Vertiport Design Guidelines

※This English version is for reference only. The original Japanese is the official version.

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Japan Civil Aviation Bureau,

Ministry of Land, Infrastructure, Transport and Tourism

Introduction

Advanced Air Mobility (AAM) currently being developed worldwide is an accessible and sustainable next generation means of air transportation, made possible by aeronautical technologies such as electrification and automation, as well as vertical takeoff and landing and other modes of operation. It is expected that AAM will lead to the reduction of travel time in urban areas, improved accessibility for transportation in remote islands and mountainous regions, and the swift response to emergency situations and rapid delivery of goods during disasters. This holds the potential to facilitate the introduction of new services and address various societal challenges. Amid growing global interest, Japan established the Public-Private Committee for AAM in August 2018, bringing together stakeholders from both public and private sectors to discuss issues relating to technology and institutional development that need to be addressed in order to pioneer the realization of AAM and thereby improve the speed and convenience of passenger and freight mobility and create a new industry. In addition, a steering group was set up in August 2020 with the aim of accelerating discussions between public and private stakeholders to build a medium- to long-term vision for AAM society. Working groups (on airworthiness, personnel licensing, flight operations, air transport regulation and vertiports (a vertiport is considered an "airport, etc." under the Civil Aeronautics Act, as a type of heliport dedicated to AAM)) formed under the steering group aimed at commencing commercial operation of AAM at the 2025 Osaka Kansai Expo have been examining regulatory issues surrounding AAM, in parallel with the development of the technical aspects of aircraft and ground infrastructure.

National standards need to be established so that vertiports are implemented in Japan. However, the development of international standards on which national standards should be based is still underway at the International Civil Aviation Organization (ICAO), and this standardization process is not expected to be finalized until around 2028. This situation gave rise to the need to develop provisional guidelines for planning the development of onshore vertiport facilities.

It was against this background that this document, “Vertiport Design Guidelines” (hereafter, “the Guidelines”) was formulated and published to guide the development of onshore vertiports to be operated under Visual Flight Rules (VFR) applied to manned aircraft with an onboard pilot. The Guidelines were formulated by referring to technical guidelines for vertiport design published to date from U.S. and European sources and in light of opinions gathered from the private sector members of the Vertiport Working Group.

The Guidelines are positioned as provisional guidance presenting the basic concepts and points to consider in developing vertiport facilities for the time being until national standards are established;

they do not have binding powers over business operators or other stakeholders. The Guidelines will be revised as appropriate depending on future developments in the international situation and progress in the technological development of AAM.

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Chapter 1 General

1.1 Objective

The objective of the Guidelines is to provide guidance on the development of onshore vertiport facilities with regard to the size, shape, configuration, strength, and other parameters that each facility should meet along with the basic principles including the thinking behind determining such parameters and points to consider.

[Comments]

(1) The Guidelines are intended to present the basic concepts and points to note as provisional guidelines for the time being until national standards are established. They are not the official standards for the development of vertiport facilities, but compliance is desirable. In the actual development of the facilities, the Guidelines should be applied in a flexible manner according to the conditions of the vertiport.

(2) In the planning and design of vertiports, the configuration, size, and structure of the facilities should be planned by taking into consideration such conditions as VTOL aircraft performance, location, constraints, weather, and the surrounding environment.

(3) The term onshore vertiports refers to those facilities that are exclusively for use by VTOL aircraft among onshore heliports defined in Article 75 of the Regulation for Enforcement of the Civil Aeronautics Act (Order of the Ministry of Transport No. 56 of July 31, 1952).

(4) Although these guidelines relate to Vertiports, the fact that the aircraft used is a VTOL aircraft does not directly imply that these guidelines apply.

1.2 Applicability

The Guidelines are applied to onshore vertiports operated under Visual Flight Rules (VFR) for aircraft with an onboard pilot.

[Comments]

(1) If an existing heliport is to be operated as an onshore vertiport, it needs to be verified that takeoff and landing can be safely and stably performed within the range of performance of the VTOL aircraft it is intended to serve.

(2) Onshore vertiports can be categorized into surface vertiports and elevated vertiports. Surface vertiports include those built on land reclaimed from water bodies.

1.3 Definitions

(1) Types of vertiport facilities are defined as follows for the purpose of the Guidelines:

FATO	: Final Approach and Takeoff area: A defined area intended for VTOL aircraft to use for transition from the final approach to touchdown or hovering and from the ground or hovering state to takeoff.
TLOF	: A defined area intended that the undercarriage of the VTOL aircraft will touchdown within a FATO, or stand, or lift off from a FATO or stand.
Safety area (SA)	: A defined area, surrounding a FATO, intended to reduce the risk of damage to VTOL aircraft accidentally deviating from the FATO.
Protected Side Slope (PSS)	: A surface that protects the side space in the takeoff or landing direction to deal with unforeseen lateral behavior during takeoff and landing.
Taxiway	: A defined area intended for VTOL aircraft to travel from one place in the vertiport to another by ground taxiing or air taxiing
Taxiway strip	: The taxiway area and a defined area intended to reduce the risk of damage to the VTOL aircraft accidentally deviating from the taxiway
Apron	: A defined area intended for loading and unloading of passengers and cargo, power charging, and other servicing operations while parking the VTOL aircraft
Aircraft stand (parking space)	: A defined area within the apron specified for servicing VTOL aircraft
Stand protection area	: A defined area surrounding the VTOL aircraft stand, intended for turning or to reduce the risk of damage to the VTOL aircraft accidentally deviating from the stand
Markings	: Facilities to support the operation of VTOL aircraft by markings and markers
Lights	: Facilities to support the operation of VTOL aircraft by lighting

(2) In addition to the terms listed in (1) above, when the following terms are used within these Guidelines, they have the following meanings:

Vertical Takeoff and Landing (VTOL)	: Taking-off or landing vertically without using a runway

VTOL aircraft	:	Aircraft that has VTOL capability, i.e., VTOL-capable aeroplane (vectored thrust, lift & cruise) and multirotor
Vertiport	:	A defined onshore area used for the arrival, departure, and surface movement of VTOL aircraft; a type of onshore heliport exclusively for use by VTOL aircraft
Vertiport facilities	:	Facilities including FATO, TLOF, Safety Areas, taxiways, taxiway strips and aircraft stands (See Figure 1.4.1)
Surface vertiport	:	All onshore vertiports other than elevated vertiports
Elevated vertiport	:	Onshore vertiport located on a rooftop of a building or other elevated structure built on the ground surface
D value	:	The diameter of the smallest circle enclosing the VTOL aircraft projection (including that of the rotating rotor(s)) on a horizontal plane, while the aircraft is in the takeoff or landing configuration, with the rotor(s) turning, if applicable. (See Figure 1.3.1)
Downwash	:	The wind pressure generated around the VTOL aircraft when the rotor(s) of the VTOL aircraft is rotating at high speed
Obstacle	:	All fixed (whether temporary or permanent) and mobile objects that: are located on an area intended for the surface movement of VTOL aircraft; extend above a defined surface intended to protect VTOL aircraft in flight; or stand outside those defined surfaces but, nonetheless, are assessed as a hazard to air navigation.
Obstacle limitation surface	:	A defined surface cleared of obstacles to allow safe VTOL aircraft operations by ensuring airspace free of obstacles above and around the vertiport
FATO elevation	:	The highest point of the final-approach and takeoff area (FATO)
AFM	:	Aircraft Flight Manual
Servicing ground vehicle	:	Vehicles used for parking of aircraft and ground servicing operations including the handling of passengers and cargo.
Taxiway fillet	:	The widening of the taxiway provided at curves or corners to prevent the tires, etc. from running off the taxiway

Figure 1.3.1 Definition of D Value

(3) The terms used in the Guidelines other than those listed in (1) and (2) above shall be pursuant to "Standards and Guidelines for Establishing Onshore Airports" and "Design Manual for Airport Civil Works" *

* Reference URL: https://www.mlit.go.jp/koku/koku_tk9_000019.html

1.4 Facilities Configuration

(1) A vertiport needs to have at least one unit each of the following facilities.
- FATO
- TLOF
- Safety area
- Protected side slope
- Markings - FATO marking and wind direction indicator
- Firefighting and emergency facilities

(2) Provision of the following facilities and equipment should be considered based on such conditions as the location, constraints, and method of operation of the vertiport.
- Aircraft stand and protection area
- Taxiway
- Taxiway strip
- Markings (other than the types listed in (1) above)
- Lights
- Fall prevention facilities
- Charging facilities
- Drainage, fence, roads, car parking, and other facilities

[Comments]

(1) Vertiport facilities should be located within the Vertiport site.

(2) When the site area is highly constrained (for example, in the case of elevated vertiports), a FATO can be used as an aircraft stand.

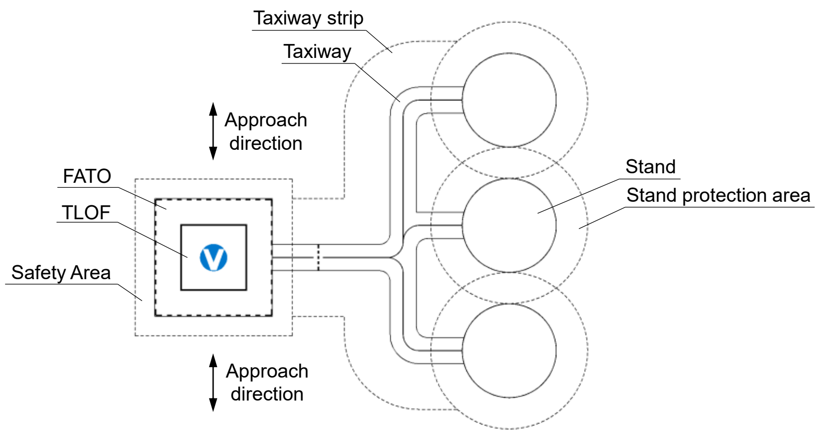
(3) Each facility should be arranged to take into account the impact of downwash and blast from VTOL aircraft.

(4) If VTOL aircraft is to land inside the FATO after final approach and before taking off, a TLOF needs to be provided within the FATO. Or if VTOL aircraft is to move by air taxiing along the taxiway and touch down inside an aircraft stand, the TLOF needs to be provided within the stand.

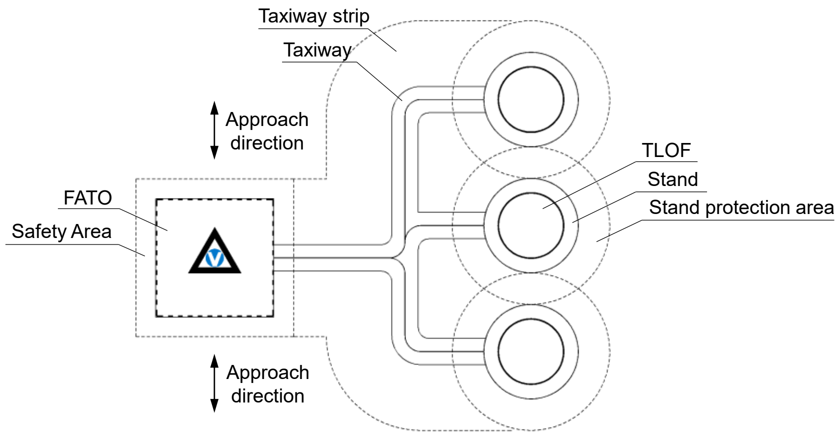
(5) If the VTOL aircraft is to operate in the middle of the taxiway, grounding or surfacing and switching between air taxiing and ground taxiing, a stand and TLOF could be provided in the middle of the taxiway.

(6) Lights will be necessary if the vertiport is intended for use at night.

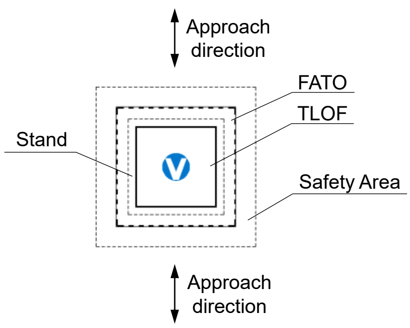
(7) Fall prevention facilities such as safety fences will be necessary in the case of an elevated vertiport.



(a) Example of a one-FATO facility, TLOF within FATO, and 3 aircraft stand facilities



(b) Example of a one-FATO facility, TLOF within aircraft stand, and 3 aircraft stand facilities



(c) Example of a one-FATO facility also serving as an aircraft stand

Figure 1.4.1 Classifications of Vertiport Facilities

Chapter 2 Vertiport Facilities

2.1 FATO

2.1.1 General

(1) A FATO should provide an area of the sufficient size, shape, strength, and surface to ensure safe navigation in the final phase of the approach and at the commencement of the takeoff of the VTOL aircraft for which the FATO is intended.
(2) Objects that can become obstacles should not be placed inside the FATO (except for objects essential for safe navigation).

[Comments]

(1) A vertiport should be provided with at least one FATO.
(2) A FATO should be paved or otherwise solid and ensure an area free of obstacles.
(3) A FATO should be surrounded by a SA.
(4) A FATO should be located so as to minimize the influence of the surrounding environment, including turbulence, which could adversely affect VTOL aircraft operations.
(5) "Objects essential for safe navigation" refer to lighting facilities and other objects which because of their function are located on the FATO.
(6) "Objects essential for safe navigation" should preferably have a fragile structure and be as low in height as possible.
(7) "Objects essential for safe navigation" should not be so tall as to penetrate the horizontal plane above the FATO elevation (the highest point of the FATO) by more than 5 cm as shown in Figure 2.1.1
(8) Guidelines for FATOs on elevated vertiports are provided in Section 2.1.7.
(9) If a FATO will also be used as an aircraft stand, the FATO should satisfy the guidelines for the size, shape, strength, and surface of an aircraft stand as shown in Section 2.7.
(10) Note that these Guidelines are not premised on the provision of an obstacle-free volume (OFV) as advocated in some overseas technical guidelines.

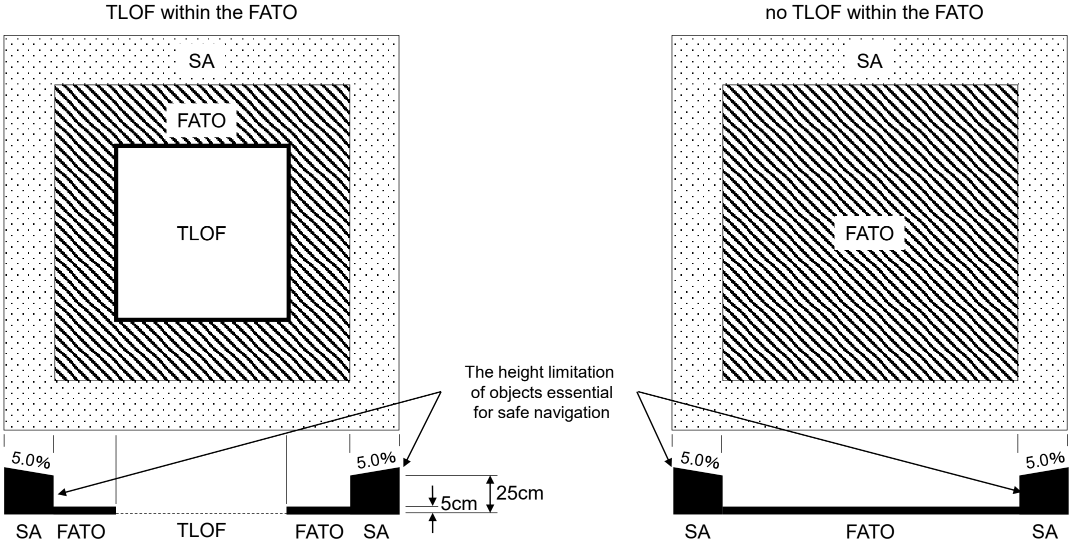


Figure 2.1.1 Height limitation of objects essential for safe navigation within FATO and SA (in the case of a rectangular FATO)

2.1.2 Size and Shape of FATO

The size and shape of a FATO should have the minimum dimensions as described below. – The length and width of a FATO should be at least the dimensions prescribed in the AFM of the VTOL aircraft for which the FATO is intended, or 1.5 D value, whichever is greater.

[Comments]

(1) Figure 2.1.2 shows examples of the size and shape of a FATO.

