

# INTERNATIONAL CIVIL AVIATION ORGANIZATION



## ASIA PACIFIC REGIONAL GUIDANCE ON STRENGTH ASSESSMENT AND CLASSIFICATION OF UNPAVED AND GRASSED RUNWAYS

VERSION 1.0 – AUGUST 2026

This guidance material was developed by the Asia Pacific Aerodrome Design and Operation Working Group (AP-ADO/WG).

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ICAO Standards and Recommended Practices (SARPs), Procedures for Air Navigation Services and Manuals shall take prevalence in the event of any conflict between the aforementioned provisions and this guidance material.

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## RECORD OF AMENDMENTS

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## **1. FOREWORD**

### **1.1 Introduction**

- 1.1.1 At the Seventh Meeting of Aerodrome Operations and Planning Sub-group (AOP/SG/7) held in Bangkok on 3 – 6 July 2023 New Zealand presented a paper regarding the strength assessment guidance for unpaved runways in New Zealand and the challenges of promulgating a strength classification for a grass runway. The paper highlighted a lack of ICAO guidance on strength assessment for unpaved runways and invited the meeting to consider the need for the establishment of recommended practices regarding unpaved runways. AOP/SG/7 agreed to assign this special task to the Asia Pacific Aerodrome Design and Operation Task Force (AP-ADO/TF).
- 1.1.2 The Fifth Meeting of the Asia Pacific Aerodrome Design and Operation Task Force (AP-ADO/TF/5) recognised the importance of assessment and classifying the strength of unpaved and grassed runway surfaces. AP-ADO/TF/5 endorsed the decision to form a Small Working Group (SWG) comprised of Australia, Nepal and Papua New Guinea to develop a *Guidance on Strength Assessment and Classification of Unpaved and Grassed Runway* for use as a reference document in Asia Pacific Region.
- 1.1.3 This guidance was developed using information derived from ICAO Annex 14 Volume I – Aerodrome Design and Operations, Aerodrome Design Manual (Doc 9157) Part 3 — Pavements, CASA Australia AC139.C-07 Strength Rating of Aerodrome Pavements.
- 1.1.4 This guidance should be read in conjunction with Chapter 3 of Annex 14, Volume I. It is expected that these requirements should be complied with for unpaved surfaces wherever practicable.

### **1.2 Background**

- 1.2.1 Some elements of the movement area at an aerodrome may not be paved but must still be capable of supporting aircraft operations. The natural ground in these instances may not have sufficient bearing strength to handle the aircraft, and therefore a strength assessment of this surface may be necessary. Adequate strength is required in order to ensure that no structural damage is sustained by an aircraft using or otherwise veering off onto the unpaved surface. The unpaved surface must also be capable of supporting any ground vehicles that may occasionally operate on the area.

- 1.2.2        The guidance provided in this section is geared toward the physical attributes most commonly left unpaved at an aerodrome. Specifically, these are runway and taxiway shoulders, Runway End Safety Area (RESA) and runway strips outside the runway shoulder area.
- 1.2.3        For any unpaved surface, the ingestion or jet blast of foreign object debris by aircraft turbine engines is an important consideration. The protection of the surface to ensure no loose material is allowed is the responsibility of the aerodrome. Some type of chemical treatment or the use of turf may be required for the unpaved surface, along with visual inspections, to ensure that foreign object debris is not present.
- 1.2.4        Any bearing strength-related guidance provided in this document should not be interpreted as a prescriptive design requirement. Such guidance is provided to support the judgment of the assessing personnel when no specific data is available.
- 1.3        Purpose and Scope**
- 1.3.1        This document provides guidance on the strength assessment and classification of unpaved and grassed runways intended for light aircraft of mass equal to or less than 5 700 kg.

## 2. DEFINITIONS, ACRONYMS AND ABBREVIATIONS

### 2.1 Definitions

When the following terms are used in this document they have the following definitions:

***Aircraft Classification Rating (ACR).*** A number expressing the relative effect of an aircraft on a pavement for a specified standard subgrade category.

