Falling Weight Deflectometers

Carl Bro Pavement Consultants
– the pavement management people

Carl Bro
Intelligent Solutions

You have the need

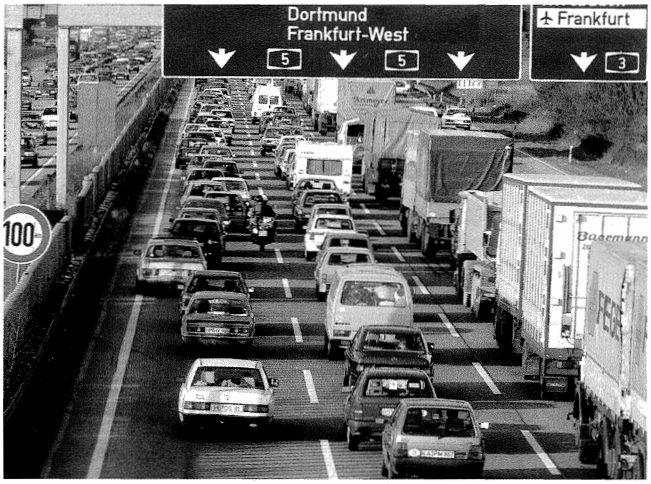
Falling weight deflectometers are effective and economical means of collecting information on the bearing capacity of roads and airport runways. They provide the key to precise performance when carrying out ongoing maintenance work or rehabilitating and reinforcing existing surfaces.

It is safer to measure than to guess
Infrastructure is an important public investment, and an efficient infrastructure is a crucial prerequisite for a modern, efficient society. It is expensive, both in terms of construction costs and of ongoing maintenance – but there is no need to make it more expensive than necessary.

Optimising investment and maintenance costs requires the right combination of specialists and precise knowledge. Where roads, airport runways and similar surfaces are concerned, precise knowledge of bearing capacity is an important element. Such knowledge allows the exact calculation of optimum quantities of material to be used, for example for road construction to match the expected traffic load. Similarly, bearing capacity is an important parameter in planning ongoing maintenance work – not too early, not too late, but well-timed – and not too much, not too little, but sufficient. Thus, lower maintenance costs and an improved maintenance standard can be achieved at one and the same time.

The falling weight deflectometer - the modern measuring device
For many years, bearing capacity was measured with a Benkelman beam. The method was time consuming and not very accurate.

Falling weight deflectometers were introduced at the end of the 1960s. They were developed and produced by, among others, the people behind the current state-of-the-art falling weight deflectometers from Carl Bro. Nowadays, falling weight deflectometers are generally accepted as being the measuring device for everyday measurement and planning tasks. Their accuracy goes without saying. And with respect to qualities like flexibility and reliability, falling weight deflectometers from Carl Bro are second to none.



Bases on more than 30 years' experience

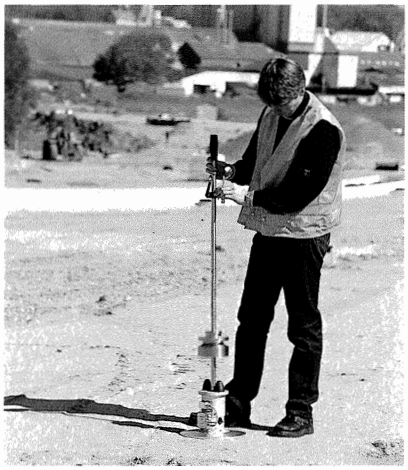
At Carl Bro, we have developed and produced falling weight deflectometers since 1969. This makes us one of the most experienced companies in this field - experience that benefits our customers.

Modular design
All our falling weight deflectometers - from the small, portable *PRI*MA 100 to the van-integrated *PRI* 2100 - are module-designed. This provides definite benefits for those purchasing and using our equipment. With *PRI*MA 100, this means that one or two additional geophones can be connected depending on the work to be performed. With *PRI* models, it is possible to move the measuring equipment from a trailer chassis into a van specially prepared for the task.

Standard components
Our falling weight deflectometers are to a large extent manufactured from standard components. They are available in most parts of the world, and can therefore be replaced locally - quickly and with little inconvenience for customers.

