CEDEX TRACK BOX (CTB)

GENERAL DESCRIPTION

CEDEX Track Box (CFC) is a 21 m long, 5 m wide and 4 m deep facility whose main objective is to test, at 1:1 scale, complete railway track sections of conventional and high speed lines for passenger and freight trains, at speeds up to 400 km/h.

The testing facility was designed, built and developed as part of SUPERTRACK (“Sustained Performance of Railway Tracks”, 2001-05) and INNOTRACK (“Innovative Track Systems”, 2005-2009) projects funded by the European Union Fifth and Sixth Framework Programs, respectively. Figure 1 shows a general view of the testing facility.

Its principal advantage is the possibility of performing fatigue tests in a fast way as in one working week, the effect of the passing-by of trains during a year in a real section can be modelled.

The reproduction of the effect of the approaching, passing-by and departing of a train in a test cross-section, as it occurs in a real track section, is performed by application of loads, adequately unphased as a function of the velocity of the train which is being simulated, produced by three pairs of servo-hydraulic actuators (that can apply a maximum load of 250 kN at a frequency of 50 Hz), placed on each rail and 1.5 m longitudinally separated, as seen in Figure 2.

Furthermore, the reproduction of wheel and track imperfection effects that produces low amplitude high frequency dynamic loads can also be carried out by the use of two piezoelectric actuators that can apply loads up to 20 kN at 300 Hz.

The railway track response, in terms of displacements, velocities, accelerations and pressures, is collected from a great number of linear variable differential transformers (LVDTs), geophones, accelerometers and pressure cells installed inside both the embankment and the bed layers (ballast, sub-ballast and form layer) of the track.

On the other hand, the railway superstructure response is recorded with mechanical displacement transducers, laser sensors, geophones and accelerometers installed on the different track components (rail, sleeper and railpad). The acquisition data unit can receive information from 150 sensors at the same time.
Figure 1: General view of the testing facility

Figure 2: View of the loading system formed by three pairs of hydraulic actuators
Figure 3: View of the piezoelectric actuators to simulate the effect of track imperfection

Figure 4: View of the surface instrumentation installed in one test
Figure 5: CTB cross-section with some of the internal sensors installed for one of the tests

Figure 6: View of the motors of the hydraulic system with a power of 350 CV each to generate a pressure of 210 bars and a flow of 1800 l/min
Figure 7: View of the tamping machine adapted to be used in CTB

Figure 8: Tool to perform lateral resistance tests mounted on a sleeper
APLICATIONS

CEDEX Track Box, as testing facility, allows the performance of different kinds of tests on 1:1 scale models of track sections with different characteristics.

Characteristics of the 1:1 scale models

The 1:1 scale models that can be built in CTB can have the following features:
- Tests on ballasted or slab tracks.
- Tests on sections in straight line or in curve.
- Tests on switches and crossings.
- Tests on transitions zones.
- Tests with different kinds of ballast, subballast, form layer or embankment.
- Tests with standard, polyvalent and three-rail sleepers.
- Tests with new materials: sleepers with USP, under ballast mats, artificial ballast, bituminous subballast, geotextiles and soils treated with lime or cement.

Kind of tests to be performed

The tests that can be performed in CTB can have the following features:
- Tests with passenger and freight trains.
- Tests with static loads to determine track stiffness.
- Tests with quasi-static loads to simulate the pass-by of trains at speeds up to 400 km/h.
- Tests with dynamic loads to simulate the effects induced by track irregularities.
- Test to determine the fatigue behaviour of any track component (mainly, fastening system, ballast, subballast) by the simulation of pass-by of millions of axle trains.
- Tests on vibration propagation.
- Tests to determine the lateral and longitudinal track resistance.

Analysis of results

The test results can be used to:
- Analyze the short and long term behaviour of railway track sections submitted to any kind of train traffic and
- Calibrate 3D numerical models to be used in other type of studies or to widen the aim of the tests.

Additionally, in the Laboratorio de Geotecnia – CEDEX, a Soil and Rock Mechanic Laboratory fully equipped with large test devices, situated in the same location, the following tests can be performed:
- Geomechanical tests on ballast, subballast and other ground materials.
- Test of the sleeper-ballast contact.
- Mechanical tests on elastomeric materials.
EUROPEAN PROJECTS

• SUPERTRACK (2001-05) “Sustained performance of Railway Tracks” in the frame of 5th European Framework Program.
  http://cordis.europa.eu/project/rcn/63386_en.html

Experience with high-speed train in recent years has demonstrated unexpected settlement problems at certain sections of railway lines. This has caused railway companies expensive maintenance work and has become a concern in expanding high speed services which provide effective and environment-friendly transportation. The objectives of the project are: i) improving performance of railway ballasted tracks and reducing maintenance costs by understanding the dynamic and long-term behaviour of ballast using large-scale laboratory tests, ii) identifying weak portions of the railway network for retrofitting these locations by innovative, cost effective methods without interrupting train operation, iii) devising a global numerical model accounting for train-track interaction and non-linear behaviour of track components for a more reliable and cost effective design.