***California Bearing Ratio (CBR).*** The bearing ratio of soil determined by comparing the penetration load of the soil to that of a standard material. The method covers evaluation of the relative quality of subgrade soils but is applicable to sub-base and some base course materials.

***Natural Surface.*** Undisturbed ground surface before excavation or construction.

***Pavement Classification Rating (PCR).*** A number expressing the bearing strength of a pavement.

***Runway.*** A defined rectangular area on a land aerodrome prepared for the landing and take-off of aircraft.

***Subgrade.*** The upper part of the soil, natural or constructed, which supports the loads transmitted by the pavement, also referred as the formation foundation.

***Unpaved Surface.*** A surface, intended for aircraft operations, composed of unbound or natural materials. Unpaved surfaces may include gravel, coral, sand, clay, hard packed soil mixtures, grass, turf or sod.

***Unprepared Surface.*** Any naturally occurring surface used as a runway that has not been altered by man.

***Using Aircraft.*** An unpaved surface satisfactorily supporting aircraft using it, can accept other aircraft if they are no more demanding than the using aircraft.

## **2.2                    Acronyms and Abbreviations**

When the following Acronyms and Abbreviations are used in this document, they have the following meanings:

|                      |                                      |
|----------------------|--------------------------------------|
| <b><i>ACR:</i></b>   | Aircraft Classification Rating       |
| <b><i>AFM:</i></b>   | Aircraft Flight Manual               |
| <b><i>AIP:</i></b>   | Aeronautical Information Publication |
| <b><i>CBR:</i></b>   | California Bearing Ratio             |
| <b><i>NOTAM:</i></b> | Notice to Airmen                     |
| <b><i>PCR:</i></b>   | Pavement Classification Rating       |
| <b><i>POH:</i></b>   | Pilots Operating Handbook            |
| <b><i>RESA:</i></b>  | Runway End Safety Area               |
| <b><i>RTF:</i></b>   | Radiotelephony                       |

### 3. CLASSIFICATION OF RUNWAY SURFACE TYPE

3.1.1 The description of the type of runway surface is required to be reported for use by pilots to correct the effective operational length.

3.1.2 The following is a list of the standard terminology for use in describing an unpaved runway surface. Only one term should be used when reporting the description of an unpaved runway surface:

*Table 3.1 – Types of Runway Surfaces*

| Surfaces                | Abbreviation | Note                                                         |
|-------------------------|--------------|--------------------------------------------------------------|
| Coral                   | CR           |                                                              |
| Firm Grass              | GR(f)        |                                                              |
| Grass                   | Gr/GRASS     |                                                              |
| Gravel                  | GRVL         |                                                              |
| Gravel (stabilised)     | GRVL(st)     |                                                              |
| Primed gravel           | PRIME        | Bitumen, oil or tar bound pavements with no stone cover.     |
| Natural Ground Surface  | NS           | undisturbed ground surface before excavation or construction |
| Sand                    | SA           |                                                              |
| Soft Grass              | GR(s)        |                                                              |
| Snow and compacted snow | SN           |                                                              |



*Figure 3.1 – Grass*



*Figure 3.2 – Firm grass*

#### **4. ASSESSMENT OF BEARING CAPABILITY OF UNPAVED AND GRASSED RUNWAY**

##### **4.1 Strength of runways**

4.1.1 Annex 14 Volume I, paragraph 3.1.21 recommends that the runway should be capable of withstanding the traffic of aeroplanes the runway is intended to serve.

4.1.2 The following subsections provide three methods which may be applied to an unpaved runway surface. It is up to the responsible Civil Aviation Authority or aerodrome operator to determine which method, or an alternative means, is most suitable for the intended operation.