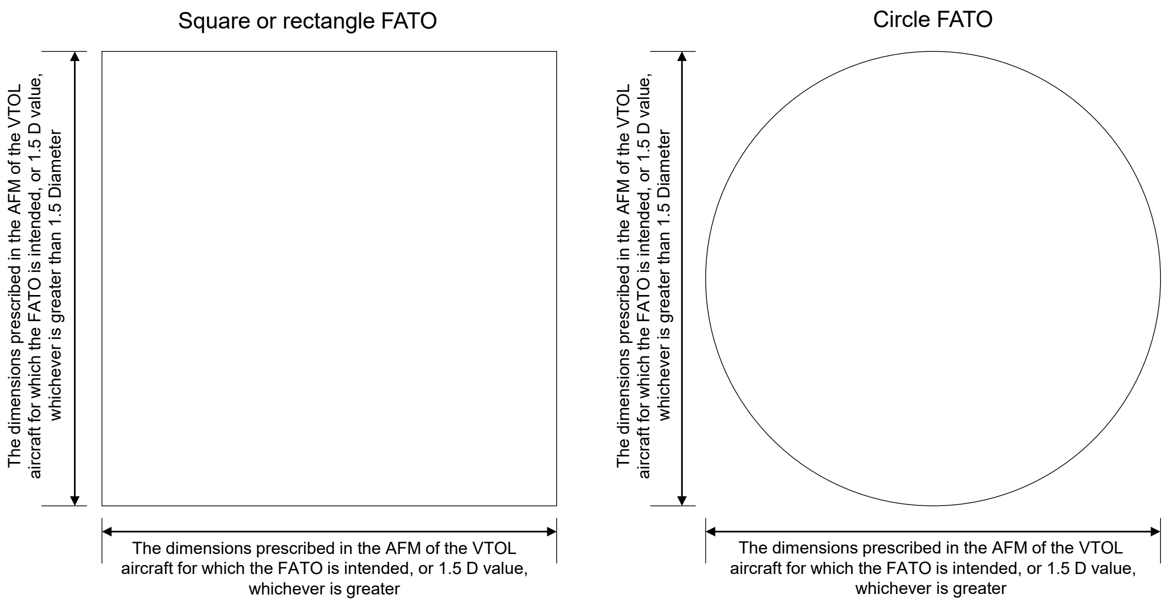


Figure 2.1.2 Example of size and shape of a FATO

2.1.3 Slope Gradients of FATO

(1) The longitudinal gradient of a FATO should not exceed 2%. (2) The transverse gradient of a FATO should not exceed 2%.

2.1.4 Strength of FATO

(1) A FATO should be strong enough to withstand the operation of the VTOL aircraft it is intended to serve.
(2) If the TLOF is to be allocated inside the FATO, the strength inside the TLOF should be according to the guidelines set out in Section 2.4.4.

[Comments]

(1) When servicing ground vehicles are intended to be used, the FATO should be strong enough to withstand the load of the servicing ground vehicles and other anticipated loads.

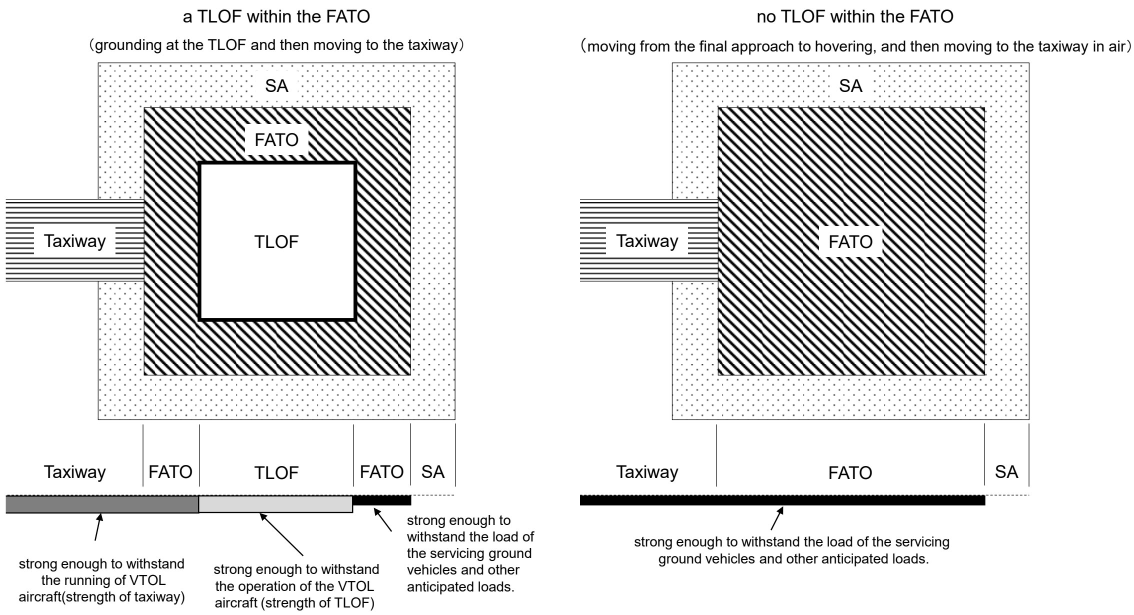


Figure 2.1.3 Example of strength level in the case of a paved FATO

2.1.5 FATO Surface

(1) The surface of a FATO should be resistant to the effects of downwash and ensure effective drainage of rainwater.
(2) If a TLOF is to be allocated inside the FATO, the surface inside the TLOF should be according to the guidelines set out in Section 2.4.5.

[Comments]

(1) Damage to the surface of the FATO from downwash effects and flying stones/gravel should be taken into consideration.

2.1.6 FATO Minimum Separation Distance

> When operating multiple FATOs, sufficient separation distance should be provided between FATOs to ensure that the safety of the operation of VTOL aircraft will not be affected.

[Comments]

(1) Separation distances between FATOs need to be determined, giving due regard to such issues as the safety of takeoff, landing, and go-around routes, downwash effects, and avoiding overlap of SAs.

(2) If simultaneous takeoff or landing operations of multiple VTOL aircraft are to take place at separate FATOs in the same vertiport, the distance between the edges of FATOs should be at least 60 m, provided that the safety aspects described in (1) above are ensured and that the maximum takeoff weight of the VTOL aircraft is no more than 3,175 kg.

2.1.7 FATOs on Elevated Vertiports

> When solid, paying due consideration to the construction conditions, a FATO on an elevated vertiport should be designed to have a safe structure in compliance with the Building Standards Act, Fire Service Act and other relevant laws and regulations.

[Comments]

(1) If liquid fuel needs to be used for the operation of hybrid VTOL aircraft and other purposes, facilities to prevent fuel leakage should be provided.

(2) A FATO on an elevated vertiport should be designed with due consideration given to downwash effects and other impacts on the surrounding environment. Guidelines on the assessment of downwash effects are provided in Section 4.1.

(3) Other than the above, the size and shape of a FATO on an elevated vertiport should be the same as that of a FATO on a surface vertiport.

(4) Air and wind turbulence may occur near the rooftop of structures. FATOs and TLOFs should preferably have a platform structure with space between the rooftop surface to allow air flow. The height of the platform from the rooftop should be determined by considering wind and other environmental conditions.

(5) FATOs used only for aircraft with advanced takeoff and landing capabilities, as specified separately, are allowed not to be solid.

2.2 Safety Area (SA)

2.2.1 General

(1) The SA should have a size and shape sufficient to reduce the risk of damage to a VTOL aircraft accidentally deviating from a FATO intended to serve that VTOL aircraft.

(2) Objects that can become obstacles should not be placed inside the SA, except for objects essential for safe navigation.

[Comments]

(1) A SA should secure an area free of obstacles.

(2) A SA should have contiguous and flush with the FATO.

(3) “Objects essential for safe navigation” refers to lighting facilities and other objects which because of their function are located on the SA.

(4) “Objects essential for safe navigation” should preferably have a fragile structure and be as low in height as possible.

(5) “Objects essential for safe navigation” located within the SA should not be so tall as to penetrate a surface originating at the edge of the FATO and at a height of 25 cm above the FATO elevation (the highest point of the FATO) sloping upwards and outwards at a gradient of 5% as shown along with the FATO in Figure 2.1.1

(6) Guidelines for SAs on elevated vertiports are provided in Section 2.2.5.

(7) Note that these Guidelines are not premised on the provision of an obstacle-free volume (OFV) as advocated in some overseas technical guidelines.

2.2.2 Size and Shape of SA

The width of a SA should be as described below.

- At least 3 m from the edge of the FATO, or 0.25 D value, whichever is greater.

[Comments]

(1) Figure 2.2.1 shows examples of the size and shape of a SA.

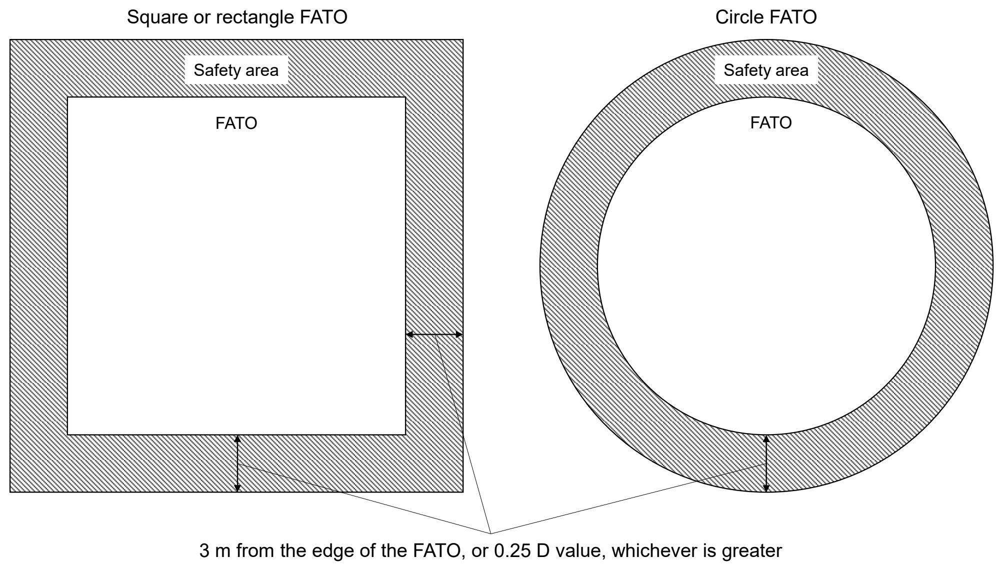


Figure 2.2.1 Example of size and shape of a SA

2.2.3 Slope Gradients of SA

If the SA is to be sloped either upwards and outwards or downwards and outwards from the FATO, the gradient of the slope should be no more than 4%.

[Comments]

(1) Slope on the SA should be as possible abrupt changes of slopes avoided.

2.2.4 SA Surface

The surface of a SA should be resistant to the effects of downwash and ensure effective drainage of rainwater

[Comments]

(1) Damage to the surface of the SA from downwash effects and flying stones/gravel should be taken into consideration.

2.2.5 SAs on Elevated Vertiports

When solid, paying due consideration to the construction conditions, a SA on an elevated vertiport should be designed to have a safe structure in compliance with the Building Standards Act, Fire Service Act and other relevant laws and regulations.

[Comments]

(1) A SA of an elevated vertiport should be designed with due consideration given to downwash effects and other impacts on the surrounding environment. Guidelines on the assessment of downwash effects are provided in Section 4.1.

(2) Other than the above, the size and shape, gradients, and surface of a SA of an elevated vertiport should be the same as those of a SA on a surface vertiport.

2.3 Protected Side Slope (PSS)

> A surface that protects the side space in the takeoff or landing direction to deal with unforeseen lateral behavior during takeoff and landing.

[Comments]

(1) A vertiport should be provided with at least one protected side slope. 「転移表面を不要とする場合は」は入れない？

(2) A protected side slope should extend outward and upward form the edge of the SA at a slope of 1:1, for 10m measured vertically from the FATO elevation.

(3) The surface of a protected side slope should not be penetrated by obstacles.

(4) The areas to have the same characteristics as safety area should satisfy the limitations of obstacles provided in Section 2.2.

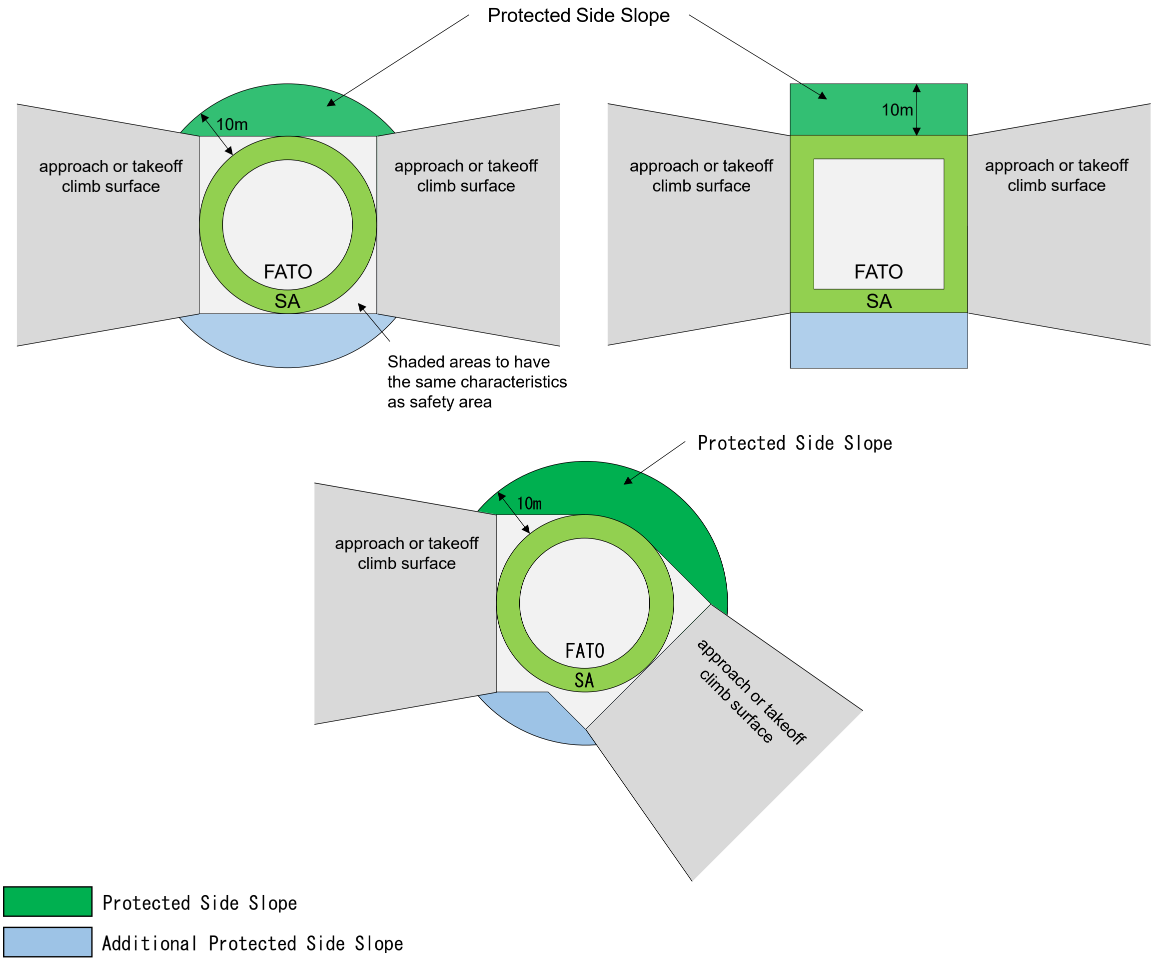


Figure 2.3.1 Example of Protected Side Slope

2.4 TLOF

2.4.1 General

(1) A TLOF should provide an area of the sufficient size, shape, strength, and surface to ensure safe navigation in the touchdown or lift-off of the VTOL aircraft it is intended to serve. (2) A TLOF should be placed at the center of a FATO or an aircraft stand, with consideration given to the operational procedures of the VTOL aircraft it is intended to serve.

[Comments]

(1) A vertiport should be provide at least one TLOF.

(2) A TLOF should be placed within the FATO, if the undercarriage of the VTOL aircraft will touchdown within a FATO after final approach and before the commencement of the takeoff.

(3) A TLOF should be placed within the aircraft stand if the VTOL aircraft is to move by air taxiing along the taxiway and touch down inside the stand. Guidelines on the size and shape of aircraft stands are provided in Section 2.7.

(4) Guidelines for TLOFs on elevated vertiports are provided in Section 2.4.6.

(5) Note that these Guidelines are not premised on the provision of an obstacle-free volume (OFV) as advocated in some overseas technical guidelines.

2.4.2 Size and Shape of TLOF

The size and shape of a TLOF should have the minimum dimensions as described below. − The length and width of a TLOF on a surface vertiport should be at least the dimensions prescribed in the AFM of the VTOL aircraft for which the TLOF is intended, or 0.83 D value, whichever is greater.

[Comments]

(1) Figure 2.4.1 shows examples of the size and shape of a TLOF.

