Escuela Técnica Superior de Ingeniería de Algeciras

UCA Universidad de Cádiz

TEP 976:

Structural Engineering and Geotechnics

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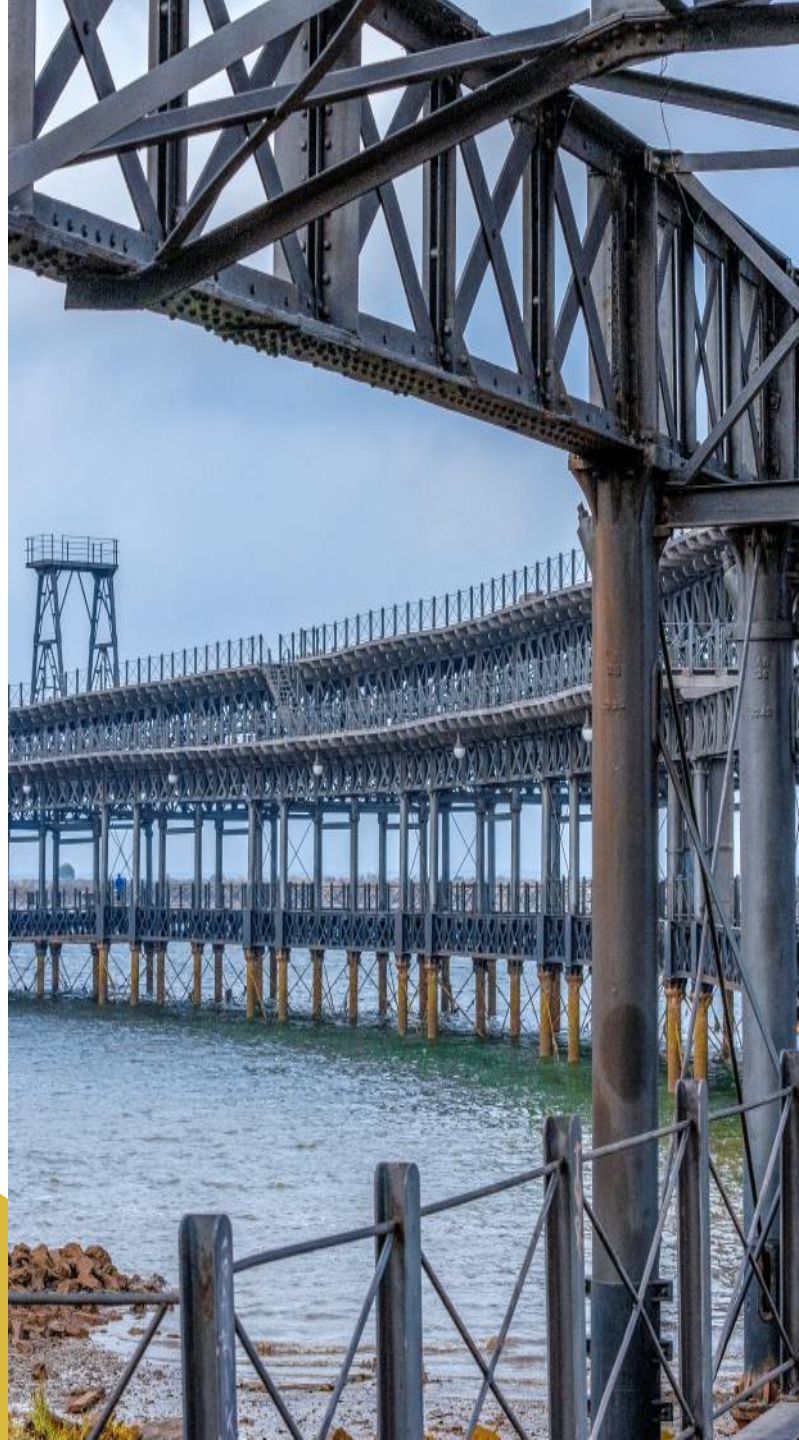


Lines of research

- Structural dynamics and earthquake engineering.
- Mechanical testing and structural characterisation of new sustainable materials for construction.
- Structure and interactions of geological materials and their processes, soil characterisation and behaviour, heritage.
- Structures and geotechnics.
- Study of structure-terrain interaction.
- Soil mechanics, tunnels, rock mechanics, mineral deposits, tectonics and urban planning.
- Sustainable structural and geotechnical engineering.
- Construction materials.
- Structural and geotechnical optimisation of infrastructures for sustainability.