Flexible calibration equipment
When you choose a falling weight deflectometer from Carl Bro, you also gain the unique opportunity to adjust individual sensor characteristics using flexible calibration equipment. This is one of the "secrets" behind the extreme accuracy of our falling weight deflectometers.

We have the Intelligent Solution



***PRI*MA 100 portable falling weight deflectometer**
*PRI*MA 100 is the latest in the range of falling weight deflectometers developed by Carl Bro. The original *PRI*MA prototype was produced in 1997, and today stands out as an effective, flexible device for use in the quality assurance.

*PRI*MA 100 is primarily used for compaction control in connection with the laying of asphalt, cobbles and flagstones, but is also ideal for measuring bearing capacity where geogrids are to be used or where pipeline trenches are to be re-established. *PRI*MA 100 is also indispensable for compaction control prior to laying industrial flooring.

***PRI* 2100 FWD trailer**
The classic, flexible solution in which the falling weight deflectometer is mounted on a double-axle trailer. The modular design ensures investment for the present and the future. The standard equipment can, for example, be adapted for heavy-duty use in airports, etc. by fitting a more powerful load cell and additional weights. Also, the FWD unit can be built into a van, and extra facilities, such as GPS, video and marking equipment, can be added.

Measuring equipment from Carl Bro carries the CE mark in compliance with EU machinery and EMC directives and is approved by CROW and SHRP.

***PRI* 2100 van-integrated**
The ideal solution where the falling weight deflectometer is in daily use. Mobilisation time is reduced, and the equipment is less bulky and more flexible in traffic.

The van-integrated *PRI* 2100 model offers the same benefits as the trailer-mounted model: modular design with flexible upgrading possibilities.

Carl Bro Group

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The Carl Bro Group
The Carl Bro Group is an international consulting company offering services in the fields of Environment, Industry & Marine, IT & Telecommunications, Management, Building, Transportation, and Energy. Over the past 40 years we have carried out projects in more than 100 countries.

Our international and national services call for innovation and cultural awareness. Our employees are constantly upgrading their skills by representing the Carl Bro Group locally and working internationally. This makes it easy and flexible to work with the company – across both cultural and geographic boundaries.

The Carl Bro Group provides intelligent solutions by being constantly one step ahead - strategically as well as professionally. This requires a broad spectrum of specialist skills. As a result, the company employs a steadily growing number of people with different professional backgrounds. By co-operating across the boundaries of our different areas of expertise, we are able to reach our common goal – the intelligent solution.

www.pavement-consultants.com
www.carlbro.com

Elementry

Every day we work with the Earth's four basic elements. But it is people who make things happen. At Carl Bro, our employees make up the fifth element.

PRIMA 100

Better safe than sorry

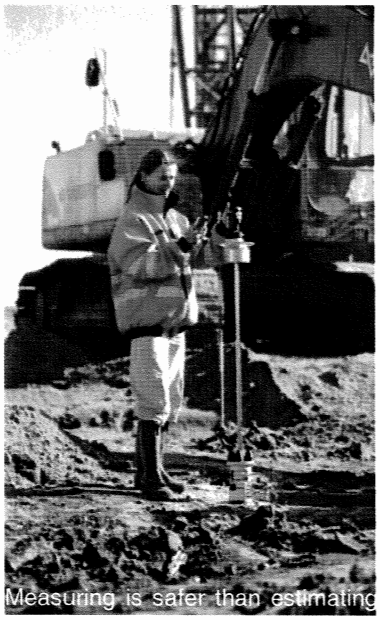
The *PRI*MA 100 portable FWD is a handy instrument for on-site measurement of bearing capacity to minimize risks and optimise quality. The best of our long FWD production experience has been used for the *PRI*MA 100.

Compared to other kinds of measuring equipment, the investment in *PRI*MA 100 FWD equipment enabling high quality data collection is very low and means a tremendous cost reduction as on-site analysis of collected data allows immediate information and printout of reports. Only one person is needed for the work and the equipment can work under very difficult conditions like in excavation trenches. Site locations can be captured by means of GPS (Geographic Positioning System), which enable presentation of data in maps or general plans of site.

