States Army Engineer Research and Development Center, Vicksburg, MS.

[18] A.M. Sowden, *Maintenance of brick & stone masonry structures*, E & F.N. Spon, London, 1990.

[19] M.Y.L. Chew, L.H. Kang, C.W. Wong, "*Building Facades: A Guide to Common Defects in Tropical Climates*", World Scientific, 1998.

[20] D. Ramsey, Tile floors, Blue Ridge Summit, PA, Tab Books, 1991.

[21] B.B.P. Lim, Control of the external environment of buildings: selected papers on the protection of the external surfaces of buildings in warm humid climate, Singapore University Press, National University of Singapore , 1988.

[22] "Maintenance of Anodic and powder coating on architectural aluminium", Association of Architectural Aluminium Manufacturers of South Africa, 2000.

[23] C.J. Thomas**,** *Twentieth-century building materials: history and conservation*, McGraw-Hill, New York, 1995.

[24] L.G.W. Verhoef, *Soiling and Cleaning of Building Facades*, Report of the Technical Committed 62 SCF, RILEM, Chapman and Hall, London, 1988.

[25] A. Field, *Home Maintenance and repair,* Michigan State University Extension, 1998.

[26] J.S. Armstock, *Handbook of Glass in Construction*, McGraw-Hill, New York, 1997.

[27] Building and Construction Authority [2001], Good Practice Guide for Paint.

[28] D. Greay, *Interior and Exterior Painting*. Reston Publishing Company, Va, 1979.

[29] J.H. Arnison, *Floor and Structural Surfaces,* Butterworths, London, 1969.

[30] C. Briffett, Design feedback — successes and failures. In A. Spedding (Ed.), *Building maintenance economics and management* (pp. 215–233). London: E & F.N. Spon, 1987.
[31] E.G. Lovejoy, Safety and security in accessibility for maintenance. In E.D. Mills (Ed.), *Building maintenance and preservation* (pp. 117–130). London: Butterworths, 1980.
[32] J.D. Harrison, Access requirements for building maintenance. In C. Briffett (Ed.), *Building maintenance technology in tropical climates* (pp. 117–138). Singapore: Singapore University Press, 1995.
[33] D. Miles and P. Syagga, *Building maintenance* (pp. 3–7). Intermediate Technology Publications, 1987.
[34] G.T. Hall, Revision notes on building maintenance and adaptation. London: Butterworths, 1984.
[35] I.H. Seeley, *Building maintenance* (20–23). London: Macmillan, 1990.
[36] A. Warszawski, Industrialization and robotics in building — A managerial approach. Harper & Row, 1990.
[37] J. Bohme, N. Elkmann, T. Felsch, J. Hortig, M. Sack, and J. Saenz, Modular climbing robot for service-sector applications. *Industrial Robot: An International Journal*, 26(6), 460–465, 1999.
[38] Council on Tall Buildings and Urban Habitat, *Tall building systems and concepts*. New York : American Society of Civil Engineers, 1980.