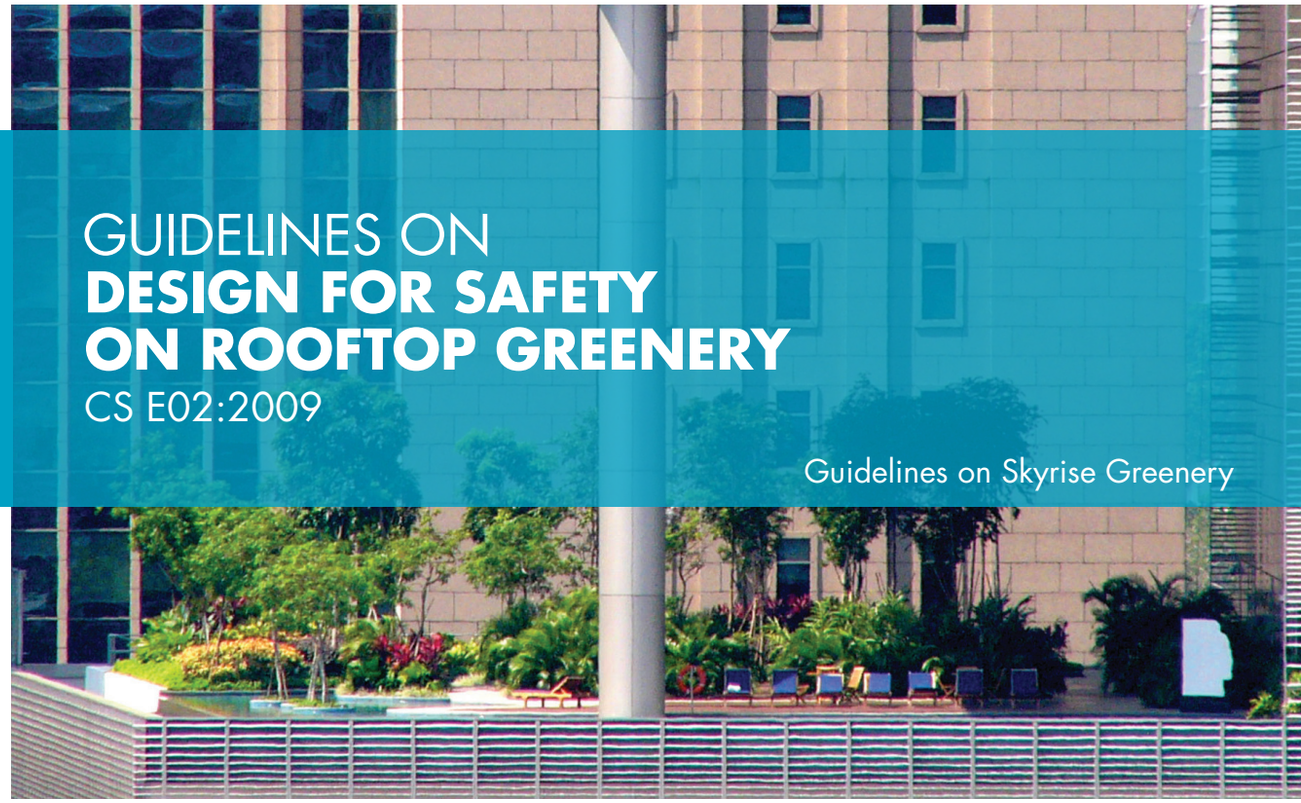
Centre for Urban Greenery & Ecology
CUGE Standards



GUIDELINES ON **DESIGN FOR SAFETY ON ROOFTOP GREENERY**

CS E02:2009

Guidelines on Skyrise Greenery

Published by:
Centre for Urban Greenery & Ecology
National Parks Board HQ
1 Cluny Road
Singapore 259569

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CS E: Skyrise Greenery

CUGE STANDARDS CS E02:2009

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The CUGE Standards Series is a set of written guidelines for adoption in the landscape and horticulture industry. They are written through a formal process that involves consultation with relevant bodies and reaching a consensus across all interested parties so that the final document meets the needs of business and industry. All standards take the form of either specifications, methods, vocabularies, codes of practices or guides.