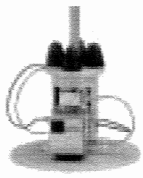
The data transfer system of the new generation of *PRI*MA 100 is very flexible and allows for wireless (Bluetooth) transfer of data. This enables unique working conditions and only one person is needed for the work. The data collection is done by means of PDA/Bluetooth and/or with Lapton/cable communication.

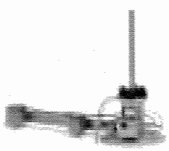
*PRI*MA 100 is unique for quick in-situ control of unbound base layers, subbases or compacted layers. All you need is a data evaluation program. All data is stored in ASCII format enabling direct conversion to e.g. Microsoft EXCEL or WORD so that data can be used directly in a report.

*PRI*MA 100 is powered by four 1.5 volt standard AA batteries and no extra power supply is needed. *PRI*MA 100 standard model has one centre geophone. Extension to three geophones is possible.



Measuring is safer than estimating





Facts

- Quick on site control measurements instead of risky estimates
- Quality optimisation
- Easy to operate
- Time history recording on load and geophone(s)
- Standard Windows software
- Made by specialists with more than 25 years of FWD experience

Top: PDA with protection cover.
Middle: Ø 300 mm load plate with load cell and rubber buffers
Bottom: Geophone beam for two extra geophones

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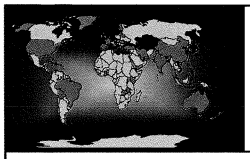


Technical specifications

Dimensions

Height:	1.40 m		
Weight, standard equipment:	20 kg	Drop weight:	10 kg (15, 20 kg)
Weight with all weights on:	30 kg	Max drop height:	85 cm

Load characteristics

Load plate:	100 – 200 – 300 mm Ø	Load pulse shape:	essentially half-sine
Load range:	1 – 20 kN	Load pulse rise time:	approx. 8 msec
Load pulse duration:	15 – 20 msec		

Load cell

Load cell accuracy:	1 % ± 0.1 kN	Frequency range:	0-400 Hz
Load resolution:	0.1 kN (1 KPa)		

Deflection sensor

Sensor type:	Seismic Velocity Transducer	Geophone resolution:	1 micron
Number of geophones:	1 – 3	Geophone range:	2200 micron
Geophone accuracy:	better than ± 2%	Frequency range:	0.2 – 300 Hz

Power supply/communication

Battery pack
4 x 1,5 volt
standard AA

Wireless Bluetooth data Standard transfer (optional) and/or Data transfer via RS-232/UPS
Automatic battery level check and presentation.

Data acquisition system (electronic box)

Time history (real time):	On geophone(s) and load cell	Sampling period:	10 – 750 msec (chosen by user)
Resolution:	16 BIT on all analog channels (load cell, geophone(s))	Data storage (peak value):	ASCII format
Sampling:	16 kHz, simultaneous sampling	Data storage: (time history)	ASCII orbinary compression (comp. software)

Data collection software
MS Windows 98/2000/NT/ME/XP/Pocket PC PDA

- Easy setup of data and sequence
- Presentation of time history and peak value
- Presentation of E modulus
- Easy setup of system configuration
- Easy file handling module with view function
- History data presentation in point or drop mode
- Full access to Poisson's Ratio and stress distribution factor.
- Compaction program - E-modulus

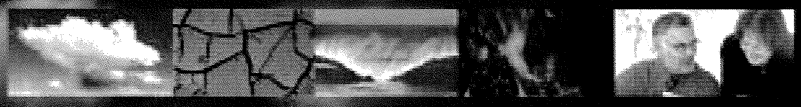
Safety: Complies with EU machine and EMC directives for mechanical and electronic devices (CE-marking). Approved by CROW and SHRP.

Calibration Standards
Load cell and geophones: DANAK FORCE Institute, National Reference Laboratory for Force and Pressure AREPA Test & Kalibrering A/S

Optional hard- and software

- 200 – 300 mm Ø load plate
- Extra weight detach type (1 x 5 kg) – up to two weights is possible
- Extra geophone with metal housing – up to two geophones is possible
- Geophone beam for two extra geophones (enabling measuring with a total of three geophones)
- Transport box
- GPS
- Wireless data transfer, range min. 100 m.
  PDA on PRIMA 100 with data on load / deflection / E moduli / status / GPS.
  Out of range check and presentation.

