A380 PAVEMENT EXPERIMENTAL PROGRAM – RIGID PHASE

C. FABRE & N. MANOURY
Airbus, France
Cyril.Fabre@airbus.com

1.1.1. P. LERAT & A. MAZARS
Airports and airforce bases engineering dept, Civil aviation administration, France
Patrick.Lerat@aviation-civile.gouv.fr

J.-M. BALAY
1.1.2. Laboratoire Central des Ponts et Chaussées, France
jean-maurice.balay@lcpc.fr

ABSTRACT

The paper describes several experimentations on rigid pavements at Toulouse Blagnac airport, tested with heavy aircraft landing gear simulator developed by Airbus S.A.S. The main contributors of this program are Airbus, the French Civil Aviation Administration (STBA) and the French Road and Bridges Laboratory (LCPC).
The first part of the program (1998 – 2000) deals with bituminous pavement. In 2001-2002-2003, the program has focused on Rigid tests. The main aim has been therefore to improve the understanding of the stresses applied to a cement concrete pavement, under aeronautical loads, in order to underscore the influence of the loading parameters (thermal and dynamic) and of the pavement design parameters. The two main targets are to provide comparative experimental data between different aircraft landing gears, considering especially the future Airbus A380, and to provide full-scale data towards a better understanding of rigid pavement behaviour in order to contribute to the research program for renewing airport pavement design methods started in 1999 by both STBA and LCPC.
There are two different experimentations :

- The rigid static test campaign are to be located chronologically within the A380 runway loading Experimental Programme. The configuration of the A380 landing gear was fixed on completion of the flexible tests and the load simulation principle by the aircraft scale simulator is validated.
  The static test principle consisted in varying the load parameters one by one. These parameters are mainly the load applied (load at wheel, pressure of loaded tyres), the geometrical configuration of the landing gears (wheel-track, wheel-base, type of bogie) under a given thermal load. These results are then to be related with the parameters of the pavement used (doweled, slab dimensions, type of foundation, base ground, etc. At the outcome, we will be able to single out the effect of the track, base, load, bogie, etc. on the stresses applied to an aeronautical-type pavement.
- The fatigue test principle consists in comparing damage for the B777-300ER and the A380-800F on each runway section, up to failure.

RESUME

Cet article décrit plusieurs expérimentations effectuées avec un simulateur de train d'atterrissage de gros porteur, sur la chaussée rigide expérimentale, située sur l'aéroport de Toulouse Blagnac. Les principaux acteurs de ce programme sont Airbus, le Service Technique des Bases Aériennes (STBA), et le Laboratoire Central des Ponts et Chaussées (LCPC).
La première partie du programme (1998-2000) a porté sur les chaussées souples. En 2001, 2002 et 2003, le programme s'est orienté sur les chaussées rigides. Le principal objectif est d'étendre la compréhension des contraintes appliquées à une chaussée en béton de ciment, sous chargement aéronautique, afin de dégager l'influence des paramètres de chargement (thermique et dynamique), et des paramètres de conception de la chaussée.
Cette expérimentation s'articule en deux campagnes principales :

- Les objectifs de la campagne statique rigide sont à situer chronologiquement au sein du Programme Expérimental de charge sur piste A380. La configuration de train d'atterrissage de l'A380 est figée à l'issue des tests flexibles (terminés en juillet 2000), et le principe de simulation des charges par le simulateur à échelle avion est validé.
  Le principe de ces tests statiques consiste à faire varier un à un les différents paramètres de chargement. Ces paramètres sont principalement la charge appliquée (charge à la roue, pression des pneus chargés), la configuration géométrique des trains (voie, empattement, type de boggie), sous un chargement thermique donné. Ces résultats sont ensuite à relier aux paramètres de la chaussée utilisée (goujonnée, dimensions des dalles, type de fondation, sol support… A terme nous pourrons dégager l'effet de voie, d'empattement, de charge, de bogie… sur les contraintes appliquées à une chaussée aéronautique type.
- La campagne fatigue consiste à comparer les dommages du B777-300ER et de l'A380-800F pour chaque section, jusqu'à rupture de celle-ci.

1. A380 PEP BACKGROUND

In the context of the NLA development, Airbus Industrie proposed the A380 program, an aircraft whose mission is to transport 555 Pax over 7920nm (A380-800).
The issue of pavement compatibility was considered to be fundamental to the programme, especially as the current ACN/PCN method, was shown to have reached its limit of reability with the unpredicted failures of pavements subject to 6 wheel bogie loads. The pavement designers from Airport and Airforce Bases Engineering Dept. (Direction Générale de l'Aviation Civile - Service Technique des Bases Aériennes DGAC-STBA), ICAO ACNSG European voting member, the pavement structure and materials experts (French Laboratory for Civil Engineering – Laboratoire Central des Ponts et Chaussées LCPC) and the European aircraft manufacturer AIRBUS INDUSTRIE felt the need for an ambitious research program aiming at defining more accurate pavement design methods.