Collaboration with other Universities

Cranfield University, United Kingdom

University of Milan, Italy

Zhytomyr Polytechnic State University, Ukraine

Kyiv Polytechnic Institute, Ukraine

University of Algarve, Portugal

University of Medellín, Colombia

Pontificia University Javeriana, Colombia

1 Field of research

- Physical, chemical and mechanical characterisation of different wastes in order to evaluate their possible valorisation.
- Development of sustainable building materials.
- Study and analysis of the different mechanical properties of materials.
- Mechanical modelling of materials, soils, rock masses, industrial parts, structures, etc.
- Determination of the carbon footprint produced by the manufacture of materials.
- Data analysis for structural optimisation using fuzzy logic techniques.

Physical, chemical and mechanical characterisation of different wastes.

The TEP 976 group has a multidisciplinary team in different disciplines. For this reason, one of the lines of research it develops is the characterisation of waste for its cataloguing according to regulations and for its use in new materials.

To do this, the physical properties of the waste, its chemical composition and its mechanical characteristics are determined, assessing whether it is a waste that is hazardous to the environment or whether it can be easily incorporated into other materials.

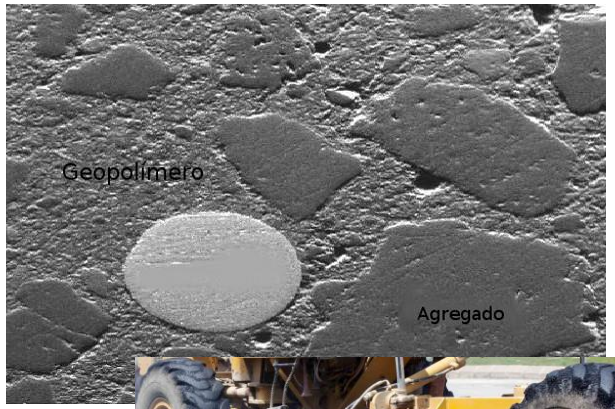
If the waste contains chemical elements of interest, these elements can be extracted through new environmentally sustainable hydrometallurgical techniques. These techniques allow a high percentage of the metallic element in the waste to be recovered.

On the other hand, if the waste is classified as hazardous, attempts are made to encapsulate it in new sustainable materials that incorporate it as a raw material and prevent it from leaching. In this way, landfill of the waste is avoided, the consumption of raw materials is reduced and the economic cost of the final material is reduced.

The wastes that have been investigated by the research group are:

- Iron and steel slag.
- Bottom ash from biomass.
- Biomass fly ash.
- Mining waste from abandoned mines.
- Contaminated soils.
- Wastes from agro-food industry.
- Acid waters produced by mining activities.

Development of sustainable building materials.



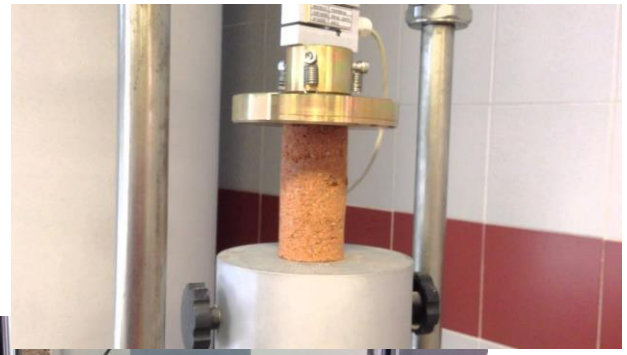
The development of sustainable materials for the construction sector, thanks to the incorporation of waste as raw materials for their formation or the use of production techniques with less environmental impact, has several advantages:

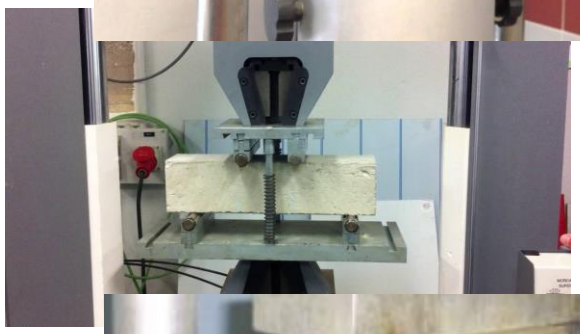
- The construction sector is one of the most polluting sectors, as it extracts large quantities of raw materials. The use of waste as a raw material avoids the extraction of virgin materials.
- The use of waste in new materials avoids the landfill of these materials, providing them with a new useful life. Circular economy.
- Reducing the consumption of virgin raw materials reduces the environmental impact.
- The cost of waste is usually very low, thus reducing the cost of the final material.
- The material developed must be able to encapsulate the possible polluting elements of the waste, preventing their leaching and contamination.

Based on this, the research group has shaped various sustainable materials for the construction sector. These include:

- Ceramics for bricks.
- Concretes and mortars.
- Geopolymers. Synthetic inorganic polymers of aluminosilicates resulting from an alkaline chemical reaction.
- Bituminous mixtures
- Polymers for thermal and acoustic insulation.

Study and analysis of the different mechanical properties of materials.





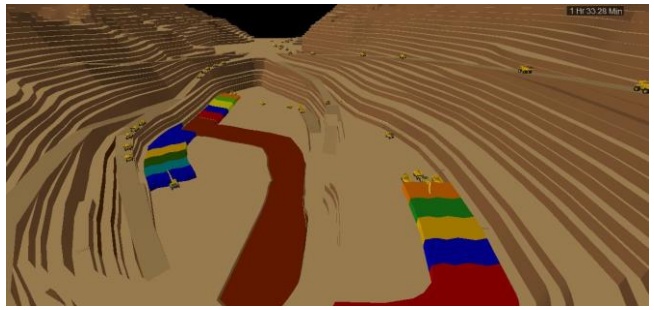
The TEP 976 research group has sufficient equipment and knowledge to determine the mechanical and physical properties of new sustainable materials developed with waste.

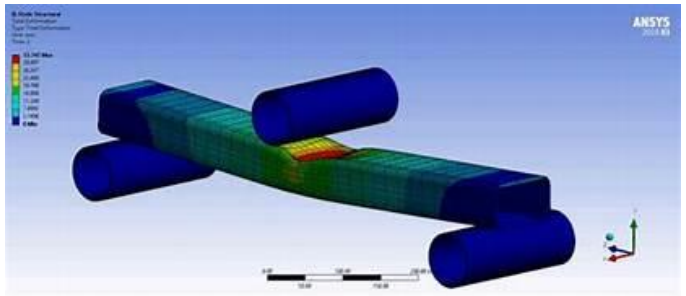
The determination of these mechanical and physical properties makes it possible to verify that the material developed complies with the corresponding current regulations and that, therefore, its manufacture and commercialisation is viable.

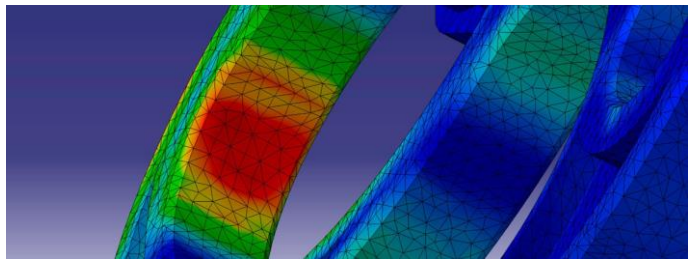
The tests carried out to determine the properties of the material are diverse, depending on the type of product. Among these tests are:

- Determination of the real and apparent density.
- Determination of porosity and egg index.
- Evaluation of thermal insulation.
- Determination of tensile or compressive strength.
- Determination of flexural strength.
- Fatigue study of materials.
- Ageing tests.
- Metrology applications.