The CUGE Standards Series comprises:

CS A Specifications on properties of planting media
CS B Landscape construction & management
CS C Urban ecology
CS D Landscape design
CS E Skyrise greenery

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Design for Safety on Rooftop Greenery
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The CS E02:2009 was prepared by the CUGE Technical Committee (CS E01:2009).
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The CUGE Standards will be reviewed every three years. Concurrently, we are also gathering information through on-going research.

CONTENTS

Guidelines on Design for Safety on Rooftop Greenery

SECTION 1 SCOPE AND GENERAL

1.1 INTRODUCTION

This part of the CUGE Standards Series sets out the basic safety requirements in the construction of rooftop greenery.

Rooftop greenery, unlike greenery at ground level, is designed and installed on the rooftop spaces of new buildings and existing structures. Rooftop greenery is therefore very much a part of a building's surface.

In tandem with the Workplace Safety and Health Council (WSH Council) Guidelines on Design for Safety in Buildings and Structures, this part of the CUGE Standards Series attempts to illustrate work safety issues from the standpoint of rooftop greenery design, installation and maintenance.

Rooftop greenery is contrived for human benefits. The construction, usage and maintenance of rooftop greenery shall in no circumstance compromise on safety.

1.2 OBJECTIVE

This part of the CUGE Standards Series is intended as a guide to address the safety performance required of rooftop greenery with respect to all three stages – the design phase, the installation phase and the maintenance phase – To act as a common reference point for ensuring safety of work on rooftop greenery.

The design, installation and maintenance of rooftop greenery shall comply with the relevant codes of practice and standards for relevant authorities.

It is necessary to promote a culture of safe practices at work site, with every member on site maintaining vigilance of potential hazards and risks.

This part of the CUGE Standards Series provides a general guidance. It is necessary to engage and consult suitably qualified and experienced professionals and experts to ensure safety of rooftop greenery implementation throughout all three phases.

1.3 DEFINITIONS

The following are definitions of common terms, as defined in WSH (Risk Management) Regulations 2006:

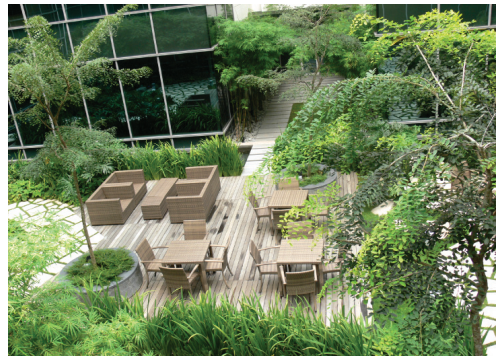
"Hazard" means anything with the potential to cause bodily injury, and includes any physical, chemical, biological, mechanical, electrical or ergonomic hazard;

"Risk" means the likelihood that a hazard will cause a specific bodily injury to any person;

"Risk assessment" means the process of evaluating the probability and consequences of injury or illness arising from exposure to an identified hazard, and determining the appropriate measures for risk control.

"Green roof" Green roofs, also known as the extensive green roofs, are in general not designed for public use and are mainly developed for aesthetic and ecological benefits (Scholz-Barth, 2001). They are distinguished by being low cost, lightweight (50-150 kg/ m2) and with shallow mineral substrates. Minimal maintenance is required and inspection is performed once or twice a year. Plants selected tend to be of low maintenance and self-generative. Extensive systems can be placed on pitched roofs of up to 30 degrees (Kalzip Nature Roof, 2001) and are common in European countries such as Germany.

"Roof garden" Roof gardens, also known as the intensive green roofs, are developed to be accessible for use (Scholz-Barth, 2001). Hence, they usually incorporate areas of paving and seating. The added weight, higher capital cost, intensive planting and higher maintenance requirements characterize intensive green roofs (Peck et al., 1999). The plant selection ranging from ornamental lawn, to shrubs, bushes and trees consequently affects the weight, build-up heights and costs of the roof garden (Zinco, 2000). Further, regular garden maintenance such as mowing, fertilizing, watering, and weeding is required for intensive landscapes.