AIRBUS INDUSTRIE set up in partnership with STBA and LCPC the experimental part of this research via the A380 Pavement Experimental Program (A380 PEP) to be able to bring in the pavement compatibility issue into the Landing gear (L/G) configuration selection decision process.

The A380 Pavement Experimental Program was to provide full-scale data to be compared to theoretical simulations carried out with Multi-Layered Elastic Models (Flexible structure) or 3D FEM (rigid structure) by STBA and LCPC.

The A380 PEP was launched in June 1998. Two main targets were assigned :

- Provide comparative experimental data sustaining Airbus A380 Landing Gear configuration selection process. (6-6-6-6, 6-4-4-6, 4-6-6-4 etc.)
- Provide fundamental full-scale information to provide a better understanding of flexible and rigid pavement structures behaviour against wide bodies loading cases for comparison with Model predictions.

The ultimate aim was to provide a design method for flexible and rigid pavement structures based on quasi static (low speed taxiing) and fatigue (cumulative damage) factors.

The simulation vehicle has been able to represent full-scale Main Landing Gear configurations of various wide bodies: A380, A340, B747, B777, MD11.Up to 22 wheels could be individually loaded up to 32 tons. The vehicle features variable dimensions for bogie position, wheels and axle spacing.

The program focused in 1998 - 1999 on Flexible tests. These tests provided data on effects of interference when wheels or legs spacing changed, comparisons between various A380, A340, A320 L/G configurations and with their main competitors. Another fatigue test campaign was launched to study structure rupture modes.

In 2001-2002-2003 the program has focused on Rigid tests. The main aim has been therefore to improve the understanding of the stresses applied to a cement concrete pavement, under aeronautical loads, in order to underscore the influence of the loading parameters (thermal and dynamic) and of the pavement design parameters.

2. A380 PEP – RIGID CAMPAIGN.

The aims of the rigid static test campaign are to be located chronologically within the A380 runway loading Experimental Programme. The configuration of the A380 landing gear was fixed on completion of the flexible tests and the load simulation principle by the aircraft scale simulator is validated.

The static test principle consisted in varying the load parameters one by one. These parameters are mainly the load applied (load at wheel, pressure of loaded tyres), the geometrical configuration of the landing gears (track, base, type of bogie) under a given thermal load.

These results are then to be related with the parameters of the pavement used (doweled, slab dimensions, type of foundation, base ground, etc.

At the outcome, we will be able to single out the effect of the track, base, load, bogie, etc. on the stresses applied to an aeronautical-type pavement.

The fatigue test principle consists in comparing damage for the B777-300ER and the A380-800F on each runway section, up to failure.

3. RIGID RUNWAY

3.1. INTRODUCTION TO RIGID PAVEMENTS

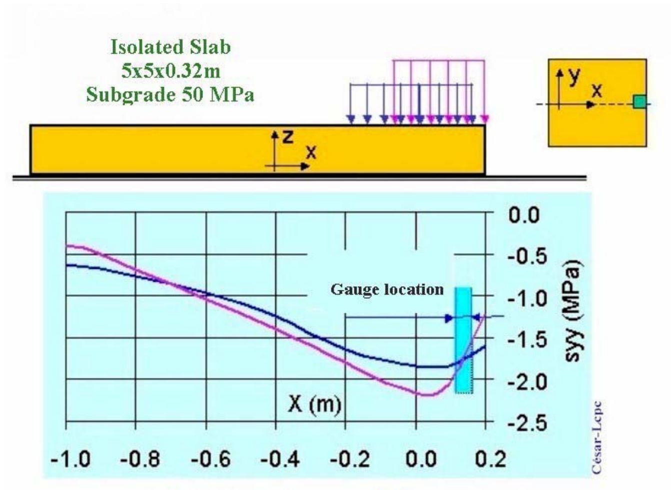
Intrinsically, rigid pavements are very different from flexible pavements. In particular, they are more rigid and have discontinuities. These basic differences lead to clearly marked behaviours and greatly influence the types of tests which are therefore not comparable with the flexible PEP especially concerning the instrumentation of the pavements, the test procedures and the analysis of the data.
The points below illustrate some of the difficulties relevant to rigid pavements.

Discontinuity effect
In theory for a flexible pavement, taking the continuity of the structure into account and applying the linear elasticity hypothesis, for a given parameter ($\square_{xx}$, $\square_{yy}$ or $\square_{zz}$,), only one gauge is required to obtain all stresses and strains in the pavement generated by the passing of a load. In practice (this is what was done for the flexible PEP), one or two gauge transversal profiles are installed to take into account a possible lateral deviation, to evaluate the repeatability of the measurement…For a rigid pavement, on account of the discontinuity of the structure, the value measured by the gauge is valid only for that point. As it is impossible to place gauges everywhere, two problems arise concerning the maximum strain (value which directly concerns the dimensioning) :

- Location of maximum strain cannot necessarily be found by tests (if the gauge is not at the right location…) and therefore a priori remains unknown.
- This location varies from one configuration to another.