Specifications subject to alteration without notice



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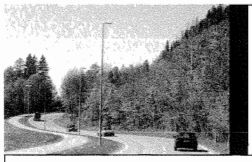
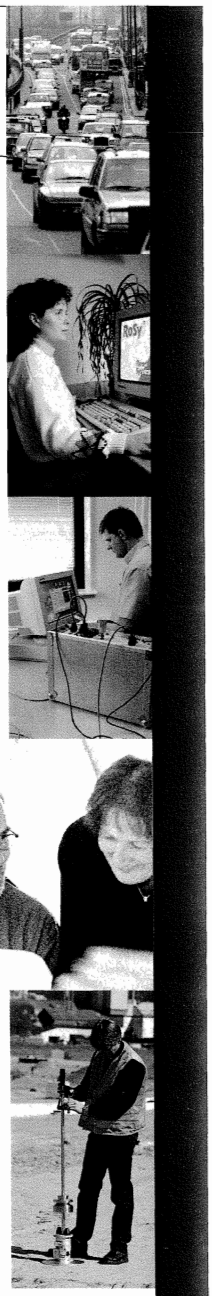


PRI 2100



*PRI*2100 FWD trailer: The classic solution

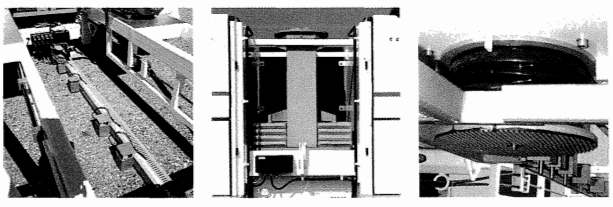
The *PRI* 2100 FWD trailer is the classic and flexible solution from Carl Bro. Mounted on a double-axle trailer it is independent of the towing vehicle and can be towed by any vehicle. The only cable connecting the trailer with the towing vehicle is the PC computer cable. The operator controls all FWD functions from the PC, which is placed in the towing vehicle. This makes the measuring work simple and easy and only one operator is needed for the work.

The modular principle means that there is no need for investment in new equipment if the demands on the equipment change. All that is necessary to upgrade the equipment from a standard 7-150 kN FWD to a 7-250 kN Heavy Weight Deflectometer (HWD) is to add more weights, a larger load cell and upgrade software. The trailer-mounted FWD can also be integrated in a van without having to invest in new basic measuring equipment.

Like all FWD equipment from Carl Bro the standard trailer-mounted FWD is supplied with personal computer, Windows FWD software, time history module, transport lock, DMI (Distance Meter Indicator) integrated in the software, three temperature sensors, four-split loading plate, 9 geophones and warning lights. Additional functions can easily be added such as video or marking equipment, GPS (Geographic Positioning System), which enables presentation of data in maps or general plans of site.

For data treatment Carl Bro supplies RoSy DESIGN, a back-calculation software for both road and/or airport data analysis. However, files generated from the equipment can be applied in any other back-calculation program.

Carl Bro attaches great importance to supplying safe and stable equipment and the newest technology forms the basis of the FWD equipment. The *PRI* 2100 software incorporates alarms that are displayed on the computer screen. If the operator ignores vital warnings, certain functions cannot be performed with the FWD e.g. in connection with pavement temperature measuring: After having inserted the asphalt temperature sensor in a hole in the pavement, the sensor registers when the temperature is stable. The temperature is measured while the loading plate is placed on the pavement and cannot be raised before the temperature sensor is placed in its holder. The equipment cannot be driven to another position with the loading plate down and strategically placed emergency switches allows the operator to stop the equipment at any time while operating manually.



Left: The geophones are easily accessible and simple to replace.

Centre: No tools are needed for replacement or removal of weights. Multi-step adjustable drop height secures very accurate load configurations.

Right: The four-split loading plate allows good contact to the surface and accurate measuring.