1.4 PROTECTION FROM FALLING

Falling from height is a major cause of injury and fatality at workplace. The need to work at height should be minimized wherever possible.

Where it is not possible to remove the need to work at height, features that reduce or eliminate the risk of falling should be introduced.

Some rooftops have no parapet. Such spaces are not intended for access, except during periodical maintenance. Should rooftop greenery, such as the extensive green roof, be installed on such parapet-free roof, there must be provision for safety features:

- Safety features, such as travel restraint belts, safety harnesses, harness-railing/rings & permanent anchors and fall arrest system can be incorporated to safeguard against falling.
- Anchors for maintenance safety harnesses and restraint belts must be coordinated with structural requirements.

It is crucial that the design, installation and maintenance of these safety features comply with industry standards and regulations.

Safety features when appropriately introduced can safe guard against workplace accidents. However, when inadequately introduced or inappropriately utilized, may create more risks and hazards.

(Please refer to WSH Code of Practice for Working Safely at Height)
http://app.wshc.gov.sg/cms/Portals/0/Code_of_Practice_For_Working_Safely_At_Height.pdf

The onus is on the owner and relevant user to make sure that the safety features, including ropes and lines, are appropriately incorporated, well maintained and correctly utilized.

1.5 APPOINTING A PROJECT SAFETY AND HEALTH COORDINATOR

In tandem with the WSH (Workplace Safety and Health) Council's initiative on "Design for Safety in Buildings and Structures", it is recommended to appoint a suitably qualified Project Safety and Health Coordinator at the concept design stage of the project, to facilitate the design safety review.

Risks inherent in the design can then be addressed and measures to eliminate or mitigate them identified.

The Project Safety and Health Coordinator should follow through with the project from the design stage, to the construction stage until the handover to the client for maintenance.

For more information on the duties of the Project Safety and Health Coordinator and the design safety review process, please refer to WSH Council's Guidelines on Design for Safety in Buildings and Structures.

1.6 PERFORMANCE REQUIREMENT

Prior to construction, considerations must be made for the design, construction and the maintenance of the rooftop greenery in compliance with the Workplace Safety and Health Act which is under the purview of Ministry of Manpower.

Please refer to relevant web-link: http://www.mom.gov.sg/publish/momportal/en/legislation/Occupational_Safety_and_Health/workplace_safety_and.html

SECTION 2 SAFETY CONSIDERATIONS FOR ROOFTOP GREENERY

2.1 SAFETY CONSIDERATIONS DURING DESIGN PHASE

Design of rooftop greenery should be streamlined for safe efficient installation and future maintenance. Safety issues when considered during design phase can contribute greatly to the buildability of the project - enhancing design functionality as well as effective future maintenance, replacement and repair.

Green roof requires periodical maintenance (approximately twice a year). Roof garden requires comparatively more care and regular maintenance.

For future maintenance work to be effectively carried out, adequate space and safe permanent access should be put in place at the design stage.

The following are some design considerations to help guide the design of a rooftop greenery project.

It is to be noted that the list is not exhaustive, nor is every item relevant to every project:

Building Considerations

- Building's established load-bearing capacity
- Rooftop greenery on sloped roof
- Protection from falling
- Roof penetration must be cordoned off
- Provision of proper access and exit during construction
- Fire safety
- Working at height
- Lighting protection

Service Considerations

- Provision of appropriate facilities for safe practices
- Washing area
- Storage provision
- Mechanical & electrical provision

Health Considerations

- Reduce use of hazardous materials
- Reduce the generation of noise
- Mosquito control

Plant Considerations

- Plant selection
- Plant maintenance on rooftop
- Proper tree anchorage & maintenance
- Height control and health control of tree on rooftop
- Removal of tree from rooftop

Work Schedule Considerations

- Features to reduce risk of falling
- Prevention of equipment falling from height
- Design to simplify construction
- Use of cranes and aerial platforms

2.1.1 BUILDING CONSIDERATIONS

The following are building design considerations relevant to the design for safety on rooftop greenery.

Building's established load-bearing capacity

The maximum load bearing capacity of the roof, as established by the structural engineer, must never be exceeded, during the installation and the subsequent maintenance of the rooftop greenery.