• INNOTRACK (2005-09) “Innovative Track Systems” in the frame of 6th European Framework Program
  http://cordis.europa.eu/result/rcn/47369_en.html

The INNOTRACK project concentrated on research issues that contribute to the reduction of rail infrastructure life cycle cost (LCC). The main objective of INNOTRACK has been to reduce the LCC, while improving the reliability, availability, maintainability and safety (RAMS) characteristics. INNOTRACK has been a unique opportunity bringing together rail infrastructure managers (IM) and industry suppliers, the two major players in the rail industry. One of the biggest challenges for railways in Europe is that track costs, the major cost component for infrastructure managers (IMs), have not significantly decreased in the last 30 years. Therefore, the main objective for INNOTRACK is to reduce costs, decrease disturbances and increase availability. In addition to the issues of cost and availability, also noise pollution has become a crucial issue for railway operations.

• RIVAS (2009-13) “Railway Induced Vibration Abatement Solutions” in the frame of 7th European Framework Program
  http://www.rivas-project.eu/

RIVAS aims at reducing the environmental impact of ground-borne vibration from rail traffic while safeguarding the commercial competitiveness of the railway sector. For several areas of concern, vibration should be reduced to the threshold of annoyance or even below. The project's goal is therefore to provide tools to solve vibration problems for surface lines by 2013.

It therefore aims to contribute to the development of relevant and leading technologies for efficient control of people's exposure to vibration and vibration-induced noise caused by rail traffic.
• FASTRACK (2013-2014) “Nuevo sistema de vía en placa para alta velocidad sostenible y respetuoso con el medio ambiente” in the frame of Spanish CDTI Research Programs. (http://www.fastrack.es/)

El objetivo principal del proyecto FASTRACK es el desarrollo de un nuevo sistema de vía en placa, focalizado para ser utilizado en líneas ferroviarias de Alta Velocidad (velocidades por encima de los 250 km/h), sostenible tanto económica como medioambientalmente. Para ello, el proyecto propondrá innovaciones en diseño y materiales que le permitirá al nuevo sistema de vía en placa:

• Abordar una fabricación asequible y medioambientalmente sostenible.
• Lograr una rápida puesta en obra, alcanzando mayores rendimientos en su construcción.
• Conseguir una máxima eficiencia de recursos, tanto en su fabricación como puesta en obra.
• Disponer de elementos que minimicen al máximo la afección social que tiene la producción de ruido y vibraciones del tránsito ferroviario.
• Necesitar de un bajo mantenimiento, aumentando las horas de disponibilidad de explotación de la infraestructura.
• Requirir de una fácil y rápida reparación en el caso de ser necesario, evitando largos cortes de vía.
• Alcanzar una considerable reducción del coste del ciclo de vida.


CAPACITY4RAIL aims at paving the way for the future railway system, delivering coherent, demonstrated, innovative and sustainable solutions for:

• Track design: transversal approach for infrastructure solutions for conventional mixed traffic and very high speed, integrated monitoring and power supply, reduced maintenance, new concept for highly reliable switches and crossings.
• Freight: longer trains, lower tare loads, automatic coupling, enhanced braking, modern, automated, intelligent, fully integrated system for efficient, reliable and profitable freight operations
• Operation and capacity: traffic capacity computation for freight and passenger, models and simulators for planners: capacity generation, traffic flow, resilience to perturbations, ability to recover from disturbance, computerized real time information to customers and operators at any time
• Advanced monitoring: Integration of Advanced Monitoring Technologies in the design and building process, for an easier-to-monitor (self-monitoring) infrastructure with low cost and low impact inspection.

The full sustainability of the developed solutions and innovations will be assessed and scenarios for a smooth migration of the system from its current to its future state will be evaluated
TESTS PERFORMED

The following tests have been performed at CEDEX Track Box:

- Determination of fatigue curve of ballast and sub-ballast material.
- Analysis of the optimum thickness of bituminous sub-ballast.
- Study of the propagation of vibration through the track bed and embankment.
- Study of the effect of fouling with sand in the behaviour of the ballast layer.
- Homologation tests of prototypes of slab tracks.
- Study of the effects of very high speed (up to 400 km/h) in the mechanical behaviour of track beds.

Figure 9: Ballast fatigue curves obtained for different track conditions

Figure 10: Rail deflection obtained in CTB tests as a function of train speed
Figure 11: Time histories of rail deflections obtained in CTB tests as a function of train velocity
### Duties

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