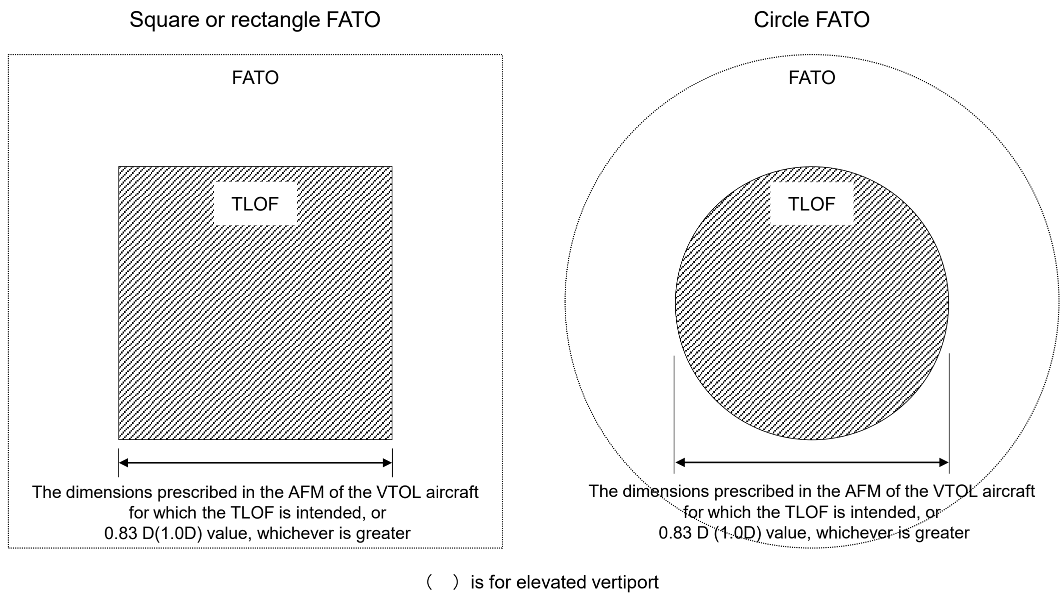


Figure 2.4.1 Example of size and shape of a TLOF

2.4.3 TLOF Gradients

(1) The longitudinal gradient of a TLOF should not exceed 2%.

(2) The transverse gradient of a TLOF should not exceed 2%.

2.4.4 TLOF Strength

A TLOF should be strong enough to withstand the load associated with the touchdown or lift-off of the undercarriage of the VTOL aircraft it is intended to serve.

[Comments]

(1) A TLOF should be designed to have adequate strength based on the performance of the VTOL aircraft it is intended to serve. A summary of considerations related to TLOF strength based on considerations on heliport strength is provided below as a reference.

(i) A TLOF should have sufficient strength to withstand the load imposed in normal operation, and the design load shall be 1.5 times the maximum takeoff weight of the largest anticipated VTOL aircraft being evenly divided into its two main undercarriage gears.

(ii) If the TLOF is intended for use only during takeoff or lift-off TLOF, the TLOF should have sufficient strength to withstand the load of the VTOL aircraft when stationary, and the design load shall be 1.5 times the maximum takeoff weight of the largest anticipated VTOL aircraft being evenly divided into its two main undercarriage gears.

(2) If the load of the servicing ground vehicles intended to be used and other anticipated loads exceed the design load described in (1) above, the load of the servicing ground vehicles and other anticipated loads shall be used as the design load.

2.4.5 TLOF Surface

The surface of a TLOF should have sufficient friction resistance and ensure effective drainage of rainwater while having no adverse effect on the stability of a VTOL aircraft during its operation.

[Comments]

(1) A TLOF surface should preferably be paved.

2.4.6 TLOFs on Elevated Vertiports

Paying due consideration to the construction conditions, a TLOF on an elevated vertiport should be designed to have a safe structure in compliance with the Building Standards Act, Fire Service Act and other relevant laws and regulations。

[Comments]

(1) The length and width of a TLOF on an elevated vertiport should be at least the dimensions prescribed in the AFM of the VTOL aircraft for which the TLOF is intended, or 1 D value, whichever is greater.

(2) A TLOF should be designed to have adequate strength based on various considerations including the performance of the VTOL aircraft it is intended to serve and potential impact on the building. A summary of considerations related to TLOF strength based on considerations on elevated heliport strength is provided below as a reference.

(i) A TLOF within a FATO on an elevated vertiport should have sufficient strength to withstand the impact from a forced landing in case of an emergency, such that the design load shall be 2.5 times the maximum takeoff weight of the largest anticipated VTOL aircraft concentrated on one main undercarriage gear.

(ii) In the case of elevated vertiport facilities, the resonant response of the platform needs to be taken into consideration when calculating the load, which should be increased by a structural response coefficient. If a specific value to accurately reflect the resonant response cannot be identified, use a value of 1.3 or more as the structural response coefficient.

(3) Other than the above, the gradients and surface of a TLOF on an elevated vertiport should be the same as those of a TLOF on a surface vertiport.

2.5 Taxiway

2.5.1 General

A taxiway should provide an area of the sufficient size, shape, strength, and surface to ensure safe navigation of the VTOL aircraft it is intended to serve, when ground taxiing or air taxiing.

[Comments]

(1) From a safety perspective, the standard should be to provide a taxiway even if the VTOL aircraft is intended to travel from the FATO to the aircraft stand by air taxiing or towing by GSE, etc.

2.5.2 Width of Taxiways

The width of a taxiway should have a minimum width of twice the largest undercarriage width (UCW) of the VTOL aircraft the taxiway is intended to serve.

[Comments]

(1) The guideline above applies to the straight portion of the taxiway.

(2) A taxiway fillet should be provided at crossings or curved portions of the taxiway. The fillets should be designed to accommodate the most demanding VTOL aircraft that is intended to move by ground taxiing.

2.5.3 Slope Gradients of Taxiways

(1) The longitudinal gradient of a taxiway should not exceed 3%.

(2) The transverse gradient of a taxiway should not exceed 2%.

[Comments]

(1) The longitudinal slope of a taxiway should preferably be designed to minimize changes in the gradient with due consideration for the maneuverability of the VTOL aircraft.

2.5.4 Strength of Taxiways

A taxiway should be strong enough to withstand the dynamic loads associated with ground taxiing of the VTOL aircraft it is intended to serve.

[Comments]

(1) A taxiway should be designed to have adequate strength based on the performance of the VTOL aircraft it is intended to serve. A summary of considerations related to taxiway strength based on considerations on heliport strength is provided below as a reference.

(i) If the taxiway is intended to serve VTOL aircraft that will move by ground taxiing, the taxiway should have sufficient strength to withstand the load imposed in normal operation, such that the design load shall be 1.5 times the maximum takeoff weight of the largest anticipated VTOL aircraft being evenly divided into its two main undercarriage gears.

(2) If the load of the servicing ground vehicles intended to be used and other anticipated loads exceed the design load described in (1) above, the load of the servicing ground vehicles and other anticipated loads shall be used as the design load.

(3) If the taxiway is intended to serve VTOL aircraft that will move only by air taxiing, the taxiway should have sufficient strength to withstand the load of the servicing ground vehicle intended to be used and other anticipated loads.

2.5.5 Surface of Taxiways

The surface of a taxiway should be resistant to the effects of downwash and ensure effective drainage of rainwater while having no adverse effect on the stability of a VTOL aircraft when ground taxiing.

[Comments]

(1) A taxiway surface should preferably be paved.

2.5.6 Taxiway Minimum Separation Distance

The minimum distance between the center lines of a taxiway and another taxiway should be at least 1.25 times the overall width of the largest VTOL aircraft intended to use the taxiways.

[Comments]

(1) The separation distance defined in the above guideline is illustrated in Figure 2.5.1.

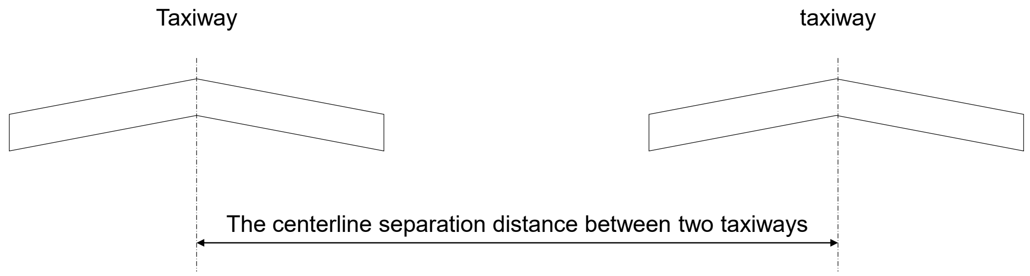


Figure 2.5.1 Centerline separation distance between two taxiways

2.6 Taxiway Strip

2.6.1 General

A taxiway strip should have sufficient width to ensure safe navigation of the VTOL aircraft it is intended to serve and be free of objects that can become obstacles, except for objects essential for safe navigation.

[Comments]

(1) A taxiway strip should secure an area free of obstacles.

(2) A taxiway strip should have contiguous and flush with the taxiway.

(3) "Objects essential for safe navigation" refers to lighting facilities and other objects which because of their function are located on the taxiway strip.

(4) "Objects essential for safe navigation" should preferably have a fragile structure and be as low in height as possible.

(5) "Objects essential for safe navigation" should not be located at a distance of less than 50 cm outwards from the edge of the taxiway.

(6) "Objects essential for safe navigation" should not be so tall as to penetrate a surface originating 50 cm outwards of the edge of the taxiway and at a height of 25 cm above the surface of the taxiway, and sloping upwards and outwards at a gradient of 5% up to the outer edge of the taxiway strip as shown in Figure 2.6.1

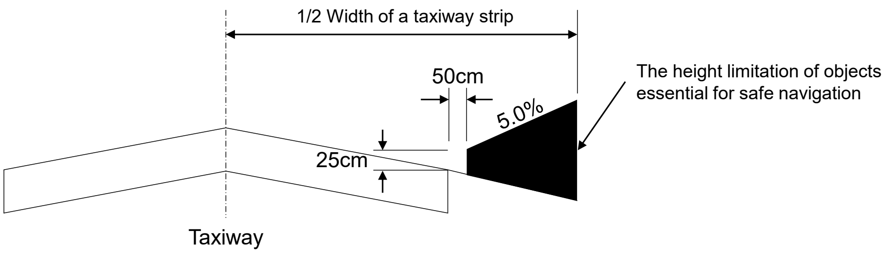


Figure 2.6.1 Height limitation of objects essential for safe navigation within a taxiway strip

2.6.2 Width of Taxiway Strips

The width of a taxiway strip should meet the following guidelines:

- If the taxiway strip is intended to serve VTOL aircraft that will move by ground taxiing, the taxiway strip should have a minimum width of 1.5 times the overall width of the largest VTOL aircraft it is intended to serve (with 0.75 times of the same width extending symmetrically on each side of the center line of the taxiway).
- If the taxiway strip is intended to serve VTOL aircraft that will move by air taxiing, the taxiway strip should have a minimum width of twice (and width from the center line of the taxiway to the outer edge of the taxiway strip should be at least the same as) the overall width of the largest VTOL aircraft it is intended to serve.

[Comments]

(1) The width of a taxiway strip is determined based on the minimum distance that should be secured between the center line of the taxiway and fixed obstacles as shown in Figure 2.6.2.

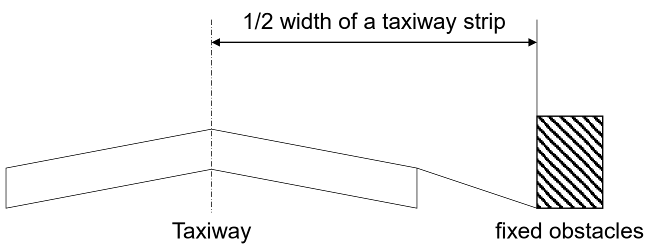


Figure 2.6.2 Width of taxiway strip

2.6.3 Slope Gradients of Taxiway Strips

Transverse slopes on any portion of a taxiway strip excluding the taxiway itself should not exceed an upward or downward slope of 4% as measured in the direction away from the taxiway.

[Comments]

(1) Slope on the taxiway strip should be as possible abrupt changes of slopes avoided.

(2) If portions of a taxiway strip overlap with a SA, the guidelines for the slope gradients of SA should supersede.

(3) If drainage structures are to be provided on the taxiway strip, the drain design needs to meet the gradient guidelines of taxiway strips by adopting flat plate-type drainage designs or suitably designed drain covers.

2.6.4 Surface of Taxiway Strips

The surface of a taxiway strip should be resistant to the effects of downwash and ensure effective drainage of rainwater.

[Comments]

(1) Damage to the surface of the taxiway strip from downwash effects and flying stones/gravel should be taken into consideration.

2.7 Aircraft Stand

2.7.1 General

An aircraft stand should provide an area of the sufficient size, shape, strength, and surface to ensure safety for parking the VTOL aircraft it is intended to serve and servicing operations such as loading and unloading of passengers and cargo and maintenance of the aircraft.

[Comments]

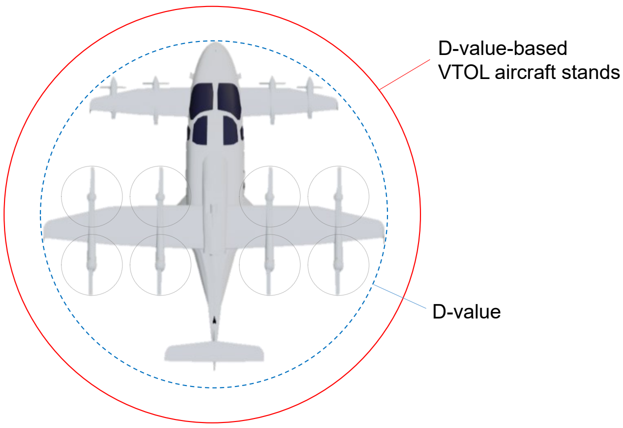
(1) When the stand is D-value-based VTOL aircraft, an aircraft stand should be surrounded by a stand protection area.

(2) An aircraft stand should be located where the parked VTOL aircraft does not interfere with obstacle limitation surfaces or protected side slope.

2.7.2 Size and Shape of Aircraft Stands

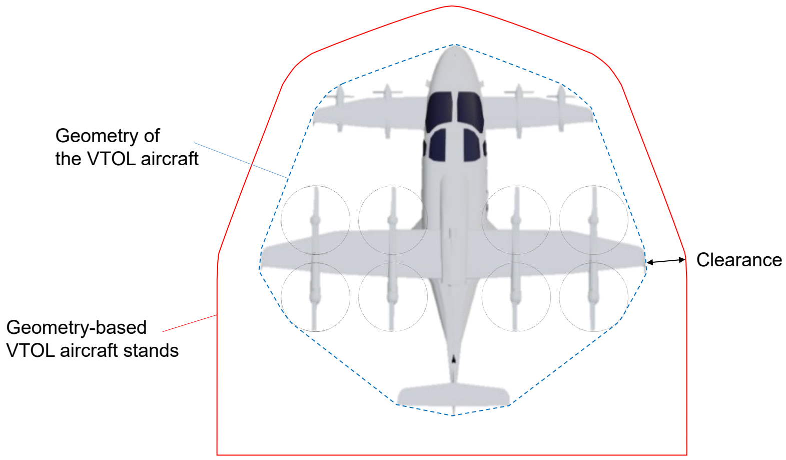
The shape of the stand should have one of the following standards, taking into consideration the dimensions and performance of the VTOL aircraft expected to be used and the method of operation.

- D-value-based VTOL aircraft stands : The minimum dimensions of a circle with a diameter of at least 1.2 D value.



- Geometry-based VTOL aircraft stands : When limited to ground travel by self-propelled, towed, or other means, this may be set to the dimensions of the VTOL aircraft that is expected to be used. The following clearances should be provided between the VTOL aircraft entering or leaving the stand and the VTOL aircraft parked at an obstruction or another stand.

VTOL aircraft width	Clearance
Up to but not including 24 m	3 m or more
24 m up to but not including 36 m	4.5 m or more
36 m and over	7.5 m or more



〔Comments〕

(1) D-value-based VTOL aircraft stands may be other than circular shapes, such as rectangles, as long as the shape has dimensions equal to or greater than a circle with a diameter of 1.2 D value.

(2) When the aircraft does not change direction by hovering or descend/float at the stand, but enters/exits the stand by ground movement by self-propulsion or towing by GSE, etc., the shape based on the dimensions of the aircraft may be applied. However, if blast or downwash occurs due to ground movement, the effect should be taken into account and appropriate measures should be taken as necessary.

(3) In the case of Geometry-based VTOL aircraft stands, if VTOL aircraft using adjacent aircraft stands are required to simultaneously operate (taxi or otherwise move), the clearance of the adjacent stands should not overlap.