Rooftop greenery on sloped roof

The design and installation of rooftop greenery on a sloped roof surface may technically be more demanding. Anchors and relevant safety features may be required to be in place to ensure that the installation, as well as the future maintenance, operations can be carried out safely.

Necessary safety measures must be taken to avoid soil erosion and manage the shear force on the growth medium.

Rooftop greenery expert and engineer have to be consulted and the shear force considered in the design of rooftop greenery on a sloped roof.

As the gradient of the roof slope increases, the installation of green roof will face more challenges in the containment of the vegetation support medium, the vegetation and moisture.

Protection from falling
Falling from height is the main cause of site injury and fatality. As much as possible, the need to work from height should be kept minimal.

Where it is not possible to remove the need to work at height, features that reduce or eliminate the risk of falling should be introduced.

Roof penetration must be cordoned off
Roof penetrations, for examples skylights, should be highlighted and cordoned off if necessary, during installation and maintenance work operation.

Provision of proper access and exit during construction
During construction and installation, there must be proper and safe access to and egress from rooftop work-site. Safe means of access to the roof should be provided, for example via working platform. Fragile roofing materials should also be removed.

For areas that are less accessible for maintenance, there must be provision for safe temporary access for maintenance.

Once the building is occupied, proper means of escape in accordance to the Fire Code shall be provided.

Fire safety
The fire safety works at the rooftop shall comply with the requirements stipulated in the Fire Safety Act, "Code of Practice for Fire Precautions in Buildings" & its relevant codes of practices.

If necessary, the Qualified Person can consult SCDF (Singapore Civil Defence Force) on the fire safety provisions at the rooftop.

Materials that pose a significant fire risk during construction must be removed. Fire risks should be minimized.

Working at height
The rooftop is a space exposed to occasional strong wind. During installation, temporary measures must be taken to secure anything laid on the roof against being uplifted and toppled by strong wind.

Should wind load be excessive, temporary measures such as the staging of temporary wind breaks can be considered to ease the installation.

Should aerial platforms be used for rooftop greenery installation and/or maintenance, the issue of possible wind loads must be considered.

(Please refer to WSH Code of Practice for Working Safely at Height)

Lightning protection

Lightning protection for rooftop greenery must be designed and installed in accordance with the requirements of the latest BCA (Building and Construction Authority) Building Control Act and Regulations. Please refer to relevant web-link: http://www.bca.gov.sg/Publications/BuildingControlAct/others/Approveddoc.pdf

For the Lightning Protection Codes, please refer to L3.1 of BCA Approved Document Acceptable Solutions

Should a tree, on a rooftop, be the highest point of a building, provision must be made to safeguard the tree from being struck by lightning.

The design of the lightning and earthing protection system is to be endorsed by a Professional Engineer.

Accessibility

In tandem with the move towards Universal Design for the built environment, design of rooftop greenery shall appropriately comply with the latest BCA (Building and Construction Authority) guidelines on barrier-free accessibility:

Building and Construction Authority, 2007, Code on Accessibility in the built environment.

2.1.2 SERVICE CONSIDERATIONS

Appropriate services and service spaces have to be provided for the effective installation, operation and maintenance of rooftop greenery.

The followings are considerations concerning design for safety on rooftop greenery. (The following is not exhaustive, nor is every item relevant to every project.)

Provision of appropriate facilities for safe practices

The design of the rooftop greenery should make provision for the following basic facilities:

- Washing area (with access to clean water)
- Space for proper handling of landscape maintenance material
- Space for proper housing and storage of equipments

Washing area

The rooftop can be an isolated and harsh environment. Availability of clean potable water can be crucial during emergency. For example, should a maintenance worker be down with a heat stroke, or should someone suffer a cut and require immediate cleansing of an open wound, proximity to clean water source can be crucial.

Storage provision
Appropriate accessible storage space, for putting away maintenance equipments, keeps the rooftop space organized, reduces clutter and allow for quick access to tools for efficient maintenance operations.

It is advisable to install all controls and electrical boxes, such as irrigation timer, etc., at accessible locations, with adequate shelter from the rain and sun.

