



# ANALYSIS AND IMPLEMENTATION OF SUSTAINABLE DRAINAGE PRACTICES UNDER SPAIN'S OCEANIC CLIMATE CONDITIONS

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- Introduction SUDS Research Line in the UC

2

- Location and Climatic Conditions of field projects

3

- Research projects: Aims and main results

4

- Main conclusions from 14 years of experience of SUDS in northern Spain

5

- Acknowledgements and questions

# 1. INTRODUCTION

## SUDS RESEARCH LINE IN THE UC

### CONSTRUCTION OF SUSTAINABLE URBAN DRAINAGE SYSTEMS



LABORATORIES



SINCE 2002

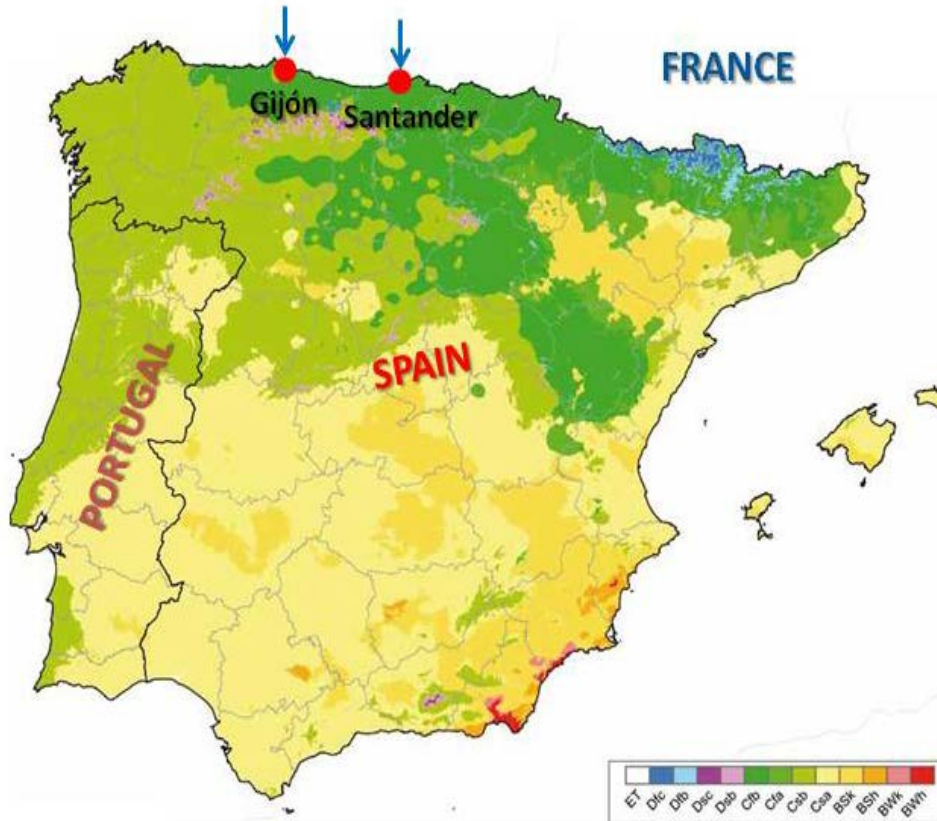


+15 PROJECTS

+60 PUBLICATIONS

2 PATENTS

5 PhD THESES



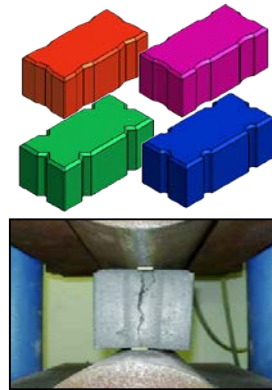
### • Climatic characteristics

- Temperate climate without a dry season and with temperate-warm summers. **Cfb climate** (Köppen-Geiger climatic classification).
- **Average temperature: 14-15°C** (year), **10°C** (winter), **20°C** (summer).
- **Average precipitation: 1,136 mm per annum** (*fourth highest annual average precipitation in Spain*).
- **125-150 days** per year with precipitation above 1 mm.

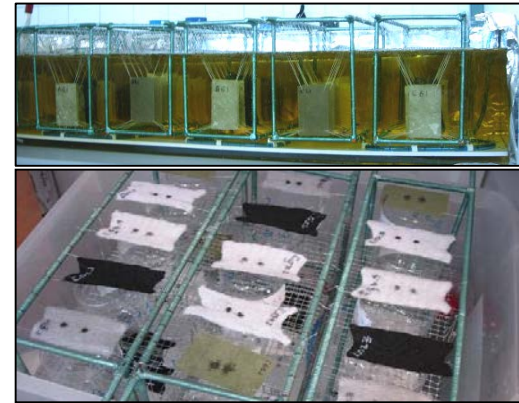
## AIMS

- 1 Development of new permeable pavement structures using recycled aggregates
- 2 Analysis of microbial communities in relation to hydrocarbon biodegradation
- 3 Testing of the performance of permeable pavements at real scale
- 4 Writing of a design manual for hydrocarbon biodegrading permeable pavements

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## MAIN RESULTS FROM THE PROJECT

- Hydrological behaviour and clogging potential of permeable pavements is directly related to the pavement design and used materials.
- Geotextile layer is a suitable media for biofilm generation within permeable pavement structures. Geotextile thickness is the main parameter influencing biofilm generation.

## AIMS

- 1 Design of a parking area with hydrocarbons degrading permeable pavements
- 2 Monitoring of water quality and quantity parameters in parking lots
- 3 Study of the water storage capacity of permeable pavement structures
- 4 Analysis of the hydrocarbons degradation capacity of permeable pavements

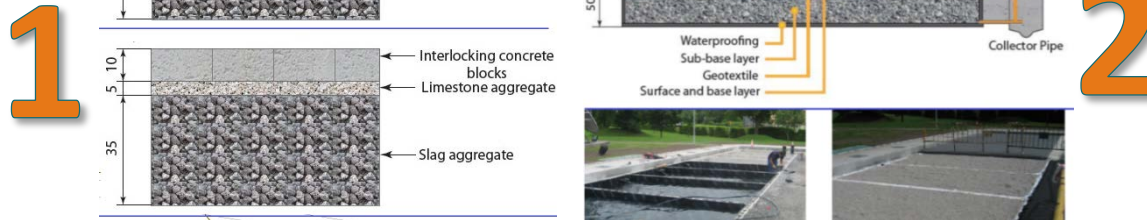


## MAIN RESULTS FROM THE PROJECT

- ❑ The impact of the surface layer is greater than that of geotextile on the rainwater harvesting capacity of PPS. Permeable surfaces can be clustered in continuous (PC and PA), discontinuous (ICB) and green surfaces.
- ❑ After 1 year of continuous use and monitoring, evapotranspiration showed limited effects on the stored water, parking bays being filled of water during most of the year in oceanic climates, except during summer periods.
- ❑ Water quality stored in parking bays showed to be enough for water reuse according to Spanish Laws

## AIMS

- 1 Design and instrumentation of permeable pavements built with BOF-Slag reservoir
- 2 Monitoring of water quality parameters in the outflow of the parking lots
- 3 Analysis of BOF-Slag as a reservoir material for permeable pavements



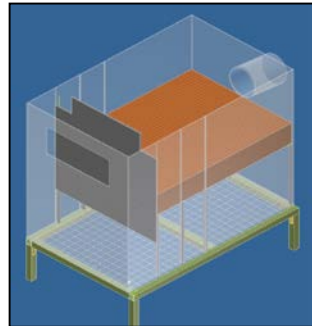
