# COURSE DESCRIPTION
# SUSTAINABLE ROAD MATERIALS

# SSD: STRADE, FERROVIE E AEROPORTI (ICAR/04)

DEGREE PROGRAMME: TRANSPORTATION ENGINEERING AND MOBILITY (P55)
ACADEMIC YEAR 2022/2023

## COURSE DESCRIPTION

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## GENERAL INFORMATION ABOUT THE COURSE

INTEGRATED COURSE: NOT APPLICABLE
MODULE: NOT APPLICABLE
CHANNEL: FG A-Z
YEAR OF THE DEGREE PROGRAMME: I
PERIOD IN WHICH THE COURSE IS DELIVERED: SEMESTER II
CFU: 9

### REQUIRED PRELIMINARY COURSES

None

### PREREQUISITES

None

### LEARNING GOALS

*The course provides extensive knowledge and analysis methodologies to design asphalt blends for bearing and base layers of a road/railway pavement and for the subbase unbound layers, focusing on all laboratory tests and on-situ procedures for accepting the mixtures. Rigid pavements are also analysed, dealing with general principles for laying runways and airport aprons.One of the main scopes is addressed to the mix design of traditional bituminous blends (hot mix asphalt) and alternative ones where a) virgin aggregates are replaced partly or totally with waste or local resources, b) neat bitumen is modified with polymers, c) warm-cold production*

*technologies are used.The study program is structured to provide theoretical knowledge and practical tools oriented to a sustainable approach for designing and testing road pavements blends, comparing different scenarios of production, construction, and maintenance to a reference case involving the use of common paving materials; mechanical performance and life cycle assessment (LCA) is investigated.This way, it is possible for the students to accomplish the course's main objectives, focused on methodological-laboratory approach for designing road pavement mixture, promoting advanced maintenance management support systems and an "end-of-waste" vision into the whole design process.*

## EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

**Knowledge and understanding**

*Students will acquire methodical and practical knowledge necessary for the design, construction and maintenance of superstructures. The bases will be defined for a correct management and planning of sustainable interventions, with reduced environmental impact, necessary to maintain the efficiency of the pavements for an effective maintenance of the mechanical and comfort performance during the expected useful life.*

**Applying knowledge and understanding**

Ability in the design of road pavements

## COURSE CONTENT/SYLLABUS

*General principles*
*•Historical Developments*
*•Pavement Types*
*•Design Factors*
*•Design Procedures*
*•Equivalent Single-Wheel Load*
*•Equivalent Axle Load Factor*
*General principles of Flexible Pavement Design*
*•Mechanistic Design Procedure*
*•Asphalt Institute Method*
*•AASHTO Method*
*Rigid Pavement Design*
*•Mechanistic Design Procedure*
*•AASHTO Method*
*•Continuous Reinforced Concrete Pavements*
*Asphalt binder*
*•Chemical composition of asphalt*
*•asphalt binder tests*
*•Superpave binder ageing procedures (Rolling Thin Film Oven, Pressure Aging Vessel)*
*•Superpave binder tests (Dynamic Shear Rheometer, Rotational Viscometer, Bending Beam Rheometer, Direct tension Tester)*

*Binder grade selection*

*•Superpave performance grades*

*•Air temperature selection*

*•Binder grade selection Based on Pavement Temperatures*

*•Adjusting Binder Grade Selection for Traffic Speed and Loading*

*Superpave Mix Design*

*•Test equipment: Superpave gyratory compactor*

*•Select design aggregate structure*

*•Specimens' preparation and compaction*

*•Data analysis*

*•Design asphalt binder content*

*•Moisture sensitivity*

*Marshall Mix Design*

*•Test equipment: Marshall Impact Compactor*

*•Select design aggregate structure*

*•Specimens' preparation by selecting at least four percentages of binder and compaction*