Mechanical & electrical provision
The rooftop is a space where mechanical and ventilation systems of a building are located. It is important for the design of the rooftop greenery to take into consideration that the proximity and design of the rooftop greenery is in harmony with the operation and maintenance of the mechanical and ventilation system.

2.1.3 HEALTH CONSIDERATIONS

Health hazards come in many forms. The following are considerations concerning design for safety on rooftop greenery.

Reduce use of hazardous materials
If appropriate, adopt simple effective system for the construction of rooftop greenery and minimize the use of hazardous materials, solvents and adhesives.

Adopt procedures that reduce the emission of harmful fumes and fine air-borne particles.

Reduce the generation of noise
Installation operations should be designed and scheduled appropriately to avoid excessive noise.

Mosquito control
The design and installation of the rooftop greenery should avoid conditions conducive to mosquito breeding, e.g. impervious depressed areas or plants that trap water.

The rooftop greenery shall be designed and constructed in accordance with the requirements of the latest NEA (National Environment Agency) guide in the Scope of Works for Mosquito Control.

Please refer to the following links to NEA:
1) Guidelines on mosquito prevention in domestic rainwater collection system for non-potable uses
http://app2.nea.gov.sg/data/cmsresource/20090618239106523150.pdf

2) Scope of works for mosquito control
http://app2.nea.gov.sg/data/cmsresource/20090618572387419312.pdf

2.1.4 PLANT CONSIDERATIONS

The followings are considerations about plants that are relevant to the design for safety on rooftop greenery. (The following is not exhaustive, nor is every item relevant to every project.)

Plant selection

When choosing rooftop landscape materials and plant choices, consider selecting materials that require less frequent maintenance and choose hardy plants that are drought tolerant and disease tolerant. In areas experiencing strong wind, plant selection should also be preferably wind tolerant.

Plants maintenance on rooftop

While rooftop greenery can enhance the architecture quality of the building, it is also worthy to note that the maintenance issues of rooftop greenery should not be neglected.

Plants are living organism and periodical maintenance is essential. It is necessary that the issue of safety during future maintenance be brought to attention as early as the design stage of the building.

Provision for proper and safe maintenance operations allow for a more thorough inspection and maintenance of the vegetation. Plants, when appropriately maintained and growing healthily, add aesthetic values to the building.

The ease of access to the plants during maintenance operations, and the extend/ frequency of maintenance work required should be considered in the design of the rooftop greenery. The choice of vegetation for the rooftop greenery should complement the building, the site context and the intended function of the rooftop space.

Proper tree anchoroge & maintenance

Tree, on rooftop greenery, must be adequately anchored, with the structural bracings' load bearing capacity established by Professional Engineer. (Tabulation of Load bearing capacity should include wind loads)

For planting of tree on rooftop, it is not advisable to plant tree close to the edge of building, which makes for cumbersome and inefficient maintenance and may compromise safety.

Long outstretched branches should be appropriately trimmed and pruned, to avoid breakage during strong winds. Regular pruning of trees avoid wind-damage and allows wind to filter through porous canopy.

Building owner and contracted landscape maintainers must adhere to the maintenance schedule. Maintenance includes inspection for potential risk, hazards and problems.

Small trees are preferred on intensive rooftop greenery.

Height control and health control of trees on rooftop

Trees need maintenance. For maintenance operations to be effectively carried out, adequate space is needed for proper access and maneuvering. It is thus not advisable to plant trees (and similarly, large high-maintenance plants) close to the building roof edges.

The rooftop, being exposed to the natural elements, has a lot of natural forces and site variables at work. For example, it is common to experience stronger wind higher up a building. Strong gust of wind, under certain conditions, can potentially break off weak branches and twigs. It is thus advisable not to grow trees close to building roof edges.

It is to be noted that trees when planted in planters may not reach its full mature height as observed when planted at ground level. It is advisable to seek the advice from suitably qualified landscape experts and arborists.

If necessary, suitably qualified experts and arborists should be engaged to inspect and maintained the tree.