Mechanical modelling of materials







The TEP 976 research group is made up of several professors from the area of Mechanics of Continuous Media and Theory of Structures. Therefore, and based on the knowledge of the members, it is possible to carry out the mechanical simulation of various materials in different real-life scenarios. This requires the use of specific software such as ANSYS and the use of mechanical properties obtained through different tests of the material.

Mechanical modelling of materials with software such as ANSYS offers a wide range of possibilities that have revolutionised materials engineering and research. These tools allow engineers and scientists to simulate and analyse the behaviour of materials under various loading, temperature and environmental conditions, facilitating the design and optimisation of products more efficiently and accurately.

The following are some of the main possibilities offered by mechanical modelling with ANSYS:

1. Stress and Deformation Analysis
2. Design Optimisation
3. Study of Complex Phenomena
4. Multiphysics Interaction
5. Virtual Validation and Certification
6. New Materials Simulation
7. Education and Training
8. Research and Development

Determination of the carbon footprint

Determining the carbon footprint of new manufactured materials is essential to understand and minimise the environmental impact of products and industrial processes.

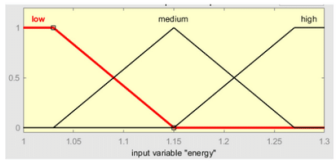
The carbon footprint measures the total amount of greenhouse gas (GHG) emissions associated with a material throughout its life cycle, from the extraction of raw materials to their final disposal.

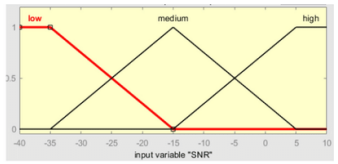
- This analysis is crucial for several reasons:
- Climate Change Mitigation
- Regulatory Compliance
- Competitive Advantage
- Process Optimisation
- Informed Decision Making

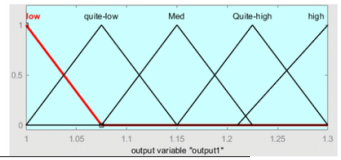
SimaPro is a leading Life Cycle Assessment (LCA) software that facilitates the determination of the carbon footprint and other environmental impacts of products and processes. This software offers a number of possibilities that make it an indispensable tool for sustainability:

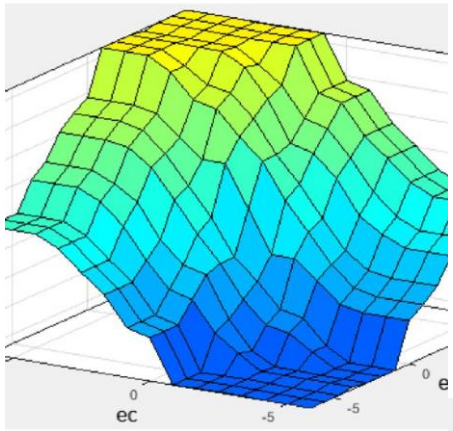
- Full Life Cycle Assessment
- Comprehensive Database
- Scenario Modelling
- Detailed Impact Analysis
- Compatibility and Flexibility
- Enables detailed assessment of environmental impacts.

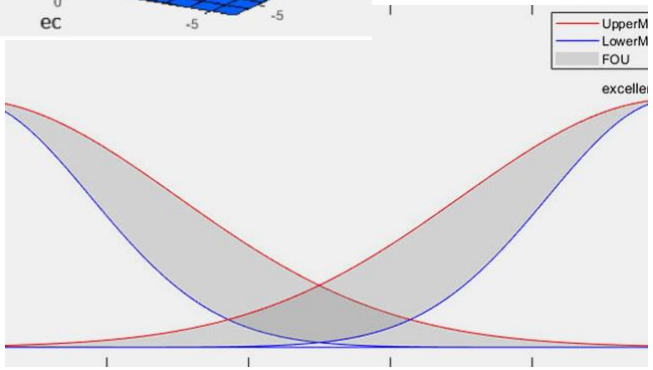
Data analysis with fuzzy logic











Fuzzy logic has been successfully applied in various studies to predict the mechanical strength of materials. For example, it has been used in the evaluation of reinforced polymer composites, ceramic materials, and metallic alloys, where mechanical properties depend on multiple variables such as composition, manufacturing process, and test conditions. These applications have demonstrated that fuzzy logic can provide accurate and reliable predictions, helping engineers to design materials with optimised mechanical properties.