For a given position of a gauge, the value measured for two different configurations can be the same whereas the maximum is very different for the two configurations and is not exactly at the same location (picture).

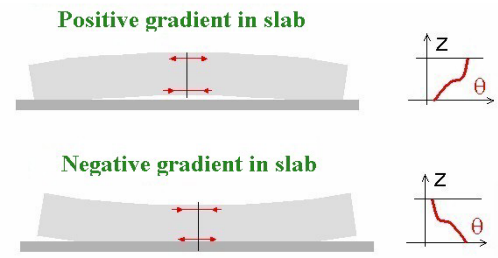
This means that any "spatial" harmonisation between the gauges (see flexible PEP brochure) and any repeatability study of the measurements on the various gauges is impossible.



Tranverse stress σ_{yy}=f(X)
Finite element 3D modelling

Temperature effect

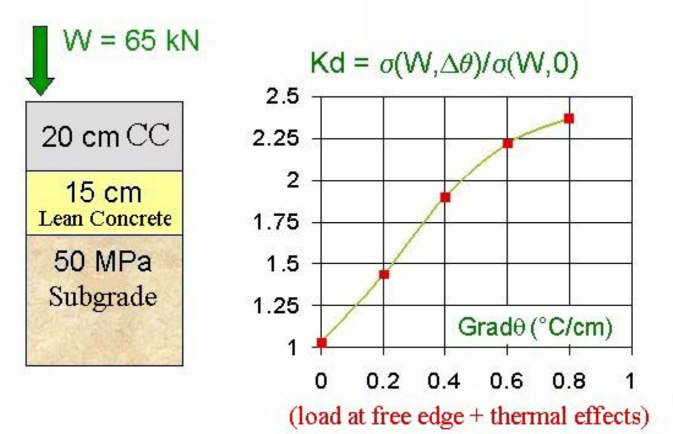
The influence of the temperature is a known phenomenon for concrete slabs:



This phenomenon can also be combined with a slab initial "curvature" (similar to the negative gradient) due to a water content gradient during the setting of the concrete (warping phenomenon).

The influence of this change in the shape of the slab on the measured strain value generated by a load is considerable:

The strain value for a non-deformed slab (at zero gradient) corresponds to $\sigma(W, 0)$ and the values for the various gradients are calculated and correspond to $\sigma(W, \Delta\theta)$. For a given load, simply changing from a zero thermal gradient (gradθ = 0) to a positive gradient of 0.08°C/cm multiplies the strain value by more than two.



This means that any measurement made during the tests will reflect not only the run of a configuration but also a given thermal condition. It is extremely important to bear this in mind when analysing the data.

3.2. SELECTING SITE - CHOICES OF SLAB PATTERN

Logically following on from the flexible pavement tests, the rigid PEP is based on the same hypotheses, that is full scale and "open air" tests under environmental conditions (especially thermal and hygrometric) representative of the operational conditions.

Many parameters are to be taken into account when designing cement concrete aeronautical pavements :

- size of the slabs ;
- dowelling or not ;
- base ground ;
- type of foundation ;
- environment (temperature, etc.).

As the life of a rigid pavement is at least twenty years, the "world-wide population" of cement concrete pavements is fairly heterogeneous and various techniques coexist: it is therefore not easy to select a typical structure. **The test runway must therefore include several zones using various techniques to evaluate their behaviours under aeronautical loads**.

Generally, even for high traffic densities, rigid pavements are mainly used for poor quality subgrades. **Only the weakest subgrades were considered**.

The test runway must allow both static tests and fatigue tests to be conducted. The fatigue tests will consist in comparing aircraft. This has several consequences on the choice of slab pattern :