The onus remains with the owner to ensure that the necessary maintenance work is appropriately carried out on the trees to safeguard against falling branches.

Rooftop greenery is contrived for the benefit of the environment and for the enjoyment of users. It should in no circumstance pose as a risk or hazard.

Removal of tree from rooftop

Should there arise a need to remove a tree from a rooftop, the operation is to be carried out safety with the relevant precautionary measures to safeguard against objects, debris and/or person falling from a height.

Any work operation from a height should comply with WSH Code of Practice for Working Safely at Height. Risk assessment must be conducted.

2.1.5 WORK SCHEDULE CONSIDERATIONS

Features to reduce risk of falling

Use of scaffolds and ladders can be reduced through early installation of permanent access, such as stairs and service lift, to rooftop. Should scaffolds be necessary, these must be erected, used and dismantled in accordance with the WSH (Scaffolds) Regulations.

Should the work operation involve working along roof edges with low or no parapet, appropriate anchor points for life-line and safety harnesses must be in place. These have to be made to the required loading, as established by suitably qualified expert.

Please refer to WSH Code of Practice for Working Safely at Height.

Prevention of equipment falling from height
Provision must be made for equipments to be properly secured to prevent falling from a height.

Design to simplify construction
The rooftop greenery should be designed and phased to simplify construction for safe installation and maintenance operation.

Installation process should minimize the need to work from height.

Design of joints should be such that the likelihood of incorrect assembly on site is minimized.

The staging of the installation process should promote safe installation from a safe location i.e. installation from the inside of the building, instead of from external scaffolding.

Trees should be appropriately located for ease of maintenance.

Use of cranes & aerial platforms
Work site scope and schedule shall be planned for efficient use of site equipments, especially in the transportation of bulky landscape materials using cranes and heavy machinery.

Very often, cranes are already removed from site when the building is ready for landscaping works. Proper planning may clarify and simplify work procedures, aiding safety control.

Should the maintenance of the rooftop greenery require the use of aerial platform, operation must also be in accordance with the instructions in the manufacturer's operational manual.

Wind loads must also be taken into consideration whenever the operation is carried out in high wind conditions.

The operation must comply with the relevant WSH regulations, standards and guidelines.

http://www.mom.gov.sg/publish/momportal/en/communities/workplace_safety_and_health/building_capabilities/Managing_Workplace_Hazards_.html

2.2 SAFETY CONSIDERATIONS DURING INSTALLATION & MAINTENANCE PHASE

The installation operations of rooftop greenery should be in accordance with the latest WSH (Risk Management) regulations / standards / guidelines.

Prior to the commencement of works, risks and hazards associated with the design and methods of construction should be identified and addressed.

It is advisable to appoint a suitably qualified Project Safety and Health Coordinator to follow through the project from the design stage, to the construction stage until the handover to the client for maintenance.

The following is a guide for the management of site-works. It is to be noted that the list is not exhaustive, nor is every item relevant to every project.

GUIDE FOR SITE-WORK MANAGEMENT

(Please refer to WSH Guidelines for the full version)

Risk Assessment to be conducted

Before any site work can commence, Safety and Health Risk Assessment has to be conducted. Risk Assessment with proper Fall Protection Plan (please refer to WSH guidelines) must be conducted. Potential hazards are to be identified. Strategies and Solutions shall be formulated to mitigate the identified risks and hazards.

Proper Briefing

Before any work starts at the site, the Site supervisor has to first and foremost conduct a site-work-briefing with the work team. This is targeted towards clarity of work scope, risk assessments, precautions, etc.

Adequate Supervision

There must be adequate supervision at the site. Should there be rooftop greenery installation and maintenance, there must be appropriate supervision at grade level.

Redirecting of Traffic

Grade level traffic, if any, must be redirected. Affected area must be cordoned off. This includes the area directly below the affected rooftop greenery. At times, barricading of work areas to prevent unauthorized entry by members of the public is necessary.

Proper Means of Communications

There must also be provision for proper communication means between the rooftop and grade level, should the instruction cannot be verbally transmitted easily and clearly. Appropriate communication equipments will then have to be properly deployed.