(4) In the case of Geometry-based VTOL aircraft stands, if VTOL aircraft using adjacent aircraft stands will not simultaneously operate (taxi or otherwise move), the clearance of adjacent stands may overlap as shown in Figure 2.7.1 but should not be less than the required clearance for the larger of the adjacent stands.

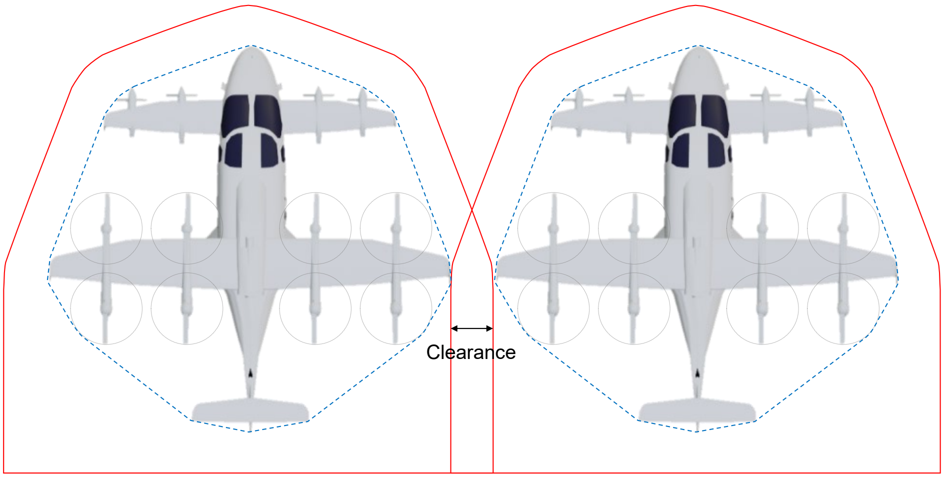


Figure 2.7.1　Overlap of Clearance

2.7.3　Slope Gradient of Aircraft Stands

The slope gradient of an aircraft stand should not exceed 2%.

[Comments]

(1) Slopes on an aircraft stand have the purpose of facilitating drainage of rainwater, but the slope should be kept as shallow as possible to prevent parked VTOL aircraft from moving on their own and causing damage.

2.7.4　Strength of Aircraft Stands

An aircraft stand should be strong enough to withstand the loads of the VTOL aircraft it is intended to serve and of servicing ground vehicles.

[Comments]

(1) An aircraft stand should be designed to have adequate strength based on the performance of the VTOL aircraft it is intended to serve. A summary of considerations related to aircraft stand strength based on considerations on heliport strength is provided below as a reference.

(i) The aircraft stand should have sufficient strength to withstand the load imposed in normal operation, such that the design load shall be 1.5 times the maximum takeoff weight of the largest anticipated VTOL aircraft being evenly divided into its two undercarriage gears.

(2) If the load of the servicing ground vehicles intended to be used and other anticipated loads exceed the design load described in (1) above, the load of the servicing ground vehicles and other anticipated loads shall be used as the design load.

2.7.5 Surface of Aircraft Stands

The surface of an aircraft stand should be sufficiently resistant to friction and the effects of downwash as well as ensure effective drainage of rainwater while having no adverse effect on the stability of a VTOL aircraft during its operation.

[Comments]

(1) The surface of an aircraft stand should preferably be paved.

(2) Where hybrid VTOL aircraft are operated, fueling service may be provided on an aircraft stand. The surface of an aircraft stand, where fueling service is provided, should be in compliance with the standards for fuel handling facilities as set out in the Fire Service Act.

(3) If such equipment as earthing rings for lightning protection and tie-down rings are to be installed in an area where VTOL aircraft will be parked, the installation location of such equipment should be considered in consultation with the aircraft operators and other relevant parties.

(4) If earth rings and tie-down rings are to be installed, signs should be provided to clearly indicate their usage and location.

(5) Earthing rings for lightning protection are used to divert the lightning current to the earth, and tie-down rings are used to tie down VTOL aircraft to the stand. Examples of structures and signs of typical earthing rings are provided in the “Design Manual for Airport Civil Works - Facility Design”.

2.8 Stand Protection Area

2.8.1 General

A protection area should have sufficient width to ensure safe navigation of the VTOL aircraft it is intended to serve and be free of objects that can become obstacles, except for objects essential for safe navigation.

[Comments]

(1) A stand protection area should secure an area free of obstacles.

(2) “Objects essential for safe navigation” refers to lighting facilities and other objects which because of their function are located on the stand protection area.

(3) “Objects essential for safe navigation” should preferably have a fragile structure and be as low in height as possible.

(4) “Objects essential for safe navigation” should not be so tall as to penetrate the surface described below as illustrated in Figure 2.8.1:

- if located at a distance of less than 0.75 D from the center of the aircraft stand, should not penetrate a surface at a height of 5 cm above the surface of the central zone;
- if located at a distance of 0.75 D or more from the center of the aircraft stand, should not penetrate a surface at a height of 25 cm above the plane of the central zone and sloping upwards and outwards at a gradient of 5%.

(5) Guidelines for stand protection areas on elevated vertiports are provided in Section 2.8.5.

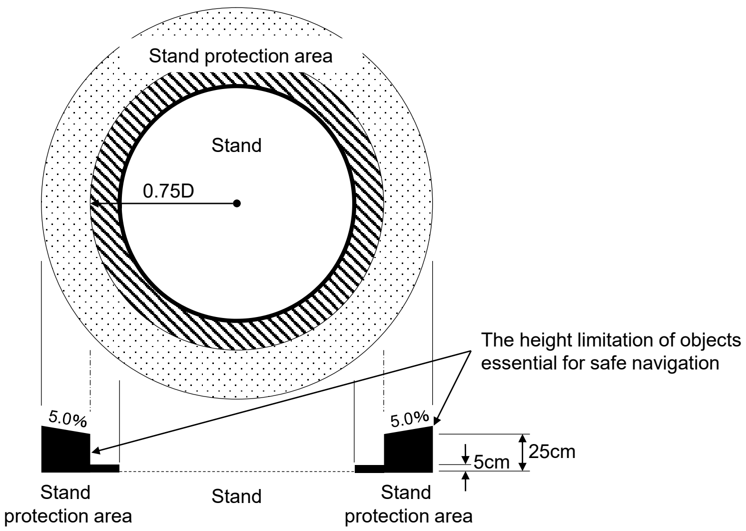


Figure 2.8.1 Height limitation of objects essential for safe navigation within a stand protection area

2.8.2 Size and Shape of Stand Protection Areas

The width of a stand protection area should be at least 0.4 D value from the outer edge of the aircraft stand.

[Comments]

(1) If VTOL aircraft using adjacent aircraft stands are required to simultaneously operate (taxi or otherwise move), the protection area of the adjacent stands should not overlap.

(2) If VTOL aircraft using adjacent aircraft stands will not simultaneously operate (taxi or otherwise move), the protection area of adjacent stands may overlap but should not be less than the required protection area for the larger of the adjacent stands as shown in Figure 2.8.2.

(3) When stand enters/exits is performed without changing direction and by self-propulsion, the stand protection area may be reduced to the width of the taxiway strip, taking into consideration the aircraft performance and the effects of the blast. However, the minimum distance between a VTOL aircraft enters/exits the stand and any other parked VTOL aircraft or obstacle should be at least 3 m.

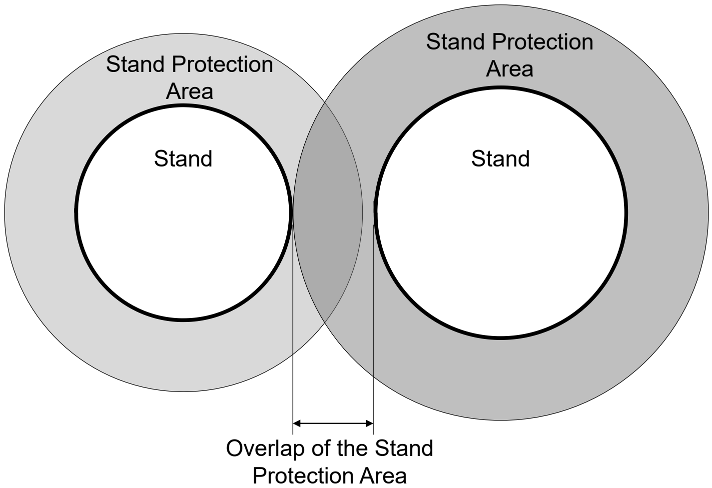


Figure 2.8.2 Overlap of stand protection areas

2.8.3 Slope Gradients of Stand Protection Areas

If the stand protection area is to be sloped either upwards and outwards or downwards and outwards from the aircraft stand, the gradient of the slope should be no more than 4%.

[Comments]

(1) Slope on the stand protection area should be as possible abrupt changes of slopes avoided.

2.8.4 Surface of Stand Protection Areas

The surface of a stand protection area should be resistant to the effects of downwash and ensure effective drainage of rainwater.

[Comments]

(1) Measures should be in place to protect the surface of the stand protection area from downwash effects and flying stones/gravel.

2.8.5 Stand Protection Areas on Elevated Vertiports

When solid, paying due consideration to the construction conditions, a Stand Protection Area on an elevated vertiport should be designed to have a safe structure in compliance with the Building Standards Act, Fire Service Act and other relevant laws and regulations.

〔Comments〕

(1) A Stand Protection Area on an elevated vertiport should be designed with due consideration given to downwash effects and other impacts on the surrounding environment. Guidelines on the assessment of downwash effects are provided in Section 4.1.

(2) Other than the above, the gradients and surface of a Stand Protection Area on an elevated vertiport should be the same as those of a Stand Protection Area on a surface vertiport.

2.9 Markings

2.9.1 General

A vertiport should be equipped with markings of categories as specified in Sections 2.9.2 to 2.9.7.

[Comments]

(1) A marking is a facility to provide the pilot with location and other information when the VTOL aircraft is operating on a FATO, taxiway, or apron. A marking should be designed so that it can be easily identified as a marking by its shape, color, and other visual features, its presence and type can be distinguished from a long distance, and the information it carries can be immediately understood.

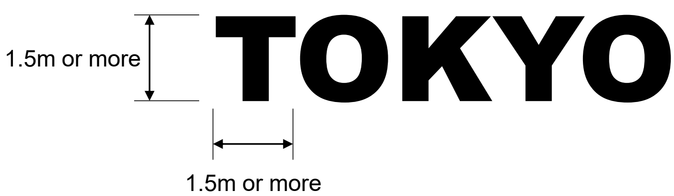
(2) A marking may be omitted if it is difficult to provide on an unpaved FATO, TLOF, taxiway, or apron.

2.9.2 Vertiport name marking

(1) The information that should comprise a vertiport name marking, vertiports required to provide a vertiport name marking, and its location are specified in the table below.

Type of marking	Information to indicate	Vertiports requiring the marking	Location
Vertiport name marking	Vertiport name	All vertiports (excluding those where the name of the Vertiport can be confirmed due to the surrounding topography etc.)	Locations that can easily be identified from an in-flight VTOL aircraft

(2) The design of a vertiport name marking should be as specified below.



Remarks

i. Roman characters should be used to spell the vertiport name.

ii. The colors used should be selected to make the vertiport name marking clearly visible and understandable.

2.9.3 FATO Markings

(1) FATO markings should be as follows.

Type of marking	Information to indicate	Vertiports requiring the marking	Location
FATO identification marking	Landing area on the FATO	All vertiports	Center of the FATO
FATO perimeter marking	The perimeter of the FATO	All vertiports (only if the FATO is paved and the edges are not clear)	Edge of the FATO
Aiming point marking	The FATO surface must not be used for landing	Vertiports with no TLOF within FATO, requiring hovering movement	Center of the FATO
Maximum allowable mass marking	Maximum takeoff weight of VTOL aircraft that can use the FATO	Vertiports with TLOF within the FATO, where VTOL aircraft can land	Within the FATO
Maximum allowable D value marking	Maximum D value of VTOL aircraft that can use the FATO	All vertiports	Within the FATO

(2) The design of FATO markings should be as specified below.

1 FATO identification marking

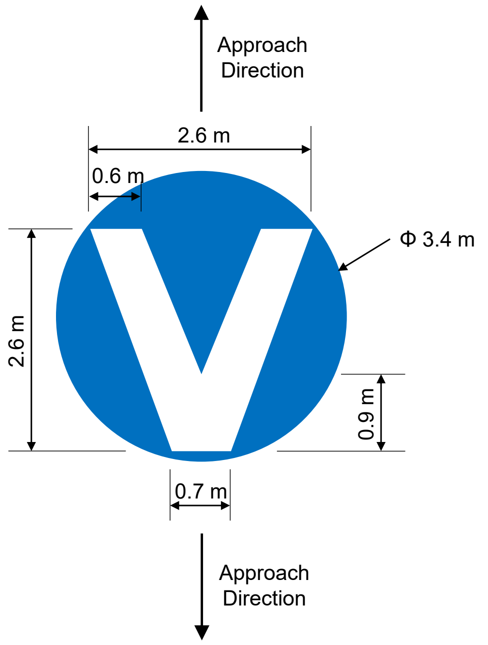


Figure 2.9.1 FATO identification marking

Remarks

i. A FATO identification marking should consist of a white letter 'V' inside a blue circle.

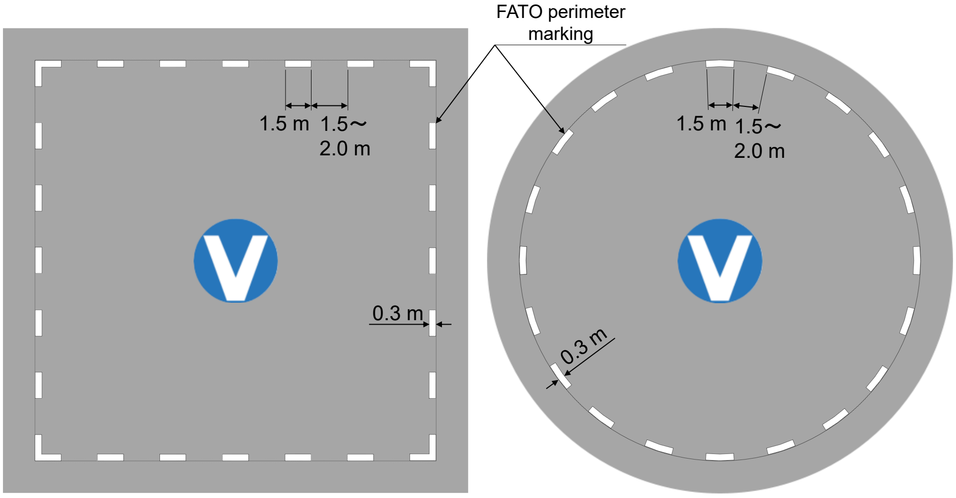
ii. A FATO identification marking should have the minimum dimensions as shown in Figure 2.9.1.

iii. Where a vertiport is equipped with two or more FATOs, the FATO identification marking should have a FATO identification number as shown in the example below.

iv. FATO identification numbers should be assigned as consecutive numbers, beginning with "1" from one side of the vertiport, increasing in a certain direction (like "2", "3", "4"…), and ending in the last of the numbered FATOs.

v. The form and proportion of the numbers should be as shown in Figure 2.9.4 and should have the minimum dimensions as shown in Figure 2.9.4.

2 FATO perimeter marking



Remarks

i. FATO perimeter markings should in general be white, but in cases where white does not contrast well against the FATO surface (e.g., areas with snow accumulation or light-colored pavement) yellow can be used to provide contrast.

ii. The FATO perimeter should normally be marked in a dashed line, with marking segments that are at least 1.5 m long and spacings of no less than 1.5 m and no more than 2 m.

3 Aiming point marking

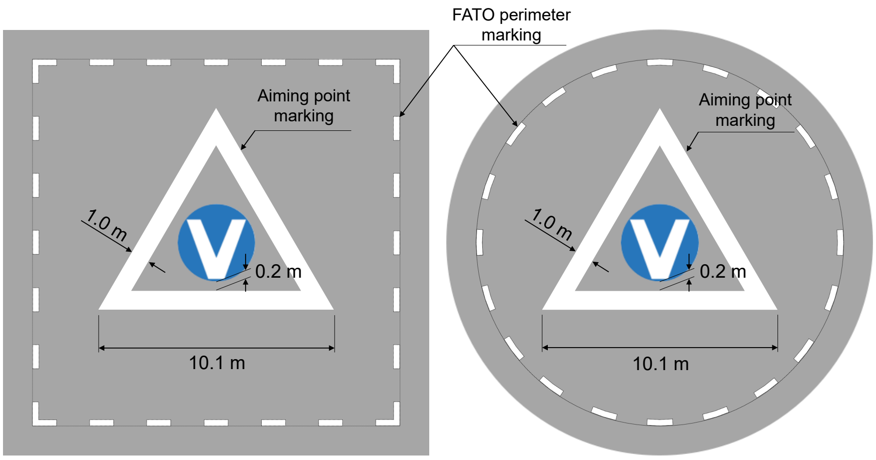


Figure 2.9.2 Aiming point marking

Remarks

i. Aiming point markings should in general be white, but in cases where white does not contrast well against the FATO surface (as in areas with snow accumulation) yellow can be used to provide contrast.

ii. An aiming point marking should be an equilateral triangle.

iii. An aiming point marking should have the minimum dimensions as shown in Figure 2.9.2.