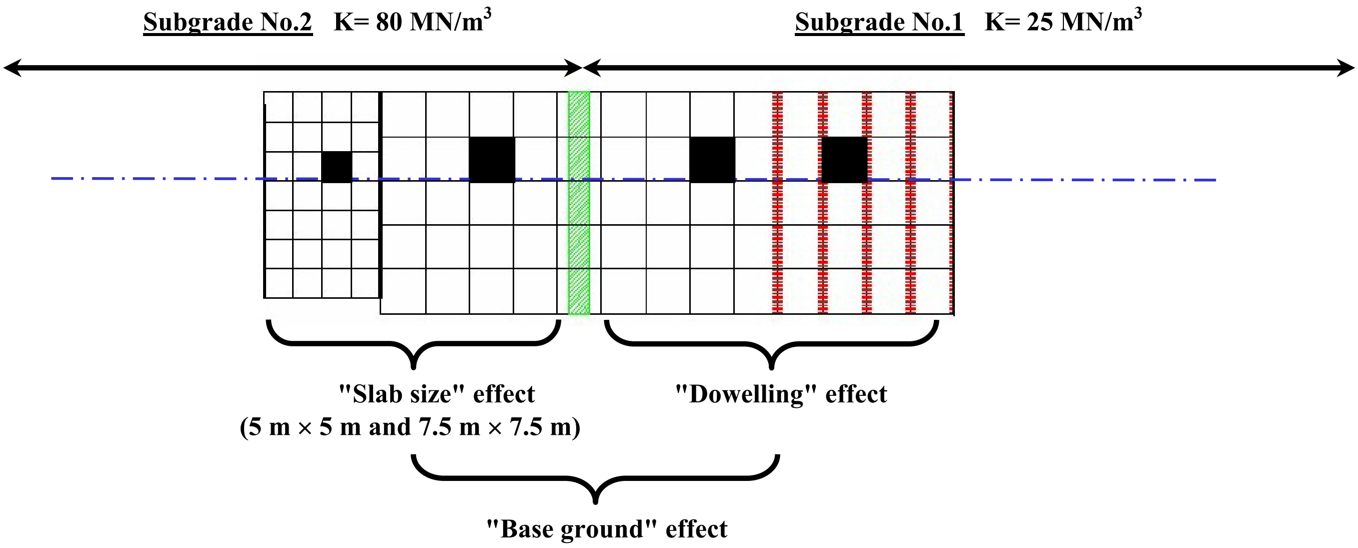
- firstly, the independency of the bogies will require at least one complete slab between each trajectory of the tested bogies (the aircraft under fatigue tests must never run on the same slab). Already at this stage, this parameter and the geometrical limits of the simulator exclude the possibility of testing four different bogies as for the flexible tests; the fatigue campaign has been devised considering the hypothesis of a hybrid simulator configuration combining the main landing gear of the B 777-300ER and 3/4 of the A380-800F landing gear,
- the second problem concerns the choice of the critical trajectory for the fatigue campaign. This trajectory varies according to the climatic conditions and, in particular, the thermal gradient in the concrete slab: thus, a longitudinal trajectory at slab edge will be penalising for negative gradients (convex curvature of the slab, corners raised), whereas a longitudinal trajectory in the centre of the slab will be penalising for positive gradients (concave curvature of the slab).

The conventional pathology of cement concrete aeronautical pavements consists mainly of cracks / corner breaks (critical trajectory negative gradient) and also cracks / breaks in the centre of the slab (critical trajectory positive gradient). To obtain best estimate of the life of a given section, several trajectories must be tested at the same time (at constant gradient), for example: on the edge, in the centre and in an intermediary zone. The advantage of this is not having to make a preliminary choice of the critical trajectory.
The selected site provides a surface area of around 250 m × 100 m. On account of the many parameters and the fact that a fatigue section can only be observed over a minimum of four slabs (longitudinally), we can see that it is impossible to study all of the parameters one by one (for example, for a given subgrade and slab size, we study the influence of the dowelling on two or three sections for the fatigue approach… then, we modify the subgrade, etc.). The test runway must at least allow a comparison by crossed parameters.

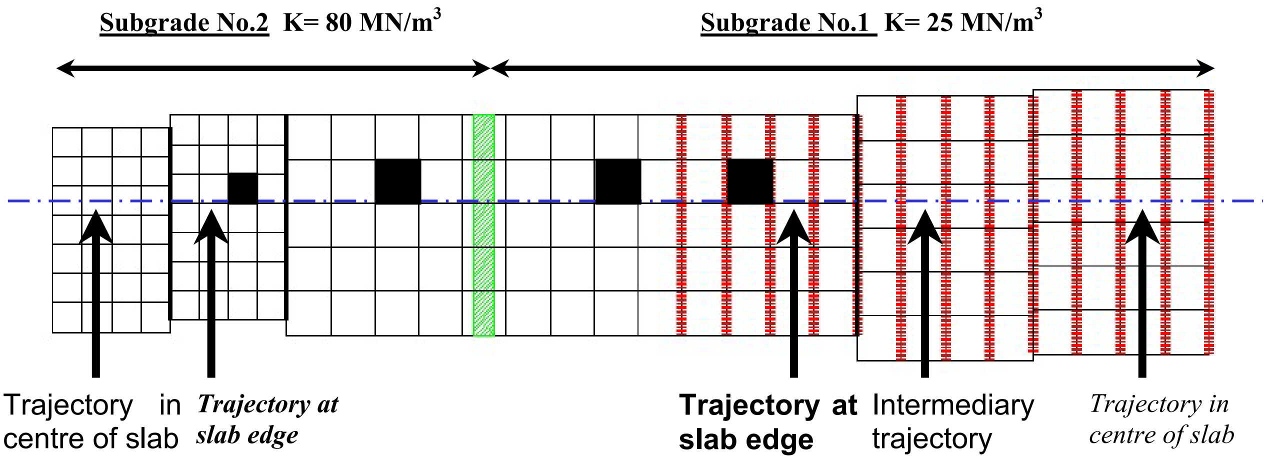
Lastly, the test runway must be constructed according to techniques used traditionally for cement concrete pavements (mainly use of slipform; all manual construction is to be prohibited). The selected slab pattern must not create constraints making the sections unrepresentative of the operational pavements.

