VERTRAGSPARTNER GTÜ
Gesellschaft für Technische Überwachung mbH

DR.P.J.WAGNER
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Workpaper

SCoRM test

Soil Control of Rolling Movements

Investigation of *strip* and *RESA* – stability according to EASA and ICAO Annex 14

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The DR.P.J.WAGNER Ltd. is a company for official expertise and a partner of the GTÜ mbH, one of state-approved organizations in Germany (as there are GTÜ, TÜV and DEKRA) raising expertise for particular project preparation, monitoring and conflict management in infrastructure projects.

Regarding Airports the company's scope covers the investigation and assessment of unpaved strips inside the graded portion and the *RESA* runway end safety area using the SCoRM test method according to ICAO Annex 14.

International rules and standards as ICAO International Civil Aviation Organization define structural requirements for operational surfaces to ensure that in case of accidental abnormal events only minimum or no damages to personnel and equipment may occur.

ICAO Annex 14 in 3.2.5 defines recommendations for acceptable consequences in case of aircraft running off paved surfaces of runways and taxiways and roll over hardened shoulders to non-hardened surfaces – strips.

(***Strength of runway strips*** / 3.4.16 **Recommendation.—** *That portion of a strip….should be so prepared or constructed as to minimize hazards arising from differences in load bearing capacity to aeroplanes which the runway is intended to serve in the event of an aeroplane running off the runway. Note.— Guidance on preparation of runway strips is given in the Aerodrome* Design Manual*, Part 1. 5.3.22 …., it should be graded in such a manner as to prevent the collapse of the nose landing gear of the aircraft. The surface should be prepared in such a manner as to provide drag to an aircraft and below the surface, it should have sufficient bearing strength to avoid damage to the aircraft…..*

Concerning *RESA* there is a special regulation in annex 14, respectively look at the aerodrome design manual 1 chapter 5.4.

According chapter 5.4.13:

1. *A runway end safety area should be so prepared or constructed as to reduce the risk of damage to an aeorplane undershooting or overrunning the runway, enhance aeroplane deceleration, and*
2. *facilitate the movement of rescue and fire fighting vehicles.*
3. *See **5.3.22** for guidance on the minimum strength of the runway end safety aera.*

Aerodrome Design Manual*, Part 1. **5.3.22** …., it should be graded in such a manner as to prevent the collapse of the nose landing gear of the aircraft. The surface should be prepared in such a manner as to provide drag to an aircraft and below the surface, it should have sufficient bearing strength to avoid damage to the aircraft…..*

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Runway strips and *RESA* have to be kept in condition such as an aircraft rolling over these will not cause major structural damage, regardless of season or weather condition and independent from the type of aircraft.

The causative risk of damage for rolling aircrafts on unpaved surfaces is the uncontrolled sinking of the wheel. Abrupt deceleration might lead to damage landing gear, fuselage, wings and / or engine, fig. 1. In case of an emergency situation on or besides runways with hardened surfaces, rescue vehicles like fire brigades, ambulances can be forced to use the unhardened / non-consolidated parts of the airfield.

Strength of runway end safety areas / 3.4.11 Recommendation.— *A runway end safety area should be so prepared or constructed as to reduce the risk of damage to an aeroplane undershooting or overrunning the runway, enhance aeroplane deceleration and facilitate the movement of rescue and fire fighting vehicles as required in 9.2.26 to 9.2.28.). – etc. (*ICAO Annex 14).

These surfaces have to be kept in such a shape to guarantee smooth passing/crossing over of rescue vehicles at all time regardless of season and weather conditions.

Main effect on the mobility of rescue vehicles driving non-hardened surfaces is the strength of the ground, without sufficient strength the mobility is limited or will fail.

Technical base

The purpose / demand of unbounded surfaces regarding "Rolling Movements" as an interaction of soil and wheel is basically determined by two factors: ***rolling resistance (rolling friction)*** and ***tangential force***. The rolling friction of a wheel is mainly a combination of two contributing effects:

- The sinking of the wheel into the ground (deformation of the surface)
- The deformation of the wheel itself

On soft ground – in contrast to hard surfaces - the wheel sinkage will increase and the resulting rolling resistance will increase exponentially too, fig. 2.