4 Maximum allowable mass marking and maximum allowable D value marking

i. When marking the maximum allowable mass and maximum allowable D value:

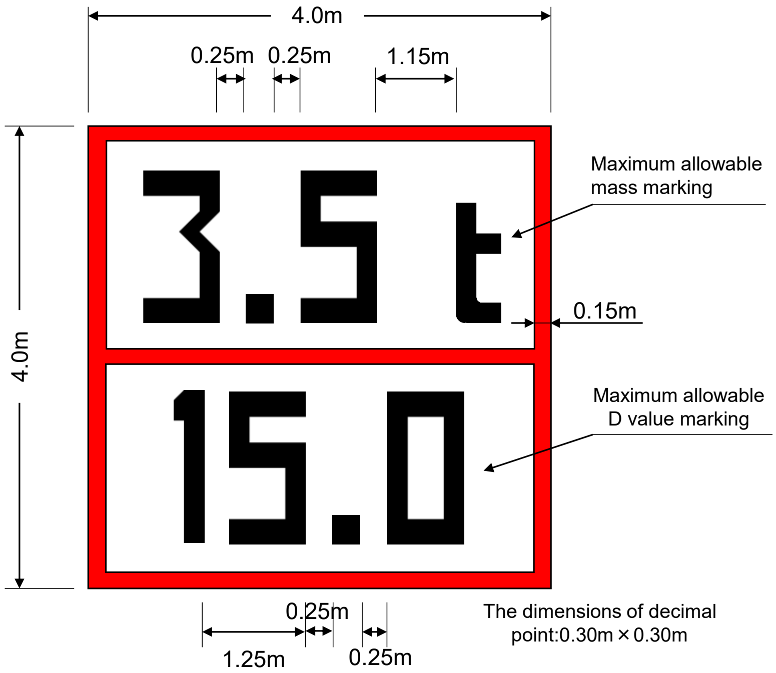
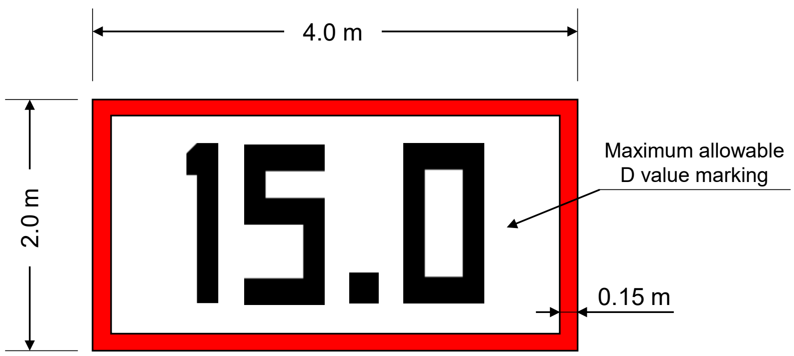


Figure 2.9.3 Example of maximum allowable mass marking and maximum allowable D value marking

ii. When marking only the maximum allowable D value:



Remarks

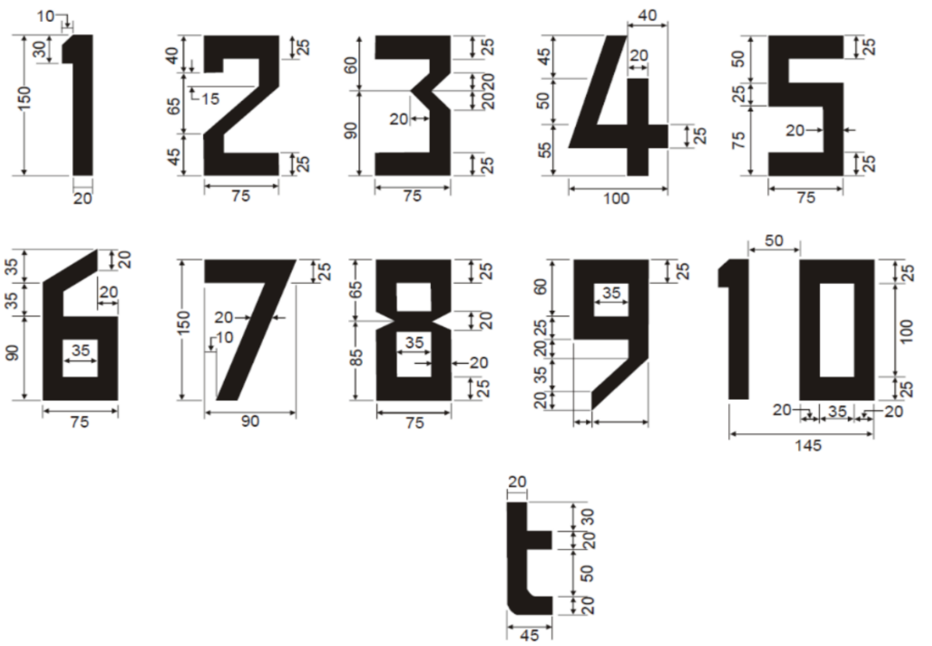
i. The numbers and the letters of the marking should be expressed in one color contrasting with the background.

ii. The maximum allowable mass and maximum allowable D value should be enclosed in a red box and should have the minimum dimensions as shown in Figure 2.9.3.

iii. The maximum allowable mass marking and maximum allowable D value marking should be located in a place within the FATO that will not affect the distinguishability of the FATO identification marking or the FATO perimeter marking.

iv. The numbers of the maximum allowable mass and maximum allowable D value should be expressed in units of tons by the letter “t” and in units of meters by the letter “m” respectively. The markings should be presented to one decimal place by rounding up to the next tenth place.

v. The form and proportion of the numbers and letters of the maximum allowable mass marking and maximum allowable D value marking should be as shown in Figure 2.9.4 and should have the minimum dimensions as shown in Figure 2.9.4 below.



Unit：centimeters

Figure 2.9.4　Numbers and letters for FATO markings

[Comments]

(1) A FATO identification marking should be oriented with its symmetry axis aligned with the preferred approach direction, when the angle between the center lines of different approach areas is less than 180 degrees.

(2) A FATO perimeter marking is required where the perimeter of the FATO is not self-evident, such as in cases where the FATO and the surrounding SA are both paved with asphalt.

(3) The aiming point marking should be oriented with one vertex of the equilateral triangle pointing at the preferred approach direction of the FATO.

2.9.4 TLOF Markings

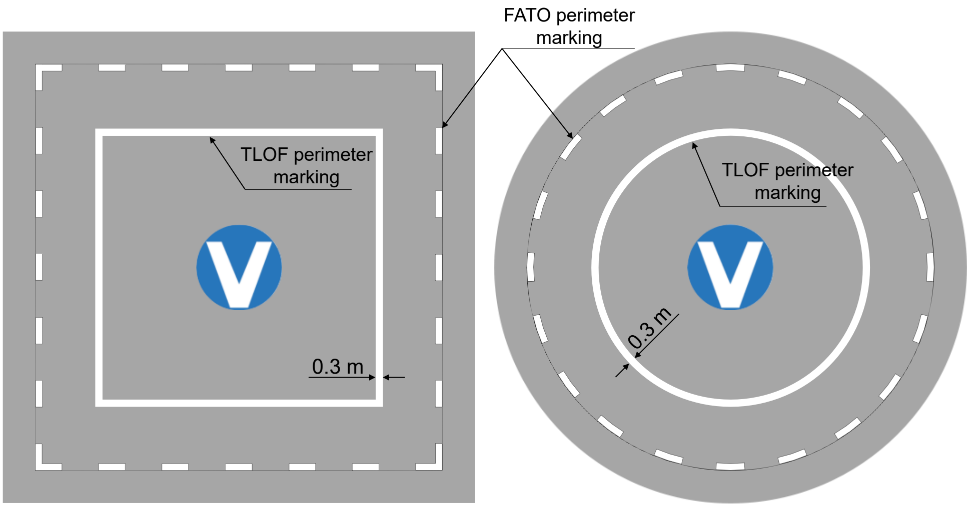
(1) TLOF markings should be as follows.

Type of marking	Information to indicate	Vertiports requiring the marking	Location
TLOF perimeter marking	The perimeter of the TLOF	All vertiports (only if the perimeter of the TLOF is not clear)	The edge of the TLOF

(2) The design of a TLOF marking should be as specified below.

1 TLOF perimeter marking

i. When the TLOF is located inside a FATO:



ii. When the TLOF is located inside an aircraft stand:

Remarks

i. TLOF perimeter markings should be white in general, but in cases where white does not contrast well against the TLOF surface (e.g., areas with snow accumulation or light-colored pavement) yellow can be used to provide contrast.

[Comments]

(1) A TLOF perimeter marking is required where the perimeter of the TLOF is not self-evident, such as in cases where the TLOF and the surrounding FATO or aircraft stand are both paved with asphalt.

2.9.5 Taxiway Markings

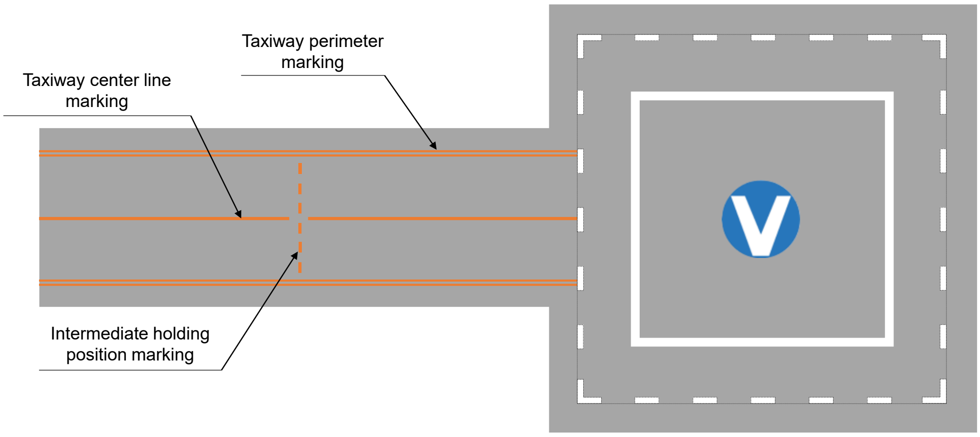
(1) Taxiway markings should be as follows.

Type of marking	Information to indicate	Vertiports requiring the marking	Location
Taxiway center line marking	Taxiway longitudinal centerline	All vertiports	Taxiway longitudinal centerline
Taxiway perimeter marking	The perimeter of a taxiway	All vertiports (only if the perimeter of the taxiway is not clear)	The edge of the taxiway
Intermediate holding	Position where VTOL aircraft	All vertiports	A place on the taxiway where VTOL aircraft will

position marking	should hold			not conflict with the obstacle limitation surfaces or downwash affected areas, etc.

(2) The design of a taxiway marking should be as specified below.

1 Taxiway center line marking

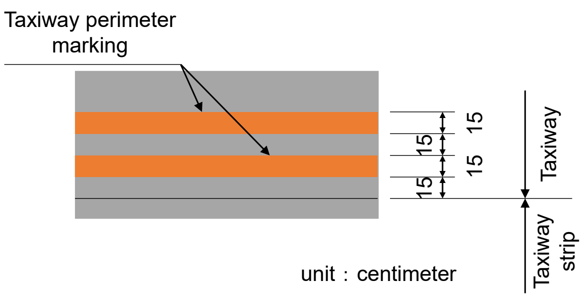


Remarks

i. The color yellow should be used.

ii. A taxiway center line marking should be a continuous line 0.15 m in width.

2 Taxiway perimeter marking

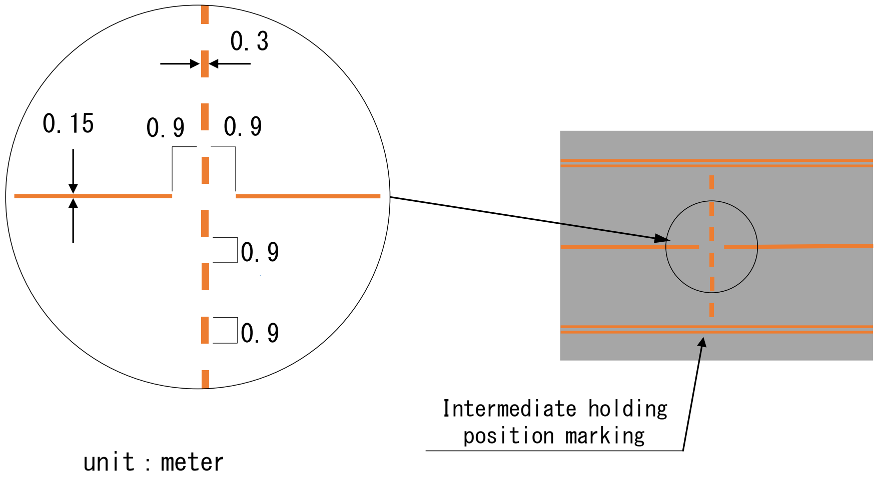


Remarks The color yellow should be used.

3 Intermediate holding position marking

Remarks

i. Intermediate holding position marking should be as the example below.



ii. The color yellow should be used.

[Comments]

(1) A taxiway center line, as a general rule, should be arranged so that the VTOL aircraft can move along the marking at an appropriate turn radius.

(2) A taxiway perimeter marking is required where the perimeter of the taxiway is not self-evident, such as in cases where the taxiway and the taxiway strip are both paved with asphalt.

2.9.6 Apron Markings

(1) Apron markings should be provided as appropriate, taking into consideration the type of aircraft it is intended to serve, parking configurations, parking position, and other factors.

(2) Apron markings should be as follows.

Type of marking	Information to indicate	Vertiports requiring the marking	Location
Lead-in/lead-out lines (guidelines)	The route into/out from the stand	All vertiports	On the route into/out from the stand
Aircraft stand number	Stand number	Vertiports with 2 or more stands	The starting point of the route to the stand and 1.5m away from the taxiway centerline
Aircraft stand perimeter marking	Parking position	All vertiports (only D-value-based VTOL aircraft stand)	Parking position

(3) The design of apron markings should be as specified below.

1 Lead-in/lead-out lines

Remarks

i. The color yellow should be used.

ii. Lead-in/lead-out lines should be marked with a continuous line 0.3 m in width.

2 Aircraft stand number

Remarks

i. The color yellow should be used.

ii. The numbers of the marking should not be less than 1.5 m in height or 1 m in width.

3 Aircraft stand perimeter marking

Remarks

i. The color yellow should be used.

ii. An aircraft stand perimeter marking should be a continuous line 0.15 m in width.

[Comments]

(1) The types and examples of apron markings are shown in Figure 2.9.5 below.

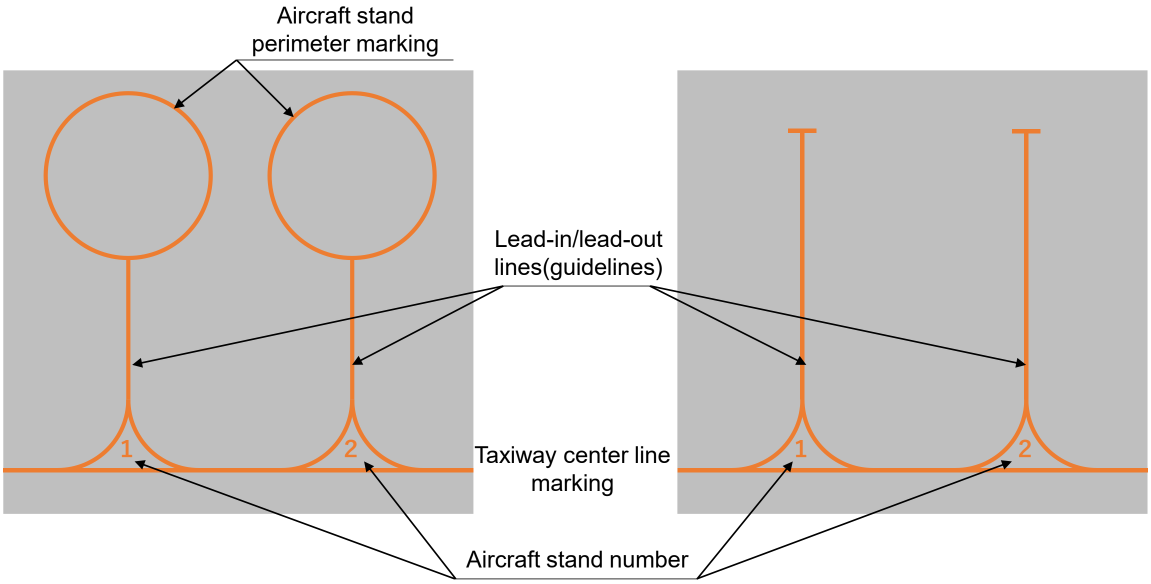


Figure 2.9.5 Example of apron markings

(2) Where the aircraft stand is designed to accommodate only VTOL aircraft with a D value smaller than the vertiport's design D value, maximum allowable mass marking and maximum allowable D value marking should be displayed on the lead-in/lead-out line as shown in Figure 2.9.6 below. Even when a mass limit is not set, both the maximum allowable mass and maximum allowable D value should be displayed together to avoid confusion with the D value.