Proper Execution of site-work Procedures

Site supervisor to oversee and ensure the proper work procedures are carried out and equipments are utilized correctly and appropriately. Co-workers are also required to maintain vigilant of one another.

Proper use and maintenance of equipments

Appropriate equipments must be used for the relevant site-work scope. Equipment must be properly checked before use, and adequately maintained after usage (and appropriately stored).

Adequately qualified workers

The workers must have appropriate qualifications and certifications to assure suitability to work scope. Proper documentation of qualifications can facilitate future deployment of workers. There must be adequate site supervision.

Promote a Culture of Safety on worksite

Safe practices shall be promoted within the team. Every member on site shall maintain vigilant of one another.

Proper use and Provision of equipments

There must be provision of necessary equipment and proper access to the relevant work-site. It is to be noted that improper access to work-site is a cause of many work-site accidents and fatalities.

Protection from falling

Depending on the work environment, workers are to don appropriate PPE such as safety harness to prevent falling from heights.

Workers working at heights must be provided with safety measures such as suitable working platforms with guardrails, and safe means of access and egress.

The construction operation must be in accordance with the WSH – Code of Practice for Working Safely at Height

Prevention of equipment falling from height

Equipments have to be properly secured to prevent dropping from a height. Workers must be properly educated on executing safety measures.

Appropriate notification during maintenance

The rooftop can be a highly isolated part of the building. Therefore, maintenance of rooftop greenery shall commence only after the building management is appropriately notified with issuance of maintenance-work permit.

2.3 TRANSPORTATION OF MATERIALS

Another major safety issue is the transportation of landscape materials onto rooftop. Lifting operation should be executed in accordance with the latest relevant Codes of Practice and Standards.

- Provision, such as guardrails, must be provided to protect against fall hazard.
  - It is advisable to take into account the necessary fall arrest systems in the bid.
- Means of transporting landscape materials onto the rooftop, during installation has to be considered and provided for.
  - It may be via elevator, temporary elevator, staircase, etc.
  - Adequate manpower must be provided to ensure safety.

The load-bearing capacity of the building structure shall be adequate to support the materials, mechanical equipment and human loads during installation and maintenance. The load established by the structural engineer shall not be exceeded.

REFERENCE STANDARDS

SS541	Specification for Restraint belts
SS528	Personal Fall-Arrest Systems
SS537-1: 2008	Code of practice for the safe use of machinery – General Requirements
SS55:1991	Code of practice for use and maintenance of portable fire extinguishers
SS531-3:2008	Code of practice for lighting of work places – Lighting requirements for safety and security of outdoor work places.
SS531-2:2008	Code of practice for lighting of work places – Outdoor
CP 5:1998	Code of practice for electrical installations.
CP 79	Code of practice for safety management system for the construction worksites
CP 14	Code of practice for scaffolds
CP 20	Code of practice for suspended scaffold
SS402	Belts & harnesses permanent anchors for Workplace Safety and Health Guidelines – Landscape and Horticulture Works (WSH Council Singapore)
CP 79:1999	Code of Practice on Safety Management System for Construction Worksite Workplace Safety and Health Guidelines – Landscape and Horticulture Works (WSH Council)
WSH	Code of Practice for Working Safely at Height
WSH	Guidelines on Design for Safety in Buildings and Structures
SS 536:2008	Code of practice for the safe use of mobile cranes
CP62:1995	Code of Practice for the Safe Use of Tower Cranes
WSH	(Risk Management) Regulations 2006

About the National Parks Board and Centre for Urban Greenery & Ecology

The National Parks Board (NParks) is responsible for providing and enhancing greenery of the Garden City of Singapore. Beyond managing public parks, the park connector network, lush roadside greenery, nature areas and nature reserves, NParks is committed to enhance the quality of life through creating memorable recreational experiences and lifestyles.

The Centre for Urban Greenery and Ecology (CUGE) is an initiative of NParks. Through its research and training programs, NParks advances knowledge and expertise in urban greenery and ecology in the landscape and horticulture industry in Singapore. It works closely with industry partners to promote good work practices and create a thriving, creative, innovative and professional industry that will support Singapore's aspiration to be a City in a Garden.