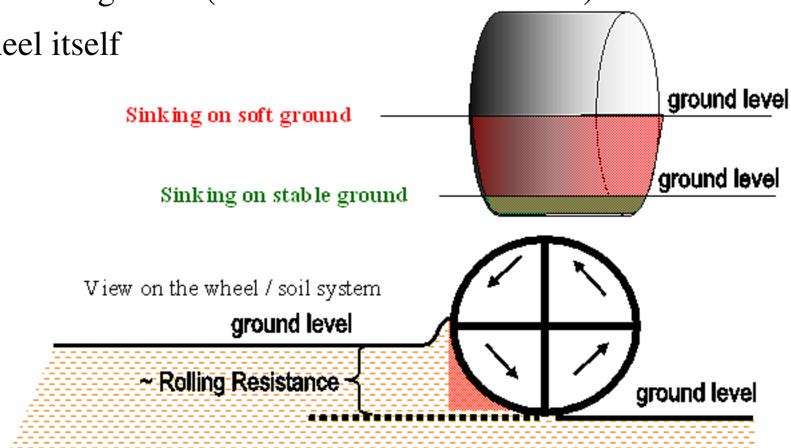

Fig. 3

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The wheels' tangential force ultimately represents the tractive energy and corresponds to the transmission of the engine power in interaction with the soil via the contact patch.

This transmission is determined by the grip between ground surface and tire (described by the coefficient of friction). If the friction is low the wheels will be able to slip reducing the tangential force. At 100% slip the wheels will turn without transmitting any tangential force to the ground so the vehicle won`t move.

On an aircraft the wheels are not powered and only very low tangential forces act on them, the necessary force to move the aircraft forward is delivered by the engine thrust (or propeller thrust in case of a propeller driven aircraft). This thrust generates a forward movement with a downward – and so into the soil- acting force, which increases further the rolling resistance of the already subsided wheel.

The resulting rolling resistance has to be absorbed by the landing gear. It is comprehensible, that the landing gear structure will be stressed disproportionately from increasingly sinking wheels and effective thrust. For each aircraft the USL *Uncritical Sinkage Limit* can be determined. Below the USL the wheel sinking doesn´t cause structure damage, only the deceleration.

On emergency vehicles (fire brigade) the tangential force of the powered wheels counterbalances the rolling resistance. The mobility of the emergency vehicles can be assured by strengthening the subsoil to such a degree that the rolling resistance caused by the sinking wheel is below the tangential force transmitted via the wheel's contact patch.

To fulfill the requirement *"........ the aeroplane without inducing structural damage.........."* it is necessary to stabilize runway strips so that a controlled sinking allows the resulting rolling resistance to slow down the aircraft and so avoiding considerable damages to persons and aircraft.

Applied accordingly for the RESA. Stabilization measures (EMAS), which only allow the deceleration for defined aircraft (arresting system) while the mobility of emergency vehicles (rescue and fire fighting vehicles) are not possible, are not recommended. Also in case of a shortened RESA modern systems of soil stabilization are available to ensure the deceleration of aircrafts and the maintaining of vehicle-mobility - regardless of (heavy) rainfall and watercontent.

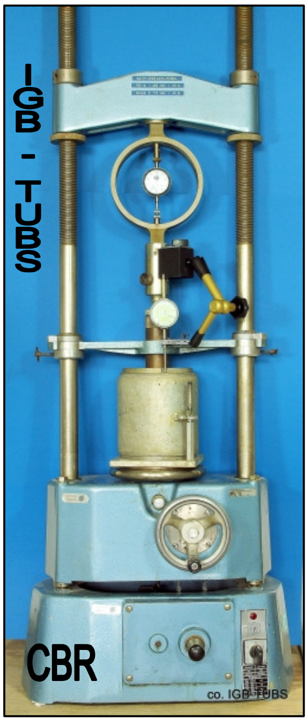
Just for airports with an extremely short RESA, such a method of deceleration for defined types of aircraft, after a risk assessment, will be or has to be evaluated differently.