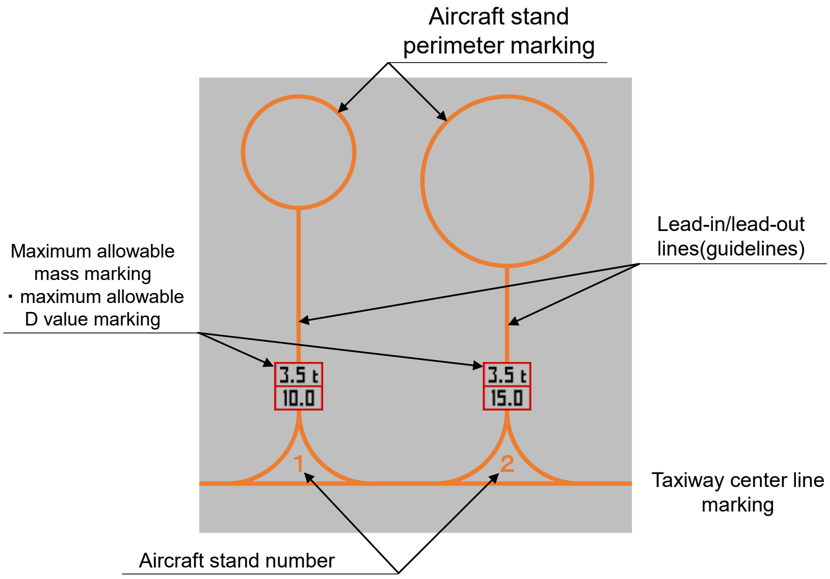


Figure 2.9.6 Example of apron markings indicating D value limitations

(3) Lead-in/lead-out lines, as a general rule, should be arranged so that the VTOL aircraft can move along the lines at an appropriate turn radius.

2.9.7 Wind Direction Indicator

(1) The information that should comprise a wind direction indicator, vertiports required to provide a wind direction indicator, and its location are specified in the table below.

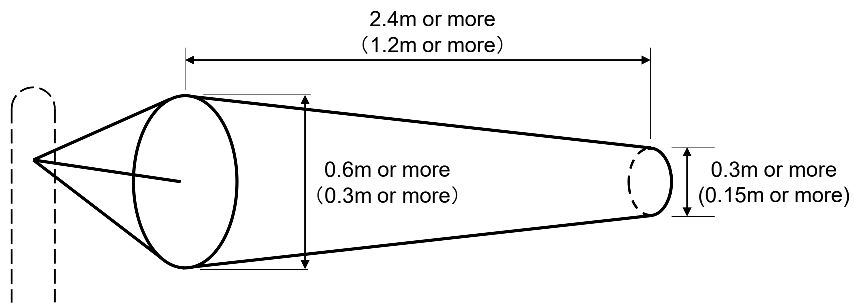
Type of marking	Information to indicate	Vertiports requiring the marking	Location
Wind direction indicator	Wind direction	All vertiports	A location not affected by air movement from nearby buildings or structures, and where it may be easily distinguished by VTOL aircraft

(2) The design of a wind direction indicator should be as specified below.

1 Wind direction indicator

Remarks

i. Wind direction indicators should be as the example below.



(figures in parentheses are for elevated vertiports)

ii. A wind direction indicator should be made of fabric.

iii. The location of the wind direction indicator should be marked by a circular band 5 m in diameter and 0.4 m wide (a circular band at least 2.5 m in diameter and 0.2 m wide for elevated vertiports) centered around the base of the wind direction indicator. If the vertiport is equipped with more than one indicator, at least one of the indicators should be marked.

iv. A wind direction indicator should have a single color or multiple colors selected to ensure contrast against the background.

2.10 Lights

2.10.1 General

Lights and lighting systems as specified in Sections 2.10.2 to 2.10.11 should be installed at vertiports for VTOL aircraft operations at night to ensure the safety of operations.

2.10.2 Vertiport beacon

(Objective)

- A vertiport beacon is lighting provided on or adjacent to the vertiport to indicate the vertiport's location to VTOL aircraft in flight.

(Applicability)

- A vertiport beacon should be provided when identifying the vertiport is difficult due to the surrounding lights.

(Location)

- The vertiport beacon should be located so that it does not interfere with the vision of pilots in the final stages of approach and landing and be placed at an elevated position so as to be visible at all angles above the horizontal.

(Performance Characteristics)

- The vertiport beacon should emit repeated series of equally spaced short-duration white flashes in the format shown in Figure 2.10.1 below. The flash pattern is comprised of three flashes with a duration of 0.5 to 2.0 milliseconds and one flash with a duration of 0.4 seconds emitted within 1.2 seconds, then a rest for 1.2 seconds.

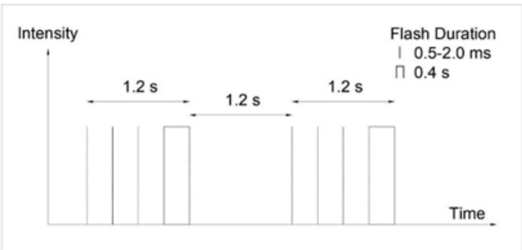


Figure 2.10.1 Vertiport beacon flash characteristics

- The light intensity should be as shown in Figure 2.10.2 below.

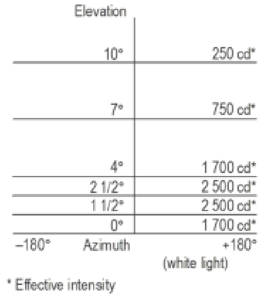


Figure 2.10.2 Vertiport beacon isocandela diagram

2.10.3 Visual Approach Slope Indicator

(Objective)

- A visual approach slope indicator is lighting to provide information to VTOL aircraft on the appropriate approach slope.

(Applicability)

- A visual approach slope indicator should be provided where one or more of the following conditions exist:
  - (i) obstacle clearance, noise abatement or traffic control procedures require a particular slope to be flown;
  - (ii) the environment of the vertiport provides few visual surface cues; and
  - (iii) the characteristics of the vertiport require a stabilized approach.

(Location)

- Visual approach slope indicator systems should be located in the vicinity of the FATO and in positions that will not interfere with VTOL aircraft operations during approach.

(Performance Characteristics)

- Visual approach slope indicator systems include Precision Approach Path Indicator (PAPI), Abbreviated Precision Approach Path Indicator (APAPI) or Helicopter Approach Path Indicator (HAPI).
- Detailed characteristics of PAPI, APAPI, or HAPI are given in the standards for aerodrome lighting as prescribed in the Regulation for Enforcement of the Civil Aeronautics Act.

2.10.4 Taxiway Lights

(Objective)

- Taxiway lights are lighting provided when taxiways are provided on a vertiport.

(Applicability)

- Taxiway lights should be provided when taxiways are provided with the vertiport.

(Location and Performance Characteristics)

- Taxiway lights should be placed in the same manner as an airport taxiway as prescribed in the Regulation for Enforcement of the Civil Aeronautics Act.

2.10.5 Wind Direction Indicator Lights

(Objective)

- Wind direction indicator lights are lighting to indicate wind direction to the VTOL aircraft at night.

(Applicability)

- Wind direction indicator lights should be provided.

(Location and Performance Characteristics)

- Wind direction indicator lights should be equipped at the wind direction indicator so that the wind direction is clearly visible and discernable from a height of at least 200 m at night.

2.10.6 FATO Perimeter Lights

(Objective)

- FATO perimeter lights are lighting to indicate to the VTOL aircraft the shape, location and extent of the FATO.

(Applicability)

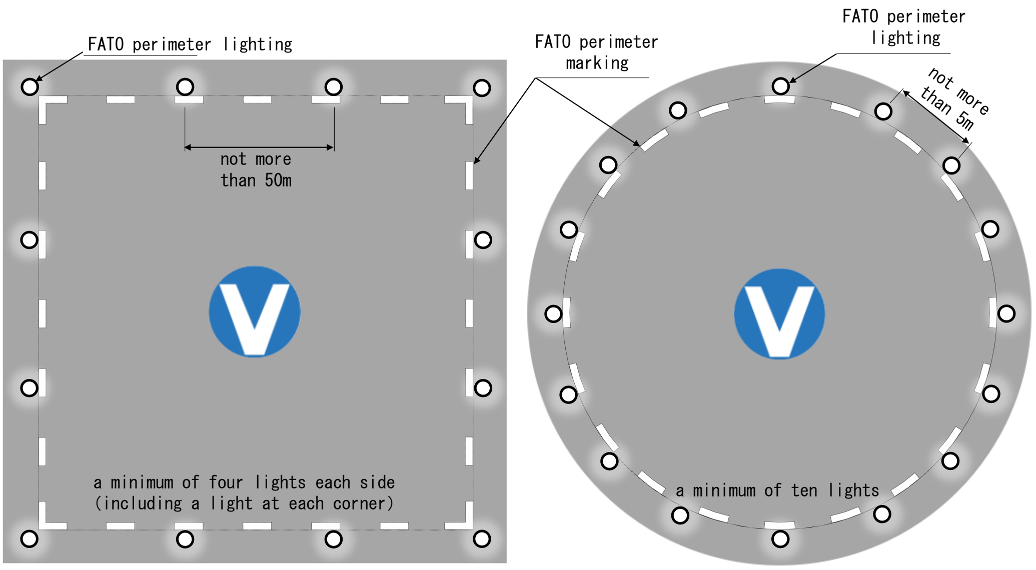
- FATO perimeter lights should be provided unless the FATO and TLOF are nearly the same. (For elevated vertiport, it is only applicable when the FATO is solid.)

(Location)

- FATO perimeter lights should be placed as follows:
  - Where the FATO area is in the form of a square or rectangle, FATO perimeter lights should be placed along the edge of the FATO perimeter marking and uniformly spaced at

intervals of not more than 50 m with a minimum of four lights on each side including a light at each corner.

– Where the FATO area is in the form of a circle, FATO perimeter lights should be placed along the edge of the FATO perimeter marking and uniformly spaced at intervals of not more than 5 m with a minimum of ten lights.



(Performance Characteristics)

- The FATO perimeter lights should be white or green fixed omnidirectional lights. The lights should be visible from all angles up to at least 30 degrees above the horizontal plane including the center of light source.
- The light distribution of FATO perimeter lights should be as shown in Figure 2.10.3 below.

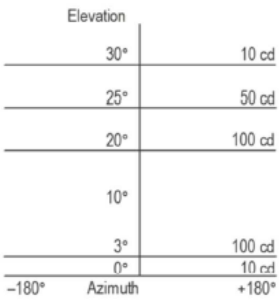


Figure 2.10.3 FATO perimeter light isocandela diagram

- FATO perimeter lights should not exceed a height of 25 cm from the FATO elevation and should be inset when a light extending above the surface would endanger VTOL aircraft operations.

2.10.7 TLOF Perimeter Lights

(Objective)

- A TLOF perimeter lighting system provides VTOL aircraft performing lift-off or touchdown with an indication of the shape, location and extent of the TLOF.

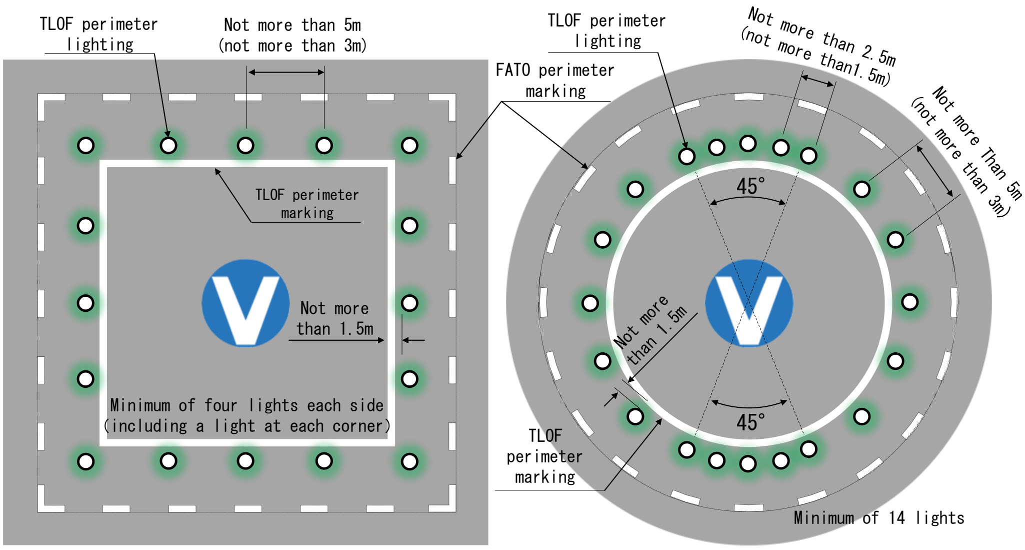
(Applicability)

- Where the TLOF is located within a FATO, TLOF perimeter lights and/or TLOF floodlighting should be provided on a surface level vertiport. On an elevated vertiport both TLOF perimeter lights and TLOF floodlights should be provided.

  Note: Given that several international organizations have shown that TLOF floodlighting will not be a viable option for lighting the TLOF perimeter of a surface level vertiport, TLOF perimeter lights are recommended to be provided rather than TLOF floodlighting on a surface level vertiport.

(Location)

- TLOF perimeter lights should be placed along the edge of the TLOF within 1.5 m from the edge, and uniformly spaced at intervals of not more than 5 m (3 m for elevated vertiports) and as follows according to the shape of the TLOF.
  - Where the TLOF is a square or rectangle, the lights should be installed with a minimum of four lights on each side including a light at each corner;
  - Where the TLOF is a circle, there should be a minimum of fourteen lights evenly spaced around the perimeter of the TLOF, except that over a sector of 45 degrees around the approach direction, the lights should be spaced at half spacing, unless a flight path alignment guidance lighting system is provided to indicate a clear visual indication of the available approach and/or departure path directions.



( )is for elevated Vertiport

(Performance Characteristics)

- TLOF perimeter lights should be green fixed omnidirectional lights. The lights should be visible from all angles and directions above the horizontal plane including the center of light source.
- The light distribution of TLOF perimeter lights should be as shown in Figure 2.10.4 below.

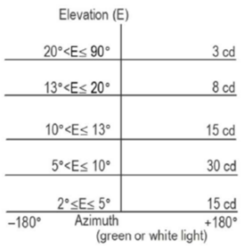


Figure 2.10.4 TLOF perimeter light isocandela diagram

- TLOF perimeter lights located within a FATO should not exceed a height of 5 cm from FATO elevation and should be inset when a light extending above the surface should endanger VTOL aircraft operations.

2.10.8 TLOF Floodlights

(Objective)

- TLOF floodlights are lighting that provides illumination of the TLOF to VTOL aircraft performing lift-off or touchdown to indicate the shape, location and extent of the TLOF.

(Applicability)

- Where the TLOF is located with a FATO, TLOF perimeter lights and/or TLOF floodlighting should be provided on a surface level vertiport. On an elevated vertiport both TLOF perimeter lights and TLOF floodlights should be provided.
  Note: Given that several international organizations have shown that TLOF floodlighting will not be a viable option for lighting the TLOF perimeter of a surface level vertiport, TLOF perimeter lights are recommended to be provided rather than TLOF floodlighting on a surface level vertiport.
- Where the TLOF is located inside in an aircraft stand, TLOF floodlights should be provided, unless the objective may be met by use of ambient lighting or apron floodlighting.

(Location)

- TLOF floodlighting should be located so as not to interfere with VTOL aircraft operations.