Fuzzy logic is an extension of classical logic that allows working with truth values that are not strictly true or false, but can have any value in between 0 and 1. Instead of classifying elements into clearly defined sets, fuzzy sets allow degrees of membership, which is particularly useful for modelling complex and non-linear systems.

In the context of mechanical strength of materials, fuzzy logic allows:

- Fuzzy Variables Modelling: Material properties, such as strength, toughness and ductility, are often not constant and can vary according to multiple factors. Fuzzy logic allows these properties to be modelled as fuzzy variables with degrees of membership.
- Fuzzy rules: Uses ‘if-then’ rules that are flexible and can incorporate expert knowledge. For example, ‘If the carbon content is high and the treatment temperature is low, then the strength is high’.
- Fuzzy Inference: Fuzzy systems use inference mechanisms to combine fuzzy rules to produce outputs that describe the mechanical strength of the material in probabilistic terms.

2 Collaboration with companies

- Geotechnical study for civil engineering projects.
- Geotechnical study for building.
- Calculation of metallic and concrete structures.
- Expertise in materials through testing and mechanical modelling.
- Control, training and evaluation of welding processes.

Geotechnical study for civil engineering projects.

The TEP 976 research group has a solid track record in collaborating with private companies to carry out geotechnical studies in the field of civil engineering, especially in projects related to road construction and maintenance.

The group specialises in carrying out geotechnical studies that are fundamental for the design and construction of road infrastructures. These studies include the characterisation of the soil, the assessment of its bearing capacity, the analysis of its stability and the design of appropriate foundation solutions. These analyses are crucial to ensure the safety and durability of roads.

One of the main focuses of the group has been the study and improvement of road infrastructures. The geotechnical studies carried out by TEP 976 range from the planning and design phase to monitoring and evaluation during and after construction.

Geotechnical study for building.

The TEP 976 group has been involved in numerous building projects, working closely with private companies to ensure that each construction is built on a solid and reliable foundation. These projects range from residential and commercial buildings to industrial and public infrastructure.

TEP 976 Group is dedicated to performing comprehensive geotechnical studies that are essential to the design and construction of buildings. These studies include:

- Soil Characterisation: Detailed analysis of soil properties, such as bearing capacity, compressibility, and behaviour under loading.
- In Situ Investigations: Use of advanced field testing technologies, such as penetrometers and borings, to obtain accurate data on ground conditions.

The choice of foundation type is a critical decision in building construction. TEP 976 Group works with private companies to determine the most appropriate foundation solution based on the soil characteristics and structural requirements of the project. The solutions they offer include:

- Shallow Foundations.
- Deep Foundations.
- Special Foundations.

Calculation of metallic and concrete structures.

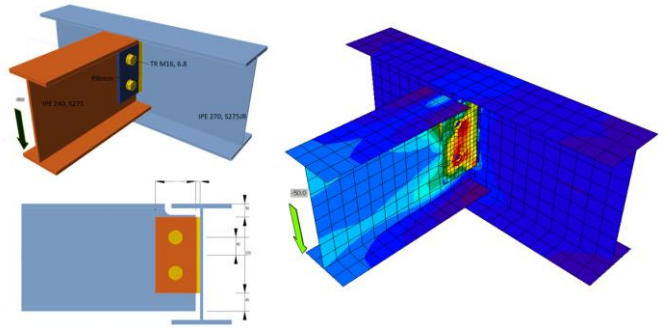
The TEP 976 group has collaborated with numerous private companies, providing consultancy and carrying out critical structural calculations for large-scale projects. These collaborations have enabled companies to benefit from the group's in-depth knowledge and technical expertise, ensuring the viability and safety of their projects.

TEP 976 group has developed a solid experience in the design and calculation of steel structures, which includes:

- Structural Design: Analysis and design of steel structures, such as buildings, bridges and towers, using advanced engineering software and international standards.
- Material Optimisation: Selection and optimisation of metallic materials to ensure maximum strength and durability with efficient use of resources.
- Load and Strength Analysis: Evaluation of the strength of steel structures under different loading conditions, including wind, seismic and static loads.