The solution retained is broken down into two main parts :

- **A centre portion dedicated to the static tests, including instrumented slabs.** The dowelling parameters, slab size and base ground are studied by comparing test sections two by two. Each section has an instrumented slab. These slabs are aligned along a common joint (reference joint); in this way, one simulator trajectory allows the responses of the various slabs to this loading to be compared under identical conditions (especially thermal).



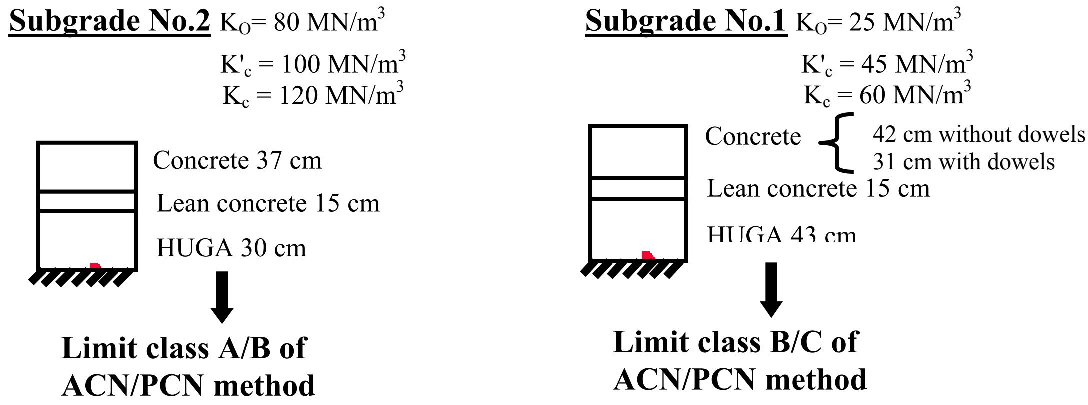
- **Two portions at each end dedicated to the fatigue tests**. The added sections have offsets; thus, one simulator trajectory will load a structurally identical section both at the joint edge and in the centre of the slab.



- **Two additional sections used to store the simulator have been added at the ends.**

The weakest category of experimental sections has been chosen so that the base ground will be "reconstructable". The limit of categories B and C has been chosen, that is K_C = 60 MN/m^3 and K_0 = 25 MN/m^3 (corresponding to a CBR = 3 which had already been difficult to reconstruct for the flexible PEP).

For coherence reasons, the second category chosen corresponds to the limit of categories A and B which has been retained, that is K_C = 120 MN/m^3 and K_0 = 80 MN/m^3.



3.3. INSTRUMENTATION

Goals - Principles chosen

The instrumentation must allow a dual goal to be attained:

- knowledge of the deflections of the complete structure (loaded slab and adjacent slabs to evaluate load transfers) and of the stresses in the slab (mainly at the base) during the loading tests,
- knowledge of the displacements of the slab under thermal loading alone. The aim here is mainly to measure the displacements of the surface concrete slab in relation to its base ground in compliance with the schematic diagrams given in paragraph.

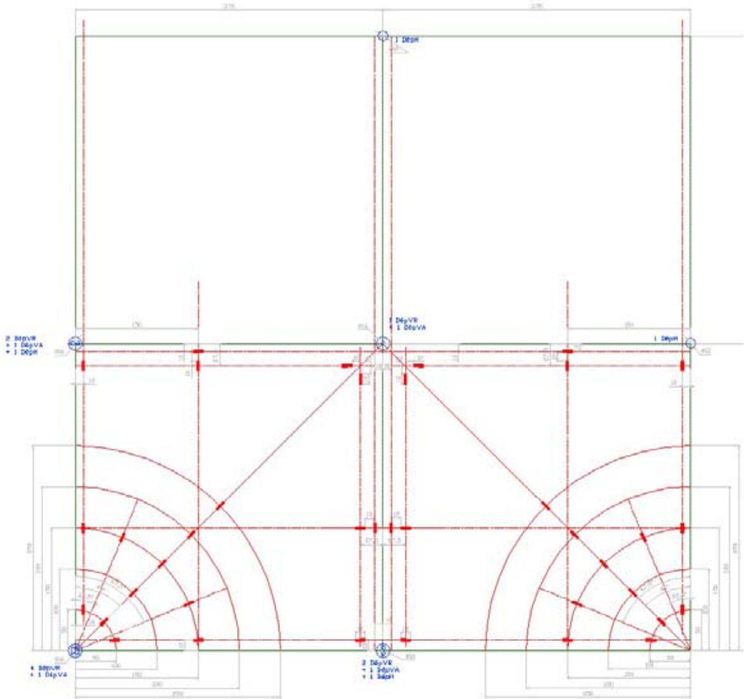
Knowledge of the stresses is obtained thanks to the measurement of the strains at the base of the slab using strain gauges.
The deflections are measured using LVDTs.