(Performance Characteristics)

- The spectral distribution of a TLOF floodlight should be sufficient to provide illumination of the TLOF surface while avoiding glare to VTOL aircraft. The average horizontal illuminance should be at least 10 lux, with a uniformity ratio (average to minimum) of not more than 8:1 measured on the surface of the TLOF.
- When located within the SA, TLOF floodlights should not exceed a height of 25 cm from FATO elevation.

2.10.9 Flight Path Alignment Guidance Lights

(Objective)

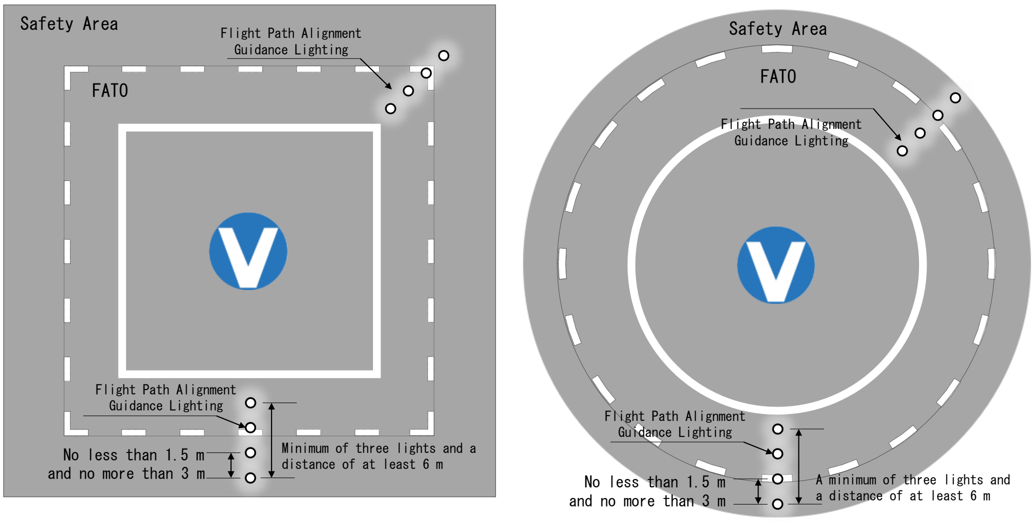
- Flight path alignment guidance lights are lighting to provide VTOL aircraft performing landing or takeoff with a visual indication of the available approach and/or departure path directions.

(Applicability)

- Flight path alignment guidance lights should be installed except in cases where the approach and takeoff climb surfaces are separated by 180 degrees and the approach and/or departure path directions are clearly identifiable by the surrounding terrain, physical marks, or TLOF Perimeter Lights (when circle shape and half spacing over a sector of 45 degrees around the approach direction).

(Location)

- Flight path alignment guidance lights should be in a straight line along the direction(s) of approach and/or departure path on one or more of the TLOF, FATO, SA or any other suitable surface in the immediate vicinity of the FATO, TLOF or SA. A minimum of three lights should be uniformly spaced at intervals of no less than 1.5 m and no more than 3 m over a distance of at least 6 m.



(Performance Characteristics)

- Flight path alignment guidance lights should be white fixed omnidirectional lights. The lights should be visible from all angles and directions higher than the horizontal plane including the center of light source.
- The light distribution should be as shown in Figure 2.10.5 below.

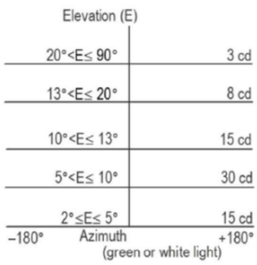


Figure 2.10.5 Flight path alignment guidance lighting system isocandela diagram

- The flight path alignment guidance lights should be inset.

2.10.10 Aiming Point Lights

(Objective)

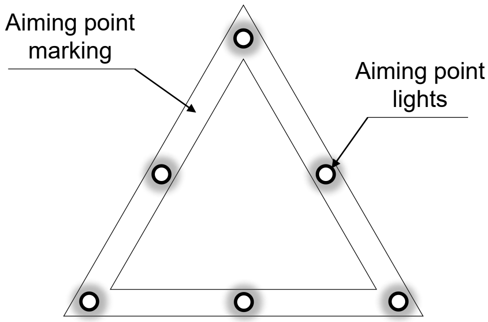
- Aiming point lights are lighting to indicate the aiming point to a hovering VTOL aircraft.

(Applicability)

- Aiming point lights should be provided at vertiports where an aiming point marking is provided.

(Location)

- A minimum of six aiming point lights should be placed along the aiming point marking.



(Performance Characteristics)

- Aiming point lights should be white fixed omnidirectional lights. The lights should be visible from all angles up to at least 30 degrees above the horizontal plane including the center of light source.
- The light distribution should be as shown in Figure 2.10.6 below.

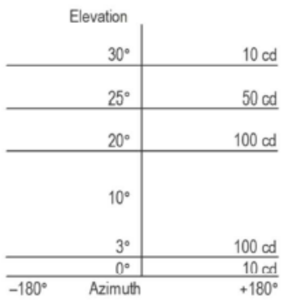


Figure 2.10.6 Aiming point lights light isocandela diagram

- The lights should be inset when a light extending above the surface could endanger VTOL aircraft operations.

2.10.11 Apron Floodlights

(Objective)

- Apron floodlights provide illumination of the apron to indicate the shape, location and extent of the aircraft stand to VTOL aircraft performing parking operations.

(Applicability)

- Apron floodlights should be provided where it is necessary to indicate the shape, location and extent of the aircraft stand to VTOL aircraft performing parking operations.

(Location)

- Apron floodlights should be located to avoid visual hazard to VTOL aircraft pilots, considering placement, mast heights, and number of lights.

(Performance Characteristics)

- The average illuminance within the aircraft stand should be at least 20 lux with a uniformity ratio (average to minimum) of 4 to 1.
- The average illuminance outside of and between aircraft stands should be at least 50% of the average illuminance on the aircraft stands with a uniformity ratio (average to minimum) of 4 to 1.
- Apron floodlights should be arranged and aimed such that an aircraft stand receives light from two or more directions.

2.11 Other facilities

2.11.1 General

Of the vertiport facilities required because of their function, such facilities as drainage, fencing, roads, and car parking (hereafter referred to as "other facilities") should be provided with due consideration to the anticipated natural environment and use conditions of the vertiport, as well as safety.

[Comments]

(1) Other facilities include facilities necessary for ensuring maintenance and management of the vertiport and convenience of users. They need to be planned and designed with due consideration of the safety, economic efficiency, potential of future development, and environmental concerns in light of the vertiport's use conditions.

(2) Points to note in planning and designing other facilities should be pursuant to the "Design Manual for Airport Civil Works."

2.11.2 Drainage

Drainage facilities should have sufficient strength to withstand the load of the VTOL aircraft and servicing ground vehicles intended for use on the vertiport facilities.

[Comments]

(1) Where drainage facilities are provided on the ground surface, the design load of the vertiport should be used as the design load of the drainage facilities. If the cross-sectional shape of the drainage facility does not meet the specified gradient of the vertiport facility being installed, it should have a covered structure.

(2) For drainage facilities installed underground, the design load should be set taking into account the load distribution within the ground. Refer to the "Design Manual for Airport Civil Works - Facility Design" for methods to calculate the underground stress with the effect of load distribution taken into consideration.

2.11.3 Vertiport fencing

(1) Fences of sufficient configuration, size, and structure should be provided to prevent unauthorized people and vehicles from entering restricted areas in the vertiport.

(2) Fences should have sufficient strength to bear wind, snow, downwash and other loads.

[Comments]

(1) Vertiport fencing can be categorized into two types: intrusion prevention fences to prevent unauthorized people and vehicles from entering restricted areas; and border fences to clarify the borders of the site managed by the vertiport.

(2) Vertiport fences should have gates necessary for the management of the vertiport. Factors such as the terrain, geological conditions, obstacle limitation surface, and ease of maintenance and management should be considered when designing vertiport fencing.

(3) Vertiport fencing, in principle, should be located where it will not interfere with obstacle limitation surfaces. If the height of the fencing violates the obstacle limitation surfaces, other measures with comparable effect to prevent intrusion should be provided.

(4) Intrusion prevention fences should generally be 1.8 m in height and topped with 0.45 m spikes to prevent intrusion. Fencing that are provided just to demarcate the site borders does not necessarily have to comply with the guidelines and structural specifications of intrusion prevention fences.

(5) In elevated vertiports and similar cases where it is evident that intrusion is extremely difficult, it may not always be necessary to install fencing.

Chapter 3 Vertiport obstacle limitation surface

3.1 General

(1) In order to safeguard a VTOL aircraft during its approach and in its climb after takeoff, surfaces where obstacles are managed ("obstacle limitation surfaces") are established around the vertiport.

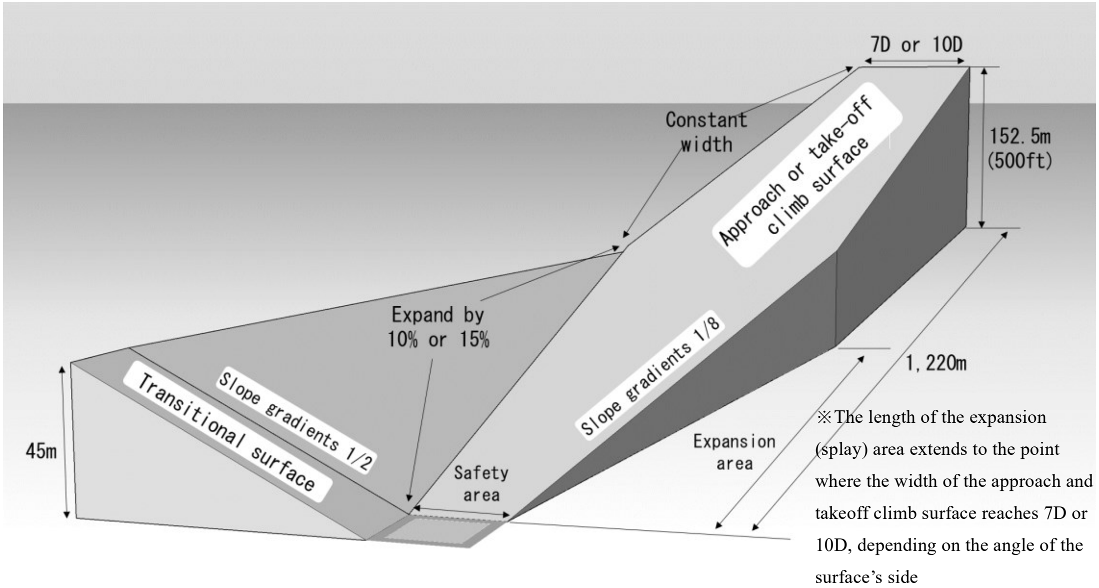
(2) Selection of vertiport sites should take into consideration future urban planning of the surrounding area and current situation of high-rise structures that may possibly interfere with obstacle limitation surfaces.

[Comments]

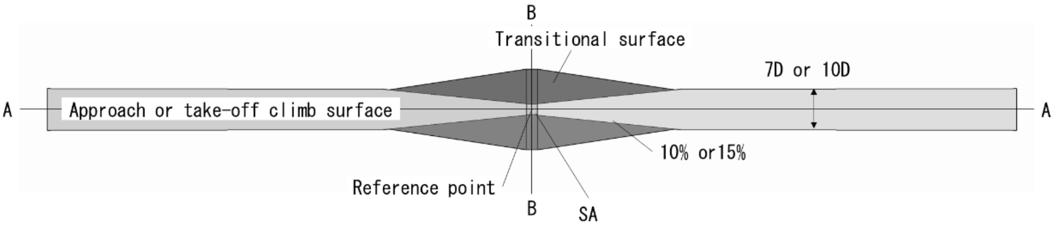
(1) The dimensions and slopes of the obstacle limitation surfaces are shown in Table 3.1.1 below.

Table 3.1.1 Dimensions and Slopes of the Obstacle Limitation Surfaces

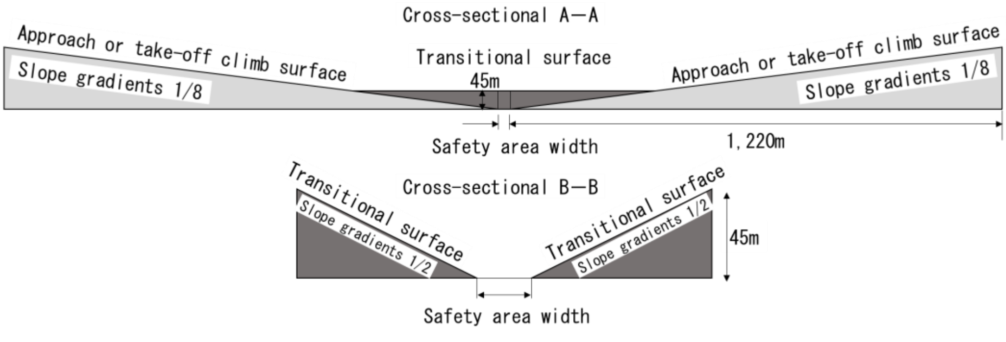
Operating conditions	Approach and takeoff climb surfaces						Transitional Surface	
	Length of projected plane	Width of inner base	Max. width	Splay angle of the width against center line of approach/takeoff climb surface	Horizontal slope gradient	Height of the edge	Horizontal slope gradient	Height from FATO elevation
Daytime only	1,220m	Same width as SA	7D Value	10%	1/8	152.5m	1/2	45m
Including nighttime			10D Value	15%				



(a) Isometric view of approach or takeoff climb surface and transitional surface



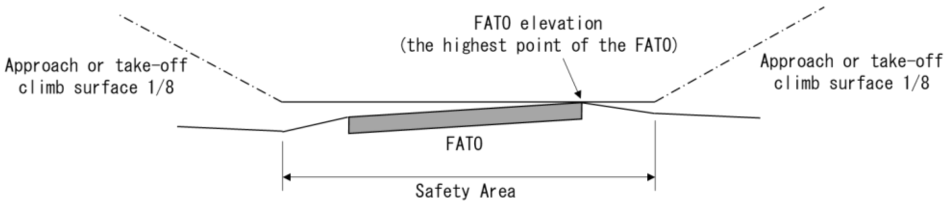
(b) Plan view of approach or takeoff climb surface and transitional surface



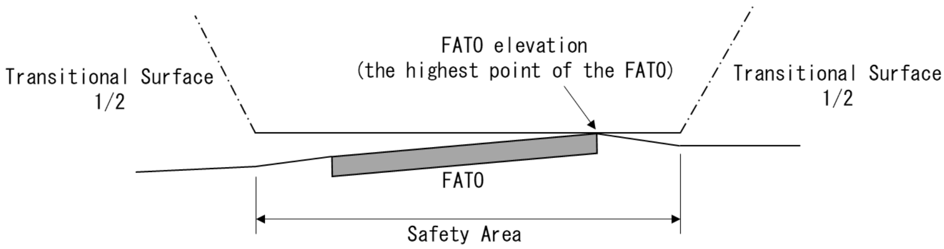
(c) Cross-sectional view of approach or takeoff climb surface and transitional surface

Figure 3.1.1 Descriptive figure of obstacle limitation surfaces

(2) The lower limit of the height of an approach surface, takeoff climb surface, or transitional surface is determined by extending the horizontal plane of the FATO elevation (the highest point of the FATO) to the edge of the SA as illustrated in Figure 3.1.2



(a) Longitudinal direction



(b) Latitudinal direction

Figure 3.1.2 Illustration of the minimum heights of approach surface, takeoff climb surface and transitional surface

(3) Where the FATO is a circle, the inner edge of the approach or takeoff climb surface should be the external tangent of the SA circle that is perpendicular to the approach or departure direction and of the same length as the SA diameter, as shown in Figure 3.1.3. Likewise, the two external tangents of the SA circle that are parallel to the approach or departure direction should be the inner edges of the transitional surfaces. The area surrounded by the SA and these obstacle limitation surfaces should have the same performance as the SA.