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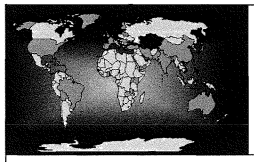
Intelligent Solutions



Technical specifications - *PRI* 2100 FWD trailer version

Dimensions

L x W x H (m): (excl. of warning lights)	4.30 x 1.84 x 1.30	Weight:	1180 kg
		No. of axles:	2

Load characteristics

Load range:	7 - 250 kN (7 - 150 kN)	Load pulse shape:	essentially half - sine
Load pulse duration:	20-30 msec	Load pulse rise time:	approx. 10 msec

Load cell

Load cell accuracy:	2% +/- 0.2 kN	Loading plate:	4-split 300 mm transverse
Load resolution:	0.1 kN (1 KPa)		

Deflection sensor

Sensor type:	Seismic Velocity Transducer	Geophone resolution:	1 micron
Number of geophones:	9	Geophone range:	2200 micron
Geophone accuracy:	better than +/- 2%	Geophone beam:	2500 mm from centre

Temperature sensor

Sensor type:	PT 100	Temperature accuracy:	better than 1%
Number of sensors:	1 manual - optional 3 (surface, air, manual)	Temperature resolution:	0.1 °C

Distance meter counter

Accuracy:	Better than 0.1%	Integrated in data collection software	

System

Capacity:	Up to 65 test points per hour	(depending on distance between test points)	

Operation

May be operated by one person		Temperature range (transport):	- 25 °C to +60 °C
Temperature range (measurement):	0° C to +45 °C		

Power Supply (FWD)

Trailer:	24 VDC generator unit mounted on trailer	/ 12 VDC towing vehicle	

Data Acquisition System

Time history (real time):	On all geophones and load	Sampling period:	60 – 120 msec (chosen by user)
Resolution:	16 BIT on all analog channels (load, geophones, temperature, falling height)	Data storage (peak value):	ASCII format
		Data storage (time history):	ASCII or binary compression (comp. software)
Sampling:	40 kHz (for 10 channels)		

Data collection software

System: MS Windows 95/98/2000/NT/ME/XP

- Easy set-up of data and sequence
- Presentation of time history and peak value displayed simultaneously
- Automatic loading of temperature with alarm for correct measurement
- Full manual mode operation from PC
- Easy set-up of system configuration with save and load functions
- Full FWD test module with all digital and analog I/O channels
- Easy file handling module with view function
- Integrated distance meter calibration module

Safety

Complies with EU machine and EMC directives for mechanical and electronic devices (CE-marking). Approved by CROW, SHRP and UK FWD Correlation Trial (Highway Agency)

Calibration Standards

Load cell and geophones: DANAK FORCE Institute, National Reference Laboratory for Force and Pressure AREPA Test & Kalibrering A/S

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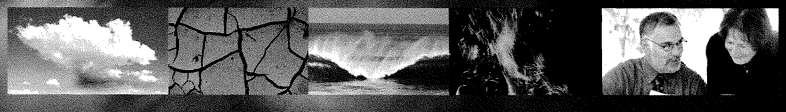

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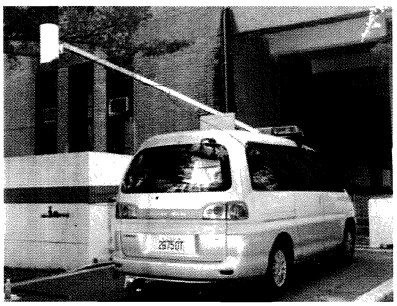
MSC- Multi Service Center A/S – APRI/2004

Surface Condition

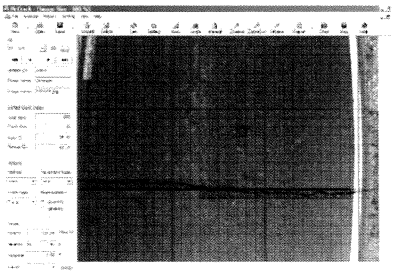
道面現況

鋪面在開放交通後，必須進行定期道面現況調查，調查鋪面表面損壞，依據調查結果評估鋪面服務效。當服務績效低於水準之下時，須採取適宜的鋪面養護作業，使鋪面服務績效恢復到一定水準之上。



調查方法

人工調查
車內調查
PicCrack 自動影像調查



相關業績

馬公機場跑滑道
道面現況調查

儀衡工程科技股份有限公司
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10087 台北市思源街 18 號台大創新育成中心 B 棟 402 室 | www.pavement.com.tw