As the number of acquisition channels is obviously limited, the transducers and gauges were placed in theoretically the most "interesting" zones of the slabs (corner, longitudinal and transverse edge, centre, etc.).

The sensors chosen for the displacement measurements are LVDTs (*Linear Variable Differential Transducers*).

The travel of the sensors used (made by SOLARTRON) for the vertical displacement measurements is +/- 10 mm. The installation principle is the 1/2 bridge principle. The average sensitivity is 33.39 mm/mV/V.

The travel of the sensors used (made by HBM) for the horizontal displacement measurements is +/- 5mm. The installation principle is the 1/2 bridge principle. The average sensitivity is 9.99 mm/mV/V.



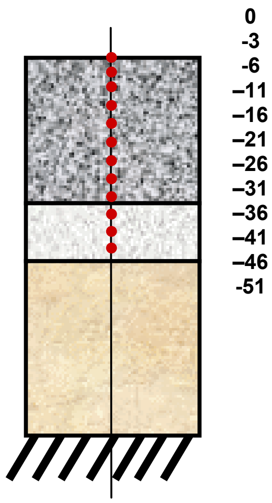
Instrumented Slab 93 – Dimensions of gauges and sensors.

These sensors are then installed on a frame attached to a plate embedded in the lean concrete through which passes a rod anchored 7 m deep. A first sensor (VA: *absolute vertical*) measures the vertical displacements of the frame (and therefore the lean concrete) in relation to the reference at -7 metres. Then, from one to four sensors according to the positioning of the system in relation to the slab (VR: *relative vertical*) measure the vertical displacements of the instrumented slab (and of the adjacent slabs) in relation to the frame (and therefore in relation to the lean concrete).

The sensors chosen for the strain measurements in the surface slab are strain gauges installed on a sensor consisting of a proof body (steel rod) and two attachment surfaces. This sensor is installed on steel supports embedded in the lean concrete.
These sensors were manufactured by the Bordeaux Laboratoire Régional de l'Equipement. The installation principle is the complete bridge principle. Identical gauges were bonded (without the sensor) at the top of the lean concrete. The installation principle is the 1/4 bridge principle, the rest of the bridge being installed at edge of test runway.
The average gauge factor is 300 µstrain/mV/V.

The sensor rod to which the strain gauges are attached is located 4 cm from the lean concrete to allow the concrete (reminder: granulometry 0/20 mm) to pass under the support.

Monitoring temperatures
On account of the importance of the effect of the temperatures on the movements of the slabs, many gauges were installed to monitor changes in temperatures on a profile in the body of the pavement. To ensure redundancy, two profiles were installed.



The temperature gauges used were Pt 100s (accuracy: 0.01°C), calibrated after 24 hours of immersion.
The profile was reconstructed in a concrete core sample then sealed with mortar in a test runway core drilling.

Acquisition unit
The acquisition unit must correspond to the general instrumentation philosophy, that is, allow acquisition of the responses of the sensors of the four-instrumented slabs under a same load on the test runway. Also, in order, on the one

hand, to facilitate analysis and avoid possible file concatenation errors and, on the other hand, to allow tests to be conducted by a single operator, it was decided that all instrumentation would be managed by a single acquisition unit (except for temperature data).

4. STATIC AND FATIGUE TESTS

4.1. STATIC TEST CAMPAIGN

General Description

The static campaign was started on 14 December 2001 and ended on 07 October 2002. Eleven different configurations were tested using the simulator. Additional static tests were performed during the fatigue campaign (especially in March 2003).

To individually isolate the various pavement design parameters (dowels, slab area, thicknesses, etc.), each trajectory was defined over the complete length of the pavement (vertical overrun of the instrumented slabs for near environmental conditions).

The geometrical discontinuity of the rigid pavements directly influences the type of test procedure itself and the abscissa of the trajectories will be defined according to these particularities. Indeed, the value measured by a gauge is valid only at this point.

This has two direct consequences on the static test procedure:

- ✈ A trajectory can be broken down into several sub trajectories spaced several centimetres apart in order to find maximum strain on a specific gauge.
- ✈ All trajectories are referenced in relation to pavement discontinuities (in this case in relation to the longitudinal joint).