The SCoRM test, technical method to determine the strip and RESA – stability

The risk of structural damage of airplane and the required mobility of rescue vehicle on unpaved fields of airports are determined by

- the wheel geometry,
- the loads acting on the wheel
- in combination with the local (varying) mechanical properties of the soil.

To analyse the overrun characteristics of the subsoil in the strips and the RESA inside the graded portion, several technical systems are possible to use like boring rod, CBR field, CBR laboratory, PIT Plate Impact Test, Fig. 4 – 7.



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Technical heart of the risk analyse is the soil investigation with the EASA ***Single Wheel Load*** test SWL according to EASA_NPA 2011-20 (B.III) — Draft Certification Specifications)

With the SWL - test we measure the soil properties of unpaved areas with respect to the representative capacity under the rolling aircraft wheel. Key element of this method is an aircraft wheel which will be pushed continuous over the field under the real weight of a rolling aircraft. In the test the wheel - sinking will be recorded and the rolling resistance ascertained, fig. 8.

Data evaluation according to the ICAO

The investigation of RESA and strips will be developed in phases. Damages of the surfaces should be avoided or kept to a minimum.

Phase I: Technical field examination

1. Areal investigation and presentation of the soil conditions in RESA and strips by SWL-test. Selection of the wheel load (weights) for the determination of sinking and rolling resistance of different types of aircraft.
2. Alternatively use of small devices (Fig. 4 – 7) in a grid for the areal determination of several features like soil type, humidity and actual stability in RESA and strips. Selection of sections to implement representative SWL – tests inside or outside the graded portion. If require the sections has to be irrigate to simulate heavy rainfall.

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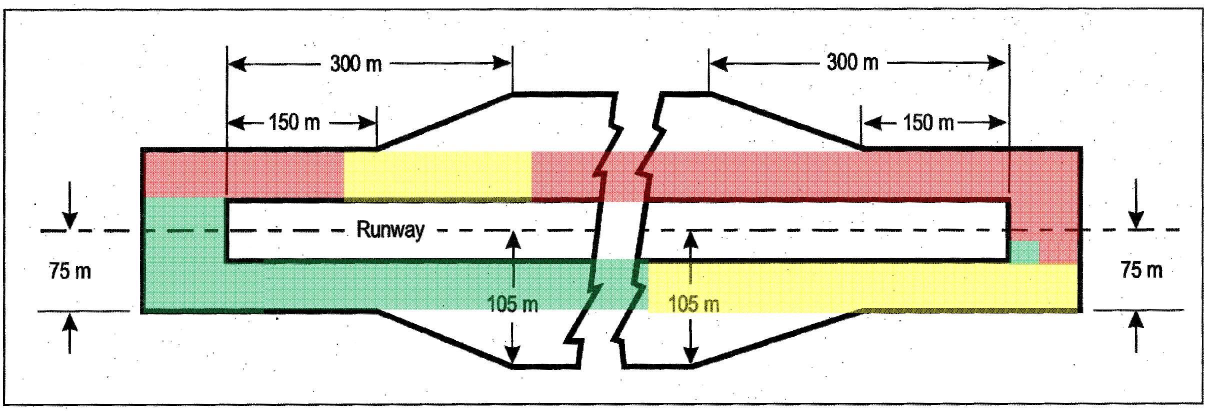
Representative SWL – test on selected sections in- or outside the graded portion, Fig. 9.

3. Transfer of results of the representative SWL – tests on the investigated areas of RESA and strips inside the graded portion according to “1”.

Phase II: Technical expertise about necessary upgrades

4. Evaluation of all technical results from “1” and “2” according to the given targets of ICAO and EASA.
5. Comparison of the given target (EASA and ICAO) with measured values from “3” for the investigated area inside the graded portion, illustrated in a map, Fig. 10.



Aeodrome Desing Manual Part 1 Runways, Figure 5-3, fig 10.