道面結構強度

道面完工後，因受交通荷重與環境因素作用影響，強度將逐漸減弱。利用重型落重撓度儀量測所得表面撓度值來反應道面各層之結構強度，乃至於計算道面分類指數（PCN），可確切掌握道面強度現況與變化趨勢。

調查設備

PRI2100 機場專用重落重撓度儀

PRIMA100 可攜式落重撓度儀

相關業績

馬公機場跑滑道撓度檢測
馬公機場跑道 PCN 調查
台東機場跑道 PCN 調查
松山機場停機坪撓度檢測
中正機場跑道撓度檢測

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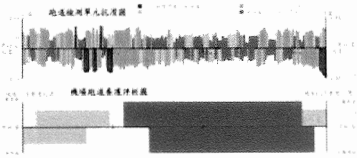
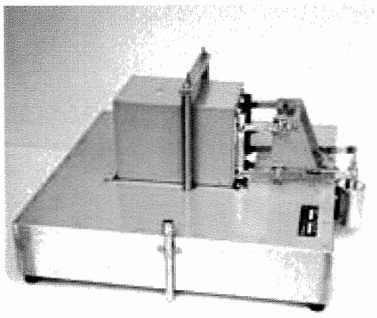
Skid Resistance

道面抗滑能力

機場跑道之良好抗滑能力有助於航空器在適當距離內煞停、在側風及引擎故障時，仍能維持良好之方向控制。抗滑能力不足時，將於雨天大幅提高水滑（hydroplaning）現象發生之機率。



調查設備



ICAO/FAA 認可 Grip Tester
動態摩擦測試儀（DFT）

相關業績

全國十六座機場跑道摩擦係數委外檢測
恆春機場跑道摩擦係數檢測
台南機場跑道翻建後摩擦係數檢測
台東機場跑道加鋪後摩擦係數檢測
胎屑清洗後摩擦係數檢測

- ✓ 嘉義機場
- ✓ 金門機場
- ✓ 台中機場
- ✓ 松山機場

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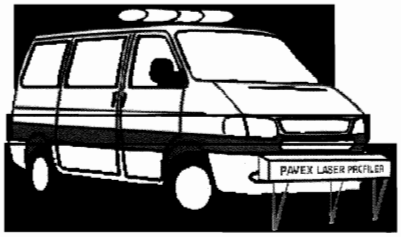
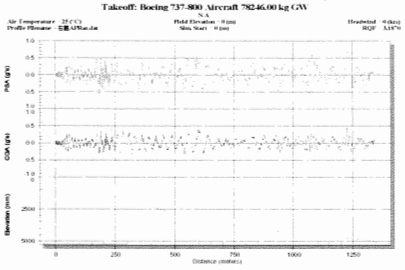
Smoothness

道面平坦度



鋪面平坦度會直接影響鋪面服務能力，鋪面平坦度量測與控制確實十分重要，為確保路面服務能力於一定水準，及避免鋪面平坦度引起的行車問題與鋪面壽年縮減之現象，維持路面之功能以及行車安全。



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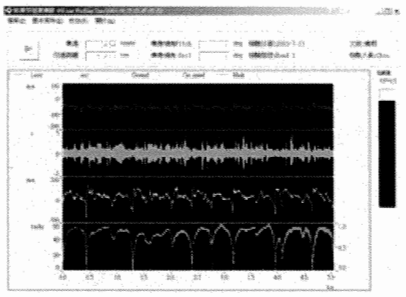
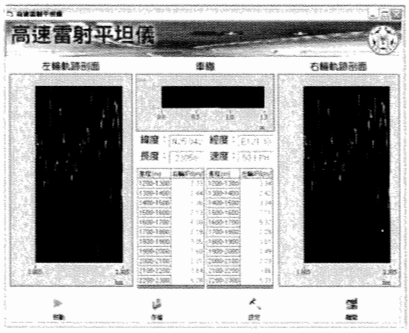


高速慣性式雷射平坦儀

APRas 航機模擬軟體

相關業績



馬公機場跑道平坦度檢測與評估

可攜式平坦儀之開發

高公局超音波平坦儀之評估

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