Certain additional acquisitions consisted in purely static stops of the configurations at positions defined in relation to the longitudinal and transverse joints (dynamic and static behaviour of a slab).

Taking the temperature into account in the analysis sometimes results in the repetition of a defined trajectory (or a complete test procedure) under various thermal gradients (in practice, at different days or times).

These various particularities led us to define a specific formalism to identify a trajectory.

Trajectory designation format

The various configurations range from the single tandem to the aircraft configuration using up to four bogies. Thus, the trajectories can be defined by an abscissa Y in relation to the free edge of the runway or in relation to the reference joint.

Some of these abscissas Y are constant and identify an axle-reference joint distance irrespective of configuration bogie track.

The other trajectories identify a specific position of the tyres in relation to the reference joint (external footprint of the tyre tangent to the joint, etc.). The abscissas of these trajectories vary according to the track of the modules.

Why a reference load?
Like the flexible campaign, a reference load is used throughout the complete rigid campaign.

The recording of the strain gauges for two configurations is necessarily staggered over a more or less long time interval. During this period, the general behaviour of the pavement changes under the effects of variations in the experimental conditions. This can be a variation in the temperature but also a change in the behaviour of the structure due to the post-compaction effects of certain materials, etc..

The need for an objective comparison of the various configurations requires a so-called temporal harmonisation of the signals. The aim is, on the one hand, to correct the measurements of the environmental effects and, on the other hand, to evaluate the influence of these environmental effects on the behaviour of the pavement (recording of thermal gradients in the pavement).

The temporal harmonisation consists in the analysis of constraints measured by all gauges for a load which remains unchanged throughout the complete static campaign. This specific load is called the reference load.

The reference load is a two-wheel bogie (tandem), without shock absorbers, loaded by 25 metric tons per wheel (internal pressure 1.29 MPa), with a track of 1400 mm. This reference module corresponds to configuration G1_2, it is hauled by the Scania truck of the S.T.B.A.

Unlike the flexible campaign, the geometrical discontinuity of a rigid pavement prevents all spatial harmonisation.

Reference load procedure
The use of the two-wheel module (M2) with a different track or load during sub configurations G1 did not allow us to use the reference tandem for configurations G1_1, G1_3, G1_4 and G1_5.

The reference module was used systematically from configuration G2.

At start of day,

- Overrun at T3 called structure installation without acquisition,
- Two overruns at T3 with acquisition,
- One overrun at T6.

The reference module makes overruns in direction S1 and returns to 547 cm from free edge.
The tests were then performed by the configuration (simulator or hauled M4 module) and, at end of day, the reference module made an overrun at T3 then an overrun at T6 (return to 547 cm from free edge).

We consider that after each interruption in the day of more than one hour (scheduled or unwanted interruptions), the reference module made an overrun at T3 and an overrun at T6 (return to 547 cm from free edge).

Configurations
The aim of each configuration is to evaluate, on the one hand, the influence of one of the changing parameters of the load and, on the other hand, the influence of the various parameters of the pavement itself. Therefore, all procedures have a constant part (to understand the dynamics of the pavement) and a specific part (to evidence the influence of the changing parameter of the load).

Configuration G0 corresponds only to a preparation of the structure for running or installation of slabs.

Configuration G1 tests the effects of the wheel track and the load (two wheels bogie).

Configuration G2 tests the effects of the wheel base, load and type of bogie (four-wheel or six wheels bogie).

Configuration G8 is the first aircraft configuration (1/2 B777-300ER / 1/2 A340-600) and in reality corresponds to a specific case of configuration G2.

Configuration G4 tests the interaction between the bogies by simulating 2/3 to 3/3 of the A340-600 main landing gear.

Configurations G5/G6/G7 correspond respectively to A380- 800/800F/Ultimate.
They give aircraft data and enhance the bogie interaction effects.

Configuration G9 corresponds to the MD11.

Configuration G9 corresponds to the B747-400.

Several additional tests to improve the understanding of specific points were conducted at the end of the static campaign.

All configurations were equipped with the same tyres 1400 x 530R23 PR36. Tyre inflation pressure[1] was adjusted to conserve the net contact surface of the operational case.

Preconditioning configuration
The aim of the configuration G0 was to obtain the opening of the joints of the concrete surface course.

Configuration G0 corresponds to overruns with bogie B747-400 (4-wheel module) loaded by 20 metric tons per wheel, hauled by the SCANIA truck or by overruns of the Scania truck alone (7 metric tons per wheel on rear axle).

Two trajectories were defined. Trajectory 1 passes on either side of the instrumented strip and trajectory 2 passes via the instrumented strip of both sides. These trajectories are made over the complete length of the test zone and the return manoeuvres are made on storage zones. Configuration G0 runs alternatively between trajectory 1 and trajectory 2.