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Legend:

The requirements of the soil strength are fulfilled for all-season, no measures of technical improvements are necessary, **measured values ≥ given target**.

The requirements of the soil strength are not fulfilled in case of high water content. In seasons with heavy rain the sinking and the rolling resistance are too high, collapses of aircraft wheels and a lack of mobility of rescue vehicle must be expected. Adapt measures of technical soil stabilization are necessary, **measured values < given target**.

The requirements of the soil strength are not fulfilled (nearly) for all seasons. In case of a *runway excursion structural damages* must be expected (>USL). For rescue vehicles sufficient mobility doesn´t exist. Taxiing on runways, taxiways and aprons will result in structural damage to the aircraft. The strips have to be stabilized, **measured values < given target.**

6. If the measured values ≥ given target certification as ICAO / EASA compliant.
7. If the measured values < given target proposal to upgrade the stability. For this, several technical systems are available like soil replacement, the installation of geogrid / geofleece systems with additional layer of gravel, compaction of soil layers, the drainage of the subsoil, the installation of *crunshible concrete* or the combination of all of these measures

Phase III: Upgrading in case for measured values < given target

8. Construction of an EMAS (Engineered Material Arresting System) according to "7". To find out the most economical and ecological construction the erection of one or more test fields are advisable. The following figures show test fields with geogrid / geofleece systems with additional layers of gravel on selected sections of RESA or strip, Fig. 11 to 12.

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Another possibility for an EMAS is the construction of the *crunshible concrete* EMASMAX® from ESCO-ZA Zodiac Aerospace, Bild 13 ATSB SAFETY REPORT AR-2008-18(2) Final.

9. Implementation of SWL – tests on the test fields “8”, Fig. 11 - 12.

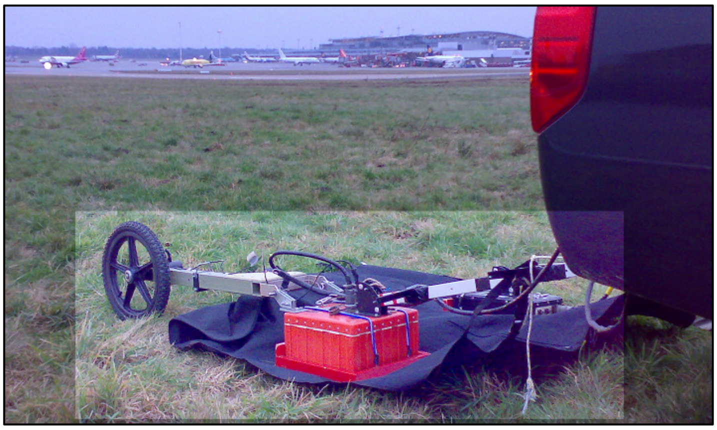
10. In case of insufficient strength, improvement of the EMAS.

11. Control of the EMAS improvement.

Phase IV Technical acceptance

11. Monitoring and documentation of the real constructed EMAS according to the technical specifications in “8” and “10” <u>during</u> the construction work or

12. sensory areal verification with the RLD System (Radar based Layer Detection) <u>after</u> finishing sections or the construction work. The verification will be carried out on continuous profile, measured form the surface of the EMAS down to the lower edge, Fig. 14 and 15.



Phase V: EASA und ICAO compliant

13. Based on the inspection reports of the investigated and constructed fields the ICAO / EASA compliant will be certified.

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Damages after a runway excursion

In ICAO Annex 14 the necessary stability of the strips and RESA are defined. On fields with an examined ICAO confirming stability runway excursions don't provoke structural damage.

After accidents with damage to the aircraft after a runway excursion expertises will be compiled to research possible causes by lack of soil stability and / or existing obstacles. For these investigations the described techniques and processes in Phase I have to be used.

In case deficits of the strip stability are detected, the (initial) reasons for the damage have to be quoted (up to 100%).

In the event of criminal proceedings, the compiled results are also used to determine the responsible.

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managing director

Experts of technical airport investigation

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