The group also specialises in the calculation and design of concrete structures, covering:

- Foundation Design
- Reinforced Concrete Structures.
- Structural Analysis.



Expertise in materials through testing and mechanical modelling.

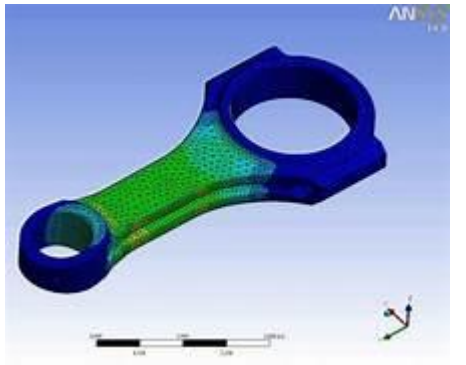
The TEP 976 group uses advanced finite element modelling techniques to simulate and analyse the mechanical behaviour of industrial parts under various loading and environmental conditions.

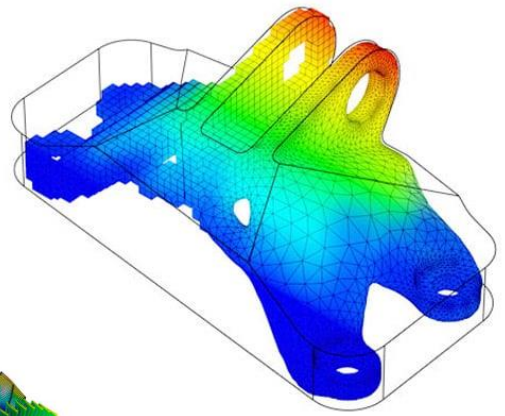
These techniques allow:

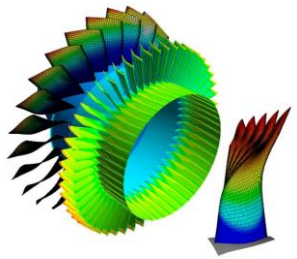
- Structural Analysis: Evaluation of the strength and stiffness of industrial components, determining how they will respond to external forces and operational loads.
- Thermal Analysis: Simulation of the temperature distribution and thermal behaviour of parts subjected to different operating conditions.
- Fatigue and Fracture Analysis: Prediction of the useful life of components subjected to cyclic loading and assessment of possible failure points.

The group has established fruitful collaborations with various companies in the industrial sector, providing modelling and analysis services that are essential for the development and optimisation of their products. These collaborations include:

- Part Design and Optimisation: Helping companies improve component design to increase performance and reduce production costs.
- Prototype Validation: Performing detailed analysis to validate the design of prototypes prior to manufacture, ensuring they meet required specifications and standards.
- Mechanical Troubleshooting: Providing solutions to complex mechanical problems, such as identifying and mitigating critical failure points in parts subjected to extreme conditions.







Control, training and evaluation of welding processes.

The TEP 976 Research Group stands out for its extensive experience in training and consultancy in the field of welding. Its cooperation with private companies ranges from the training and approval of welders to technical advice and welding coordination. This experience not only ensures compliance with the highest quality and safety standards, but also contributes to the development and continuous improvement of welding processes in industry.

Group offers comprehensive training programmes for welders, covering everything from the fundamentals to advanced techniques. These trainings include:

- Theoretical and Practical Courses: Instruction in the most common and advanced welding techniques, such as MIG/MAG, TIG and arc welding.
- Knowledge Upgrading: Ongoing training programmes to keep welders up to date with the latest technologies and industry standards.

The group provides homologation services, ensuring that welders comply with international standards and regulations. This includes:

- Assessments and Certifications: Conducting practical and theoretical tests to assess welders' competencies and issuing recognised certifications.
- Re-certification: Periodic re-certification programmes to ensure welders keep their skills and knowledge up to date.

Thank you for your time.

Any comments or queries can be addressed to

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GRACIAS

POR SU ATENCIÓN

THANK YOU FOR YOUR ATTENTION