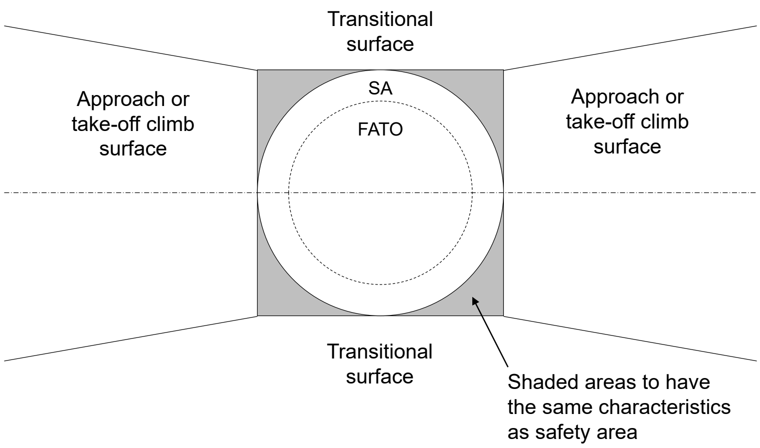


Figure 3.1.3 Illustration of obstacle limitation surfaces for a circle shaped FATO

3.2 Approach or Takeoff Climb Surfaces

The approach/takeoff climb surfaces ensure the safety of a VTOL aircraft during its straight flight in the final approach and immediately after takeoff by defining the area for limiting obstacles.

[Comments]

(1) The surface ends where the surface slope reaches 152.5 m (500 ft) above FATO elevation.

(2) The length of the projected plane of an approach or takeoff climb surface should be in principle 1,220 m. This length, however, can be reduced in consideration of such factors as the ascent and turning performance of the VTOL aircraft and safety distance from objects that may become obstacles.

(3) An area for splay, or expansion of the width of approach or takeoff climb surfaces should be provided and the outer width of the expansion area should remain fixed.

(i) Where operation of VTOL aircraft is limited to daytime, the width of the approach or takeoff climb surface should expand at a rate of 10% starting from the inner edge along the center line of the surface until the width reaches 7 D.

(ii) Where night operation of VTOL aircraft is intended, the width of the approach or takeoff climb surface should expand at a rate of 15% starting from the inner edge along the center line of the surface until the width reaches 10 D.

(4) As a general rule, the approach surface and takeoff climb surface should preferably be aligned along the same horizontal axis (i.e., separated by 180 degrees). However, where the approach surface and takeoff climb surfaces cannot be aligned, the surfaces should be separated by at least 135 degrees. The separation may be decreased or the number of take-off and climb and approach surfaces reduced to one, if the safety assessment determines that it would not adversely affect the safety or significantly affect the regularity of operations of VTOL-capable aircraft at vertiport.

(5) When setting an approach or takeoff climb surface with a curved portion, the sum of the radius of the arc defining the center line of the surface and the length of the straight portion originating at the inner edge should not be less than 575 m as shown in Figure 3.2.1 below. The curve radius should not be less than 270m. Where there are more than one curved portion in an approach or takeoff climb surface, the curved portions should be separated by a straight portion of at least 150 m.

$S + R \geq 575\ \mathrm{m}$ and $R \geq 270\ \mathrm{m}$

Where S is the length of the straight portion (m) and R is the radius of turn (m)

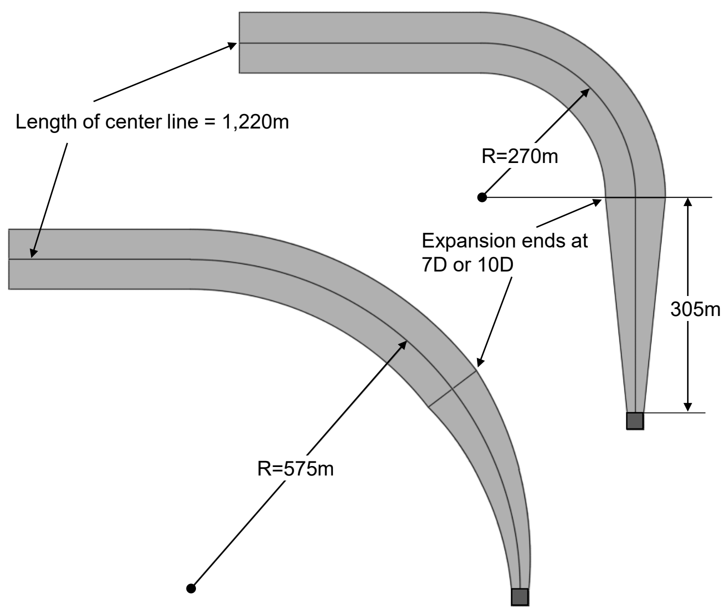
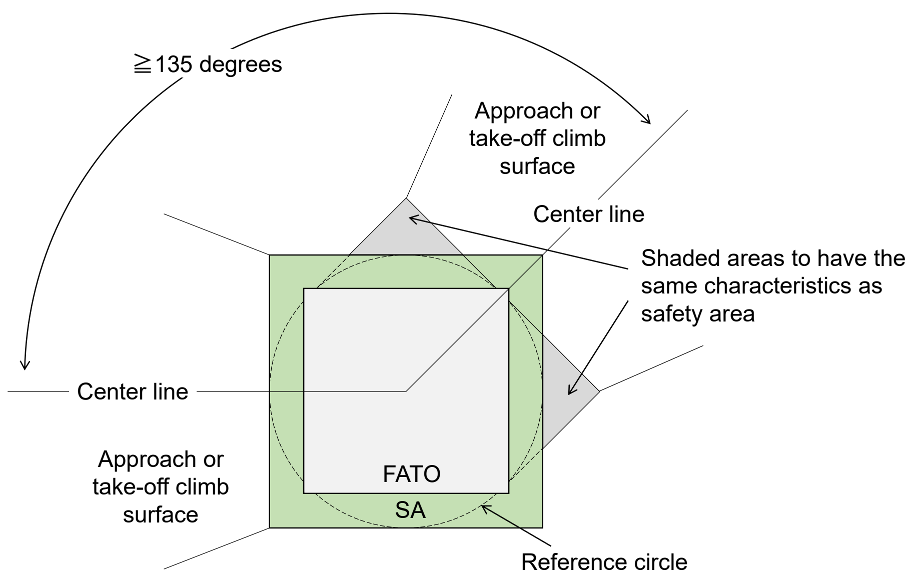
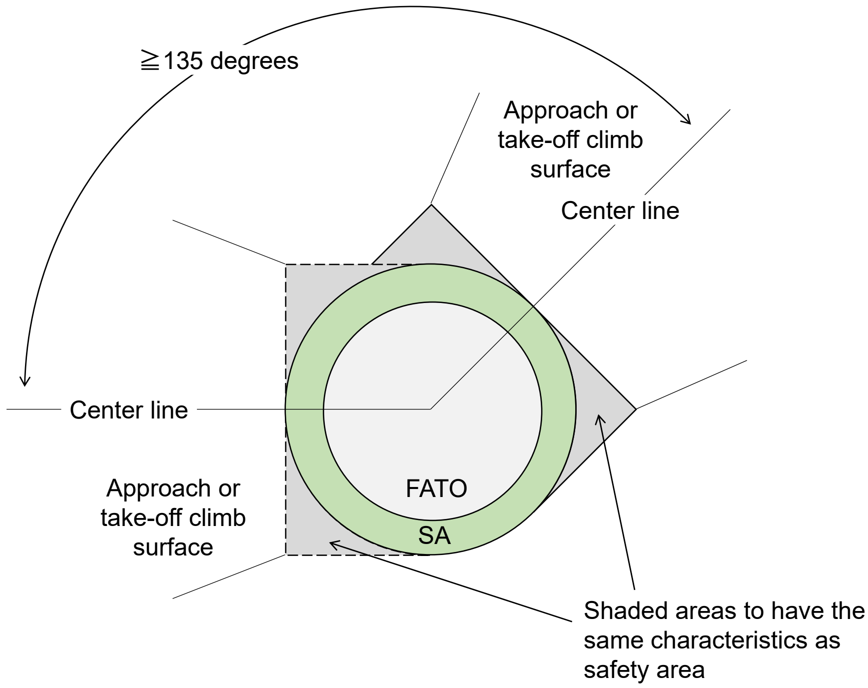


Figure 3.2.1 Example of an approach or takeoff climb surface with a curved portion

(6) Where the approach and takeoff climb surfaces are separated by an angle of 135 to 180 degrees, the area formed between the inner edge and SA by the turn of the inner edge of the surface (Figure 3.2.2) should have the same performance as the SA.



(a) In case of a rectangular SA



(b) In case of circular SA

Figure 3.2.2 Illustration of approach direction crossing angles

(7) When applying special exceptions to the guidelines on the design of approach or takeoff climb surfaces, it should be noted that if the surface design is based on the aircraft with the lowest performance among all the aircraft intended to operate on the vertiport, aircraft with lower performance than that aircraft will not be able to operate on the vertiport thereafter.

3.3 Transitional Surface

Transitional surfaces ensure the safety of a VTOL aircraft on a go-around route by defining the area for limiting obstacles.

[Comments]

(1) A transitional surface should be provided at VFR vertiports for the safety of VTOL-capable aircraft when vertical procedures with lateral transit are planned.

(2) The slope gradient of transitional surfaces should be 1/2 as a general rule.

(3) The height of transitional surfaces should be from the FATO elevation to 45 m above the FATO elevation.

Chapter 4 Other

4.1 Evaluation of Downwash Effects

> Vertiport facilities should be arranged so that the downwash generated by VTOL aircraft during approach/departure or hovering will not adversely affect people and vehicles within and outside the vertiport.

[Comments]

(1) Where the effect of downwash on the surrounding area is of concern, measures should be taken to mitigate the effects, such as expanding the SA or installing a blast fence.

(2) The downwash of a VTOL aircraft is evaluated based on the downwash velocity measured when the aircraft is hovering at a height of 1 meter above ground under windless conditions.

(3) The effects of downwash should be evaluated to confirm that there will be no adverse impact on passengers and personnel within the vertiport, people and vehicles in public areas adjacent to the vertiport, and equipment, etc. to be installed on the apron.

(4) Note that, in the case of elevated vertiports, downwash may have an effect on a wide stretch of area below the vertiport.

4.2 Safety Devices

> Safety devices should be provided at elevated vertiports to prevent VTOL aircraft and people from falling off the vertiport.

[Comments]

(1) Safety devices should be provided on the edges of an elevated vertiport and where deemed necessary.

(2) When using safety nets, the net width should be at least 1.5 m.

4.3 Rescue and Firefighting Systems

4.3.1 General

Vertiport operators should be prepared to cope with aircraft accidents that may take place at the vertiport or in its vicinity. Systems should be developed to ensure rapid and appropriate execution of rescue and firefighting operations, including deployment of rescue and firefighting equipment and training of vertiport firefighting staff.

4.3.2 Vertiport Category

Vertiport operators should select an applicable category from Table 4.3.1 below, based on the fuselage length or width of the largest VTOL aircraft the vertiport is intended to serve.

Table 4.3.1 Vertiport Category

Vertiport Category	Length or width of the VTOL aircraft
V1	Less than 15m
V2	15m or more but less than 24m
V3	24m or more but less than 35m

4.3.3 Fire-extinguishing agents

Vertiports should be equipped with both primary and complementary extinguishing agents.

(1) Types of primary extinguishing agents

Foam extinguishing agents used in aircraft fires are designed to mix with air and form a film around the surface of the fuel. In principle, vertiports should be equipped with aqueous film-forming foam agents for firefighting purposes.

Simultaneous use of extinguishing foams from aqueous film-forming foam agents together with foams generated from protein-based and fluoroprotein foaming agents when fighting a fire is not a problem, but never mix different types of extinguishing agents.

(2) Complementary extinguishing agents

Powder agents should be used as complementary extinguishing agents. When using an alternate agent, select one with equivalent extinguishing performance.

If using carbon dioxide, it should be in compliance with the various requirements of ISO-5923.

(3) When both primary and complementary extinguishing agents are to be used simultaneously, care must be taken to ensure the compatibility of the agents.

(4) Surface vertiports should be equipped with firefighting equipment and/or vehicles, etc. with the minimum usable amounts of extinguishing agents as set out in Table 4.3.2 below.

Where firefighting vehicles are to be provided, refer to the minimum performance recommended for firefighting vehicles as set out in Table 4.3.3 below.

Table 4.3.2 Minimum amount of water for foam production, discharge rate, and complementary extinguishing agent to be provided at surface vertiports

Vertiport category	Primary extinguishing agent (Aqueous film-forming foam agent)		Complementary extinguishing agent (Powder agent)
	Water volume for foam production	Discharge rate (foam solution volume per min)	
V1	500ℓ	250ℓ／min	23kg
V2	1,000ℓ	500ℓ／min	45kg
V3	1,600ℓ	800ℓ／min	90kg

Table 4.3.3 Minimum performance recommended for firefighting vehicles

Items	Firefighting vehicle with	Firefighting vehicle with

	<4,500ℓ capacity	>4,500ℓ capacity
Main turret (vehicle water cannon)	V1and V2 are optional; V3 required	Required
Turret discharge	High discharge power	Both high & low discharge power
Turret discharge distance	Covers the longest aircraft dimension	Covers the longest aircraft dimension
Hand line	Required	Required
Undertrack nozzle	Optional	Required
Bumper turret	Optional	Optional
Acceleration performance	Ability to accelerate from 0 to 80km/h within 40 seconds	Ability to accelerate from 0 to 80km/h within 40 seconds
Maximum speed	100km/h or more	100km/h or more
Drive system	All-wheel drive preferred	All-wheel drive
Gear shift system	Automatic preferred	Automatic
Rear wheel system	Single wheel preferred for V1-3	Single wheel
Approach angle	30 degrees or more preferred for V1 to 3	30 degrees or more
Departure angle	30 degrees or more preferred for V1 to 3	30 degrees or more
Maximum stable tilt angle (At rest)	28 degrees or more preferred	28 degrees or more
Indication of compliance with Article 21-16-3 of the Fire Service Act "Technical standards for appliances subject to voluntary labeling"	Required	Required

(5) Elevated vertiports should be equipped with firefighting equipment, etc. with the minimum usable amounts of extinguishing agents as set out in Table 4.3.4 below.

Table 4.3.4 Minimum amount of water for foam production, discharge rate, and complementary extinguishing agent to be equipped at elevated vertiports

Vertiport category	Primary extinguishing agent (Aqueous film-forming foam agent)		Complementary extinguishing agent (Powder agent)
	Water volume for foam	Discharge rate (foam solution per min)	

	production		
V1	2,500ℓ	250ℓ／min	45kg
V2	5,000ℓ	500ℓ／min	45kg
V3	8,600ℓ	800ℓ／min	45kg

4.3.4 Special Firefighting Equipment Related to Elevated Vertiports

Elevated vertiports should be equipped with at least one hose line capable of delivering the primary extinguishing agent as a solid stream or in dispersed form at a minimum rate of 250 liters/minute.

Operators of elevated vertiports falling under categories V2 or V3 should seek to install at least two monitoring systems to ensure that primary media can be directed to all areas of the vertiport under all weather conditions.

4.3.5 Rescue and Firefighting Equipment

Vertiports should be equipped with rescue and firefighting equipment as set out in Table 4.3.5 below.

Table 4.3.5 Rescue and firefighting equipment list

Rescue equipment	Quantity
Rescue ax	One
Burr (900mm or more)	One
Bolt clipper	One
Cable cutter	One
Flashlight	Two
Ladder (suitable for eVTOL aircraft served)	One
Rescue rope (approximately 15m, φ9-13mm)	One
Air saw or metal saw (hacksaw) (including spare blades)	One
Seatbelt/harness cutting tool	One
Toolbox (screwdriver, hammer, pliers, spanners, etc.)	One
Fireproof clothing (normal) (recommended)	One set for each firefighter

4.3.6 Response Time

Surface vertiport and elevated vertiport operators should make efforts to enable rapid delivery of rescue and firefighting services.

4.3.7 Points to Note in Fighting VTOL Aircraft Fires

(1) Fires involving lithium-ion batteries require rapid cooling to prevent thermal runaway. When the battery catches on fire, quickly respond to contain the fire, and once the flame has subsided the battery needs to be kept cooled by applying water spray or foam. (If the battery is contained in a battery housing case, do not attempt to remove the battery from the case.) Spraying is used in the cooling procedure because the electric resistivity of the water used can be increased by spraying in the form of a fine mist to reduce the risk of electric shock.

(2) Be careful to prevent electric shock when approaching fire-affected aircraft to rescue passengers and crew.

(3) When spraying water or foam as a means of fire prevention, take note not to delay or impede the evacuation of passengers and crew.

4.3.8 Cooperation with Related Agencies

(1) Vertiport operators should build systems for close cooperation with related firefighting agencies to facilitate execution of rescue and firefighting operations.

(2) In case of emergencies, vertiport operators should secure cooperation in rescue and firefighting operations from related business operators with an office within the vertiport.

4.4 Vertiport Location

As a general rule, vertiports should be located in areas where sufficient space can be secured for a VTOL aircraft to land without causing harm to people and/or property on the ground or on the water if the power unit stops while the aircraft is flying a departure route, an approach route, or routes around the vertiport.

[Comments]

(1) There may be cases where such landing space will not be required depending on the performance of the VTOL aircraft or for other reasons.