*•Marshall Stability curve*

*•Marshall Flow curve*

*•Design asphalt binder content*

*Asphalt Mixture volumetrics*

*•bulk specific gravity*

*•apparent specific gravity*

*•effective specific gravity*

*•maximum specific gravity*

*•voids in mineral aggregate*

*•effective asphalt content*

*•voids filled with asphalt*

*Material Characterization of asphalt mixtures*

*•Indirect Tensile Strength*

*•Dynamic Modulus of Bituminous Mixtures*

*•Fatigue Characteristics*

*•Permanent Deformation Parameters*

*•Other Properties*

*Stresses and Strains in Flexible Pavements*

*•Theory of Elastic Layer Systems*

*•Comparison with Available Solutions*

*•Computer program*

*Reusing secondary raw materials*

*•practices and methods for testing the effects of polymer modified binders and polymer modified asphalt*

*•practices and methods for testing the effects of waste into asphalt mixtures*

*Pavement Performance EvaluationGeneral Principles of Life Cycle Assessment*
*•Definition of the four LCA Phases*
*•Performing an LCA*
*•Comparison of LCA with other environmental analysis tools*
*Inventory analysis of Emissions and Extraction*
*•principles of inventory analysis*
*•calculation and assessment of energy consumption and CO2 emissions*
*•input-output approach for extractions and emissions inventory*
*•coproducts and allocation*
*Life cycle Impact Assessment*
*•purpose and general principles*
*•steps of impact assessment: classification, midpoint characterization, damage characterization, normalization, grouping, weighting*
*•overview of the main Impact Assessment Methods*
*Interpretation of results*
*•Identification of priorities*
*•Uncertainty, variability and data quality*
*•Sensitivity study*
*•Application to product comparisons*
*Application to long term decision-making.*

## READINGS/BIBLIOGRAPHY

*Slides, lecture notes, technical papers.*
*Textbooks:· Yang H. Huang, Pavement Analysis and Design, Pearson, 2003.· Asphalt Institute, SUPERPAVE Performance Graded Asphalt Binder Specification and Testing, Superpave Mix Design. Superpave Series No. 1-2, 1997.· Faiq M. S. Al-Zwainy, Esam Hewayde, Firas Jaber, Pavement Maintenance and Management, Lulu Press, 2020.· Olivier Jolliet, Myriam Saade-Sbeih, Shanna Shaked, Alexandre Jolliet, Pierre Crettaz. Environmental Life Cycle Assessment, CRC Press; 1st edition (November 18, 2015)*

## TEACHING METHODS OF THE COURSE (OR MODULE)

Lectures, interactive tutorials, laboratory activities and exercises.

## EXAMINATION/EVALUATION CRITERIA

**a) Exam type**

☑ Written
☑ Oral
☑ Project discussion

☑ Other : There is a test during the middle of the course and at the end of the course an oral exam based on the discussion of the project work carried out during the course.
Written exam (first half of the course): consists of solving questions on the topics covered (General principles, General principles of Flexible Pavement Design, Rigid Pavement Design, Asphalt binder, Binder grade selection, Superpave Mix Design, Marshall Mix Design, Asphalt Mixture volumetrics, Material Characterization of asphalt mixtures).
Project work: technical report on the design of a road superstructure and its environmental characterisation through LCA analysis.
Oral exam: Oral presentation of the project work followed by questions of a technical nature regarding the second part of the course (Stresses and Strains in Flexible Pavements, Reusing secondary raw materials, Pavement Performance Evaluation, General Principles of Life Cycle Assessment, Inventory analysis of Emissions and Extraction, Life cycle Impact Assessment, Interpretation of results).

**In case of a written exam, questions refer to**

☐ Multiple choice answers

☑ Open answers

☐ Numerical exercises

**b) Evaluation pattern**

*The result of the **Written exam (first half of the course)** is positive if ³18/30. The result accounts for 40% of the final mark.*

*The **project work** accounts for 20% of the final mark.*

*The passing of the written test and the completion of the project work are access to the oral test*

*The **oral exam** accounts for 40% of the final mark.*