On account of the two slab sizes (5 m and 7 m 50), G0 is offset to run at 50 cm from the joint when approaching the 5 x 5 m slab zone.

Load and Track effects
Configuration G1 corresponds to the 2-wheel module (M2). The module is hauled by the SCANIA truck.

The aim of this configuration is to test the effects of variations in load and track. It is broken down into 5 sub configurations as follows:

			Bogie B1				
Family	Configuration	Number of bogies	Number of wheels	Track (cm)	Base (cm)	W/wheel (tons)	Pnz B1 (bars)
G1	G1_1	1	2	**130**	0	**25**	12.9
G1	G1_2SG	1	2	**140**	0	**20**	**10.3**
G1	G1_2	1	2	**140**	0	**20**	12.9
G1	G1_3	1	2	**140**	0	**25**	12.9
G1	G1_4	1	2	**140**	0	**30**	15.4
G1	G1_5	1	2	**150**	0	**25**	12.9

For each sub configuration, we did the usual trajectories. The trajectory, which produced the maximum elongation, was then selected and we wandered around this trajectory at dimensions –20, -10, 0, +10, +20 cm.

We repeated the operation for other gradients.

For slab 93 (two 1/4 instrumented) certain favoured trajectories were taken by five configurations G1 in opposite direction.

Several diagonal or transverse trajectories are also made.

To complete tests G1, additional tests consisted in acquiring data during a purely static position (or stop) of the module.

Base and Bogie type effects
Configuration G2 corresponds to the simulator equipped with a four-wheel bogie and a six-wheel bogie. The two modules are spaced around 10 metres apart to prevent all bogie-bogie interactions on a given slab. The aim was to test the load and base effects of these types of bogies.

For the two bogies, we have:

- G21 : Load 20t / Base1700mm
- G22 : Load 25t / Base 1700mm
- G23_1 : Load 30t / Base 1700mm
- G23_2 : Load 28t / Base 1700mm
- G24 : Load 25t / Base 1600mm
- G25: Load 25t / Base 1800mm

The procedure for configuration G2 is similar to that for G1. Alternating between the four-wheel module and the six-wheel module was done per trajectory and not per overrun, that is, if there was a repetition of a given trajectory for a module, the 2 or 3 overruns of this module were done and then the overruns with the other module started.

Additional tests were defined to specify the mechanical behaviour of the joints on the overrun of the load for the two-, four- or six-wheel bogies.

For this, two favoured trajectories were retained: T3 and T6 and, for each trajectory, we defined several positions to be taken into account to do the pure static acquisitions. These positions were identified from the free edge of the slab to the axle centreline. They can be defined according to the instrumentation (vertical to a gauge) or according to the edge of the slab (tyre footprint tangent to the joint).

Module stopping accuracy was to within 0.5 of a centimetre.

We then made successive two, four and six wheel overruns on trajectories T2 and T6. The next configurations simulate aircraft landing gear. It aims to estimate the bogie interaction (A340-600 tests), to compare several aircraft between them and compare the data with 3D FEM CESAR (theoretical data).

5. FATIGUE TEST CAMPAIGN

The fatigue test campaign has been initiated in October 2002 on the same rigid runway than the static test.

The fatigue campaign aims to compare damage between A380-800F (600 tons version) and B777-300ER. The simulator is equipped with four bogies (One 4-wheels and three 6-wheels). It simulates ¾ of the A380 main landing gear and a half of the B777-300ER main landing gear.

The distance between the B777 bogie and the A380 is a compromise between runway width and simulator technical parameters. This distance must be sufficiently large to avoid any interference between the aircrafts. It was fixed at exactly 9.666m to simulate the same loading case between the second A380 6-wheels bogie and the B777 bogie, on 7.5x7.5m slabs section.

Because the runway was used during the static campaign, the trajectory was fixed on strip not often run during the static tests.

The different section offsets (see figure page 8) allow a straight-line trajectory to simulate several loading cases for the same environmental parameters.

So far, 3000 passes have been done. First fatigue damages have appeared.

6. CONCLUSION

As a first result of this research, a very complete full scale under operational condition database has been obtained. First it permits a complete understanding of landing gear simple geometrical effects (Wheel base, Wheel track, Loads and pressure). Then it will permit to compare different struts (6-wheels, 4-wheels, or tandem bogies) and to understand bogie interaction on aircraft landing gear. It secondly gathers sufficiently data to compare the different rigid pavement parameters under large aircraft loading cases. It provides information for airport pavement design too. Thirdly, the fatigue campaign will bring important data to compare damage between the B777-300ER and the A380-800F related to the different sections. Finally, the whole campaign will permit 3D FEM Models calibration to allow simulation.

The analysis of rigid phase results is still continuing and the fatigue tests are still underway. The finally results will be presented later.