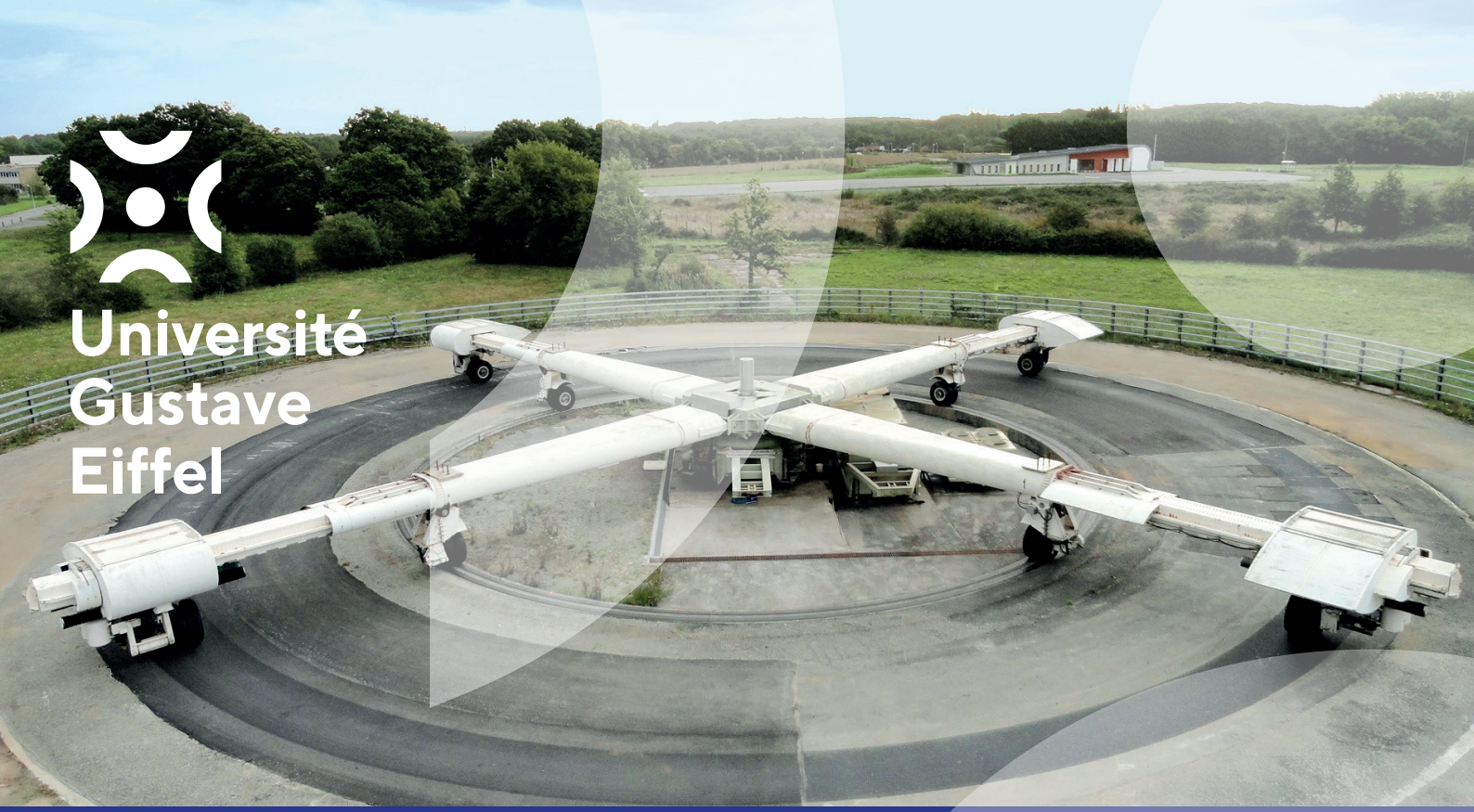


Université Gustave Eiffel

A major facility of Université Gustave Eiffel

THE PAVEMENT FATIGUE CAROUSEL

An exceptional accelerated pavement testing simulator

The fatigue carousel of Université Gustave Eiffel is an accelerated pavement testing simulator designed to study the full-scale behavior of pavements under accelerated heavy traffic loading. Commissioned in 1984, over 130 pavement structures have been tested to date, in partnership with industry stakeholders.

With a diameter of 40 m, the facility is capable of applying loads exceeding 13 tons, positioned at the end of the loading arms, at speeds up to 100 km/h. Two months of continuous operation can simulate up to 20 years of heavy-vehicle traffic on a medium-traffic pavement structure (T3: 150 heavy vehicles per day), corresponding to approximately one million load applications. The experimental campaigns may focus on newly constructed pavement structures incorporating innovative materials, as well as maintenance and reinforcement techniques, in addition to various road infrastructure components and pavement monitoring or diagnostic systems.

Owing to its performance characteristics (a 120-m long test track and loading speeds of up to 100 km/h), it is one of the largest facilities of its kind worldwide.

The Carousel

The carousel consists of a central rotating tower and four radial arms, at the ends of which moving loads can be mounted to reproduce the axle configurations commonly encountered in heavy vehicles (single or dual wheels mounted on single, tandem, or tridem axles).

An intermediate support located at the mid-span of each arm and rolling on a reinforced concrete ring ensures arm stability while limiting dynamic overload effects. The running gear positioned at the end of each arm is equipped with an original low-stiffness suspension system, enabling precise control of the loads applied to the experimental pavement structures regardless of their level of deterioration. During carousel operation, the loads can be laterally shifted to simulate the transversal distribution of real traffic.



Dual-wheel half-axle © Myr MURATET

The test tracks

The site comprises three test rings, allowing the carousel to be moved from one configuration to another within one week. The tracks have an average radius of 17.5 m, and the pavement width is 6 m. The running gears can be mounted at different effective radii along the arms (from R = 15.50 m to R = 19.50 m). Each ring has an average circumference of 110 m, which can be subdivided into several test sectors dedicated either to a single research topic or to multiple independent studies.

One of the rings is equipped with a 3 m-deep and 10.40 m-wide concrete basin, filled with clayey sand and fitted with pumping systems enabling control of the groundwater table within the subgrade of the experimental pavements. The groundwater level can be varied during testing to reproduce seasonal hydrological cycles.



Aerial view of the three test tracks © Antoine SOHM



Concrete basin for groundwater table control © LAMES

Pavement construction

The tested pavements are constructed using conventional road construction equipment.





Construction of a test track on the fatigue carousel © LAMES

Instrumentation and monitoring of pavements

The pavement structures are instrumented during construction in order to monitor their evolution over time. The parameters commonly measured include pavement deflection, longitudinal and transverse strains in bound material layers, vertical strains in unbound layers, and temperature. Additional sensors may be employed for specific applications, such as accelerometers, geophones, moisture probes, optical fibers, and others.

The pavements are also monitored through visual inspections and non-destructive testing techniques. The measurements routinely performed include deflections using the Benkelman beam and the Falling Weight Deflectometer (FWD), transverse profile measurements (rut depth assessment), and crack surveys. Ground-penetrating radar investigations are also conducted, both conventionally to determine pavement layer thicknesses and to detect material evolution or deterioration.

The dimensions of the test track allow the use of most road inspection equipment. Instrumentation and monitoring techniques are adapted for each experimental campaign. Collaborations with other research teams located on the Nantes campus of Université Gustave Eiffel enable numerous additional measurements to be carried out, including rolling noise, texture and skid resistance, and particle emissions. Mechanical characterization tests are systematically performed on the materials.



Deflection measurements performed using a Falling Weight Deflectometer (FWD) © LAMES

Technical specifications

Installed power: 650 kW
Wide single-wheel load: 45 kN
Dual-wheel load: 65 kN
Tandem single-/dual-wheel loads: 90 kN/130 kN

Tridem single-wheel load: 135 kN
Maximum speed at R = 19 m: 100 km/h
Maximum daily traffic: 55 000 loadings at 70 km/h
Transverse wandering: +/- 52 cm (adjustable for reduced wandering)

In 2022, the former engines were replaced with electric motors. Studies and measurements indicate a reduction in energy consumption of approximately 30 to 50% (depending on speed), which is substantial. This work was co-funded by the European Regional Development Fund and Université Gustave Eiffel.

UNION EUROPÉENNE
RÉGION PAYS DE LA LOIRE
Université Gustave Eiffel
CE PROJET EST CO-FINANCÉ PAR LA RÉGION ET LE FONDS EUROPÉEN DE DÉVELOPPEMENT RÉGIONAL

Application Areas of the Carousel

Accelerated pavement testing allows to investigate the long-term behavior of pavements under real loading conditions within significantly reduced timeframes (typically ranging from 3 to 6 months). Such testing is essential for the validation of road innovations and for research purposes, as it enables the investigation of pavement deterioration mechanisms, the validation of predictive models, and the development of advanced monitoring and instrumentation techniques.



Testing a charging rail for electric heavy-duty trucks © LAMES

Common fields of investigation include:

- Testing of new materials and innovative pavement structures
- Validation of pavement design models,

However, the experimental capabilities extend far beyond these applications, including:

- Maintenance and reinforcement techniques
- Evolution of surface characteristics
- Pavement structures dedicated to public transport systems
- Road components and ancillary equipment subjected to traffic loading (utility trenches, manhole covers, etc.)
- Evaluation of monitoring and instrumentation methods
- Innovative infrastructure systems (vehicle charging technologies, energy harvesting systems)

Accelerated testing thus helps address the needs of future road infrastructures:

- Improvement of durability and resilience to climate change
- Development of materials that are more resource- and energy-efficient
- Adaptation to new vehicle technologies (electric, autonomous vehicles, etc.)



Testing removable urban pavement slabs © MIT

Multiple partnerships

Road construction companies: Colas, Eiffage, Vinci Construction

ANR projects: Recyroute, Soldugri, Binary

European projects: BioRepavation, NEMO

PIA project: CAYD (electric roads)

Urban and composite pavements: Alstom, Bombardier, Saint-Gobain, Gaz de France, Tensar, 6D Solutions, EJCO

Material producers: Shell, Total Energies, UNPG (National Union of Aggregate Producers)

Stakeholders in the cement industry and concrete pavements: SPECBEA, France Ciments

Direction générale des infrastructures, des transports et des mobilités (DGITM)

Association des sociétés françaises d'autoroutes, ASFA

Ministère des Transport du Québec.

Contacts

Université Gustave Eiffel

LAMES
LABORATOIRE AUSCULTATION, MODÉLISATION, EXPÉRIMENTATION DES INFRASTRUCTURES DE TRANSPORT

Juliette BLANC
juliette.blanc@univ-eiffel.fr

Mai-Lan NGUYEN
mai-lan.nguyen@univ-eiffel.fr

Allée des Ponts et Chaussées,
CS 5004
44344 Bouguenais Cedex
France