##### **4.2 Using aircraft experience (intended aircraft)**

4.2.1 This method relies upon the operational experience of aircraft utilizing an existing runway surface.



*Figure 4.1 – Using aircraft experience relies on aircraft utilizing the runway*

4.2.2 This method is very simple to use however the limitations below need to be understood first before it is applied.

- 4.2.3 This method is not recommended for aircraft with an apron (ramp) mass greater than 5 700 kg. In these cases, a technical evaluation should be used to more accurately define the bearing strength properties of the surface. Refer to subsection 4.4.
- 4.2.4 This method also relies upon previous experience which may not be reflective of future performance. For example, an existing aircraft type may have successfully used an unpaved surface however its strength may have been compromised through repeated use. Environmental conditions, the absorption of water, temperature variability, soil reactivity and other factors such as any depression, distress and undulation of the surface could make a previously suitable surface no longer serviceable for the intended operation.
- 4.2.5 Aircraft factors, including its mass, tyre pressure, braking application and take-off/landing speeds can also impact upon the performance of the unpaved runway surface and need to be considered.
- 4.2.6 To mitigate against this potential hazard, regular inspections of the surface should be undertaken. Refer to subsection 5.1.
- 4.2.7 To use this method:
- 4.2.7.1 **Step 1:** Select the intended aircraft type based upon the desired or expected use of the existing unpaved runway surface.
- 4.2.7.2 **Step 2:** Obtain the maximum take-off mass and tyre pressure(s) for the selected aircraft. This information can generally be located from the Pilots Operating Handbook (POH), the Aircraft Flight Manual (AFM) or officially published technical data from the aircraft manufacturer.
- 4.2.7.3 **Step 3:** Publish these technical parameters for the unpaved runway surface in Aeronautical Information Publication (AIP) or another suitable document.
- 4.2.7.4 This method can also be used in conjunction with the vehicle-based method, or other evaluative or empirical methods.

#### **4.3 Vehicle-based method**

- 4.3.1 An aircraft can land anywhere between the provided runway or runway strip surface markers (if provided), not necessarily along the centreline. If the aircraft encounters a surface soft spot at high speed, it may lose directional control or a wheel assembly may be torn off, resulting a roll or nose over. The vehicle-based assessment method for indicating the bearing capability of a runway surface involves the simulation of impact an aircraft may cause to the runway surface by using a test vehicle of correlating weight as shown in the table below.

Table 4.1 – Aircraft / Vehicle Weight Correlation

| Type of aircraft                                                                                                                                                                          | Test vehicle                                                                                                                            |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|
| Light single or twin aircraft (i.e., Beechcraft 36, Piper 28, or Cessna 172, 182, 206, 210, etc.                                                                                          | Light laden 3 tonne truck with repetitive passes in wet areas                                                                           |
| Medium single or twin such as Aero Commander, Beechcraft Baron, Kingair, De Havilland Canada DHC-6 Twin Otter, Dornier 228, L 410, Cessna Caravan 208, 421, Daher Kodiak 100 or 900, etc. | Fully laden 3 tonne truck with repetitive passes in wet and moist areas associated with your experience of aircraft using the aerodrome |
| Heavier aircraft such as F27, Caribou, DC3 etc.                                                                                                                                           | Fully laden 5 tonne truck with repetitive passes in wet and moist areas                                                                 |

- 4.3.2 A test vehicle as indicated should be driven in a zigzag pattern at a speed not exceeding 15 km/hr for the full length and width of the runway. Particular attention should be paid to suspect areas with possibly three passes of the test vehicle over these areas.



Figure 4.2 – Uneven runway surface

- 4.3.3 If tyre imprints exceed a depth of 25 mm, the surface is not suitable for aircraft operations particular to the test vehicle. Unnecessary disruption of the surface is to be avoided because such impacts such as tyre imprints are hard to remove when the surface has dried out. In some instances, the surface may be unsafe with a lesser imprint, and this is at the discretion of the assessing personnel.
- 4.3.4 Remember, that the above test may leave wheel ruts, which will need to be filled in later before the runway can be reopened for aircraft movement.



*Figure 4.3 – Unserviceable runway due to hardened tyre imprints*

- 4.3.5 Because the 5 700 kg limit for light aircraft represents pavement loads only two-thirds or less of common highway loads, the assessment of traffic using pavements should extend to consideration of heavy ground vehicles, such as fuel trucks, fire trucks, snow ploughs, service vehicles, etc. These must also be controlled in relation to load limited pavements (*Doc 9157 Aerodrome Design Part 3 – Pavements, Third Edition 2022, clause 3.5.12*).
- 4.3.6 To test for slippery condition, any 4-wheel drive vehicle may be used, but it is necessary to use the same or similar vehicle throughout the test. During dry conditions the vehicle is driven over the runway at 50 km/hr and the brakes applied to lock all four wheels. The length of skid is measured and recorded. During wet conditions the operation is repeated and the length of skid measured. If this dimension exceeds 1.5 times the recorded dry skid distance the surface is considered to be unacceptably slippery.

4.3.7 The test for rough surface condition is to drive a stiffly sprung vehicle such as a Land Rover, without discomfort to the passengers, at a speed not less than 75 km/hr for the central 30 m, and not less than 50 km/hr for the remainder of the runway strip.

4.3.8 The maximum allowable width of cracks and size of stones permitted is 25 mm within the central 30 m and 50 mm for the remainder. If there is a soft wet condition within the runway strip area, the entire direction must be closed if it is unacceptably rough.

#### 4.4 Empirical method

##### Paved surfaces

4.4.1 The bearing strength of a pavement intended for aircraft of apron (ramp) mass equal to or less than 5 700 kg shall be made available by reporting the following information (*Annex 14, Volume I, 2.6.8*):

- a) maximum allowable aircraft mass; and
- b) maximum allowable tire pressure.

Example: 4 000 kg/0.50 MPa

4.4.2 Light aircraft are those having a mass of 5 700 kg or less. These aircraft have pavement requirements less than that of many highway trucks. Technical evaluations of those pavements can be made but an evaluation based on “using aircraft” is satisfactory. It is worth noting that, at some airports, service vehicles such as fire trucks, fuel trucks or snow ploughs may be more critical than aircraft. Since nearly all light aircraft have single-wheel undercarriage legs, there is no need for reporting subgrade categories. However, since some helicopters and military trainer aircraft within this mass range have quite high tire pressures, limited quality pavements may need to have tire pressure limits established (*Doc 9157 Aerodrome Design Part 3 – Pavements, Third Edition 2022, clause 3.3.6*).

4.4.3 In evaluating pavements meant for light aircraft — 5 700 kg mass and less — it is unnecessary to consider the geometry of the undercarriage of aircraft or how the aircraft load is distributed among the wheels. Thus, subgrade class and pavement type need not be reported, and only the maximum allowable aircraft mass and maximum allowable tire pressure need to be determined and reported. For these, the foregoing guidance on techniques for “using aircraft” evaluation should be followed (*Doc 9157 Aerodrome Design Part 3 – Pavements, Third Edition 2022, clause 3.5.11*).

##### Unpaved surfaces

4.4.4 Due to the nature of unpaved surfaces, an empirical method for assessing the bearing capability has inherent limitations. An unpaved or natural surface may not have a consistent bearing capability across the entire surface; therefore, consideration should be made for developing a process that considers the capability of the surface so far as reasonably practicable. Additionally, prevailing weather conditions may significantly affect the capability of the runway.



*Figure 4.3 – Unserviceable runway due to melting snow*

- 4.4.5 One example of a bearing capability assessment is the use of a Dynamic Cone Penetrometer which can generate a strength estimate of the surface.
- 4.4.6 An aerodrome operator should develop an assessment process that includes sufficient measurements to develop an appreciation of the capability of the entirety of the unpaved runway and the associated surfaces that should be load-bearing.
- 4.4.7 An aerodrome operator should engage with aircraft operators to ensure aircraft operators understand the capability data of the runway, and the conditions in which the measurements were taken. With the assistance of subject-matter experts, aircraft operators should consider the criteria under which the runway has been determined usable for a design aircraft.

## **5. INSPECTION AND REPORTING PROCESS**

### **5.1 Inspections of unpaved surfaces**

5.1.1 Inspections of the movement area should be planned to ensure that an appropriate level of vigilance is maintained at all times.

5.1.2 The inspection of unpaved surfaces should cover, at a minimum, the following items:

- a) the runway;
- b) the remaining manoeuvring area, including taxiways and adjacent areas; and
- c) the apron and service areas as applicable.



*Figure 5.1 – Uncompacted gravel runway with loose stones*

5.1.3 During the inspection, particular attention should be given to:

- a) surface conditions including signs of damage or distress;
- b) detection of FOD or other surface contamination;
- c) detection of surface depressions, rutting or undulation;
- d) detection of areas with a weaker surface strength including mud, sinkholes, standing water, erosion, etc.;

- e) The general condition of the surface grass/vegetation, particularly any areas of blast. Rotor wash or prop wash erosion; and
- f) the grass length including any weed growth.

5.1.4 Ideally, a first inspection should be conducted prior to daily operations. Subsequent inspections should also be undertaken in the event of:

- a) significant precipitation or snow;
- b) high winds;
- c) heavy rain;
- d) extreme or seasonally uncommon weather event; and
- e) abnormal (i.e., heavy) landing.

5.1.5 A log should be kept recording the results of the inspection.

## **5.2 Reporting of unpaved surface condition**

5.2.1 If a dangerous or otherwise hazardous unserviceability is discovered during an inspection it should be immediately reported.

5.2.2 If a NOTAM service is available at the aerodrome, it should be used to advise aircraft operators and other stakeholders of the change to aerodrome condition or capability.

5.2.3 If a radiotelephony (RTF) service is available and the reporter is sufficiently qualified and experienced to use such equipment, the provision of advice via RTF to any arriving or departing aircraft should be considered.

5.2.4 The entity in charge of aerodrome operations should also be informed.

5.2.5 Consideration should also be given to updating any published information, such as in AIP or other operational documents.

## **6. RISK MITIGATION**

6.1.1 If there is any doubt as to the serviceability of an unpaved runway surface, appropriate mitigation options should be immediately considered to protect aircraft operations.

6.1.2 This may include but not be limited to the following:

- a) The affected runway, taxiway and/or apron should be restricted or closed to aircraft operations until the conditions improve.
- b) Visual aids in the form of unserviceability markers should be used to alert pilots of the restricted or closed portion of the movement areas.
- c) If the unpaved surface is available for nighttime operations, any lighted visual aids should be extinguished or covered so that they are no longer visible.
- d) Vehicles and person should avoid driving on the unserviceable areas as they may become stranded or may exacerbate the surface condition.



*Figure 6.1 – Unpaved runway well graded and compacted*

6.1.3 Once the conditions return to a serviceable state, the closed or restricted areas can be returned to service, visual aids removed/reinstated and appropriate reports made as to the aerodrome condition.

## REFERENCES

- 1) ICAO Annex 14, Volume I
- 2) PANS-Aerodromes (Doc 9981)
- 3) Aerodrome Design Manul Part 3 – Pavement (Doc 9157)
- 4) CASA Australia AC139.C-07V1.0 Strength Rating of Aerodrome Pavements
- 5) New Zealand AC139-6 Aerodrome Design Requirements – All aeroplanes above 5700kg MCTOW, Sections 2.5 & 2.6
- 6) Transport Canada Advisory Circular (AC) No. 300-004: Unpaved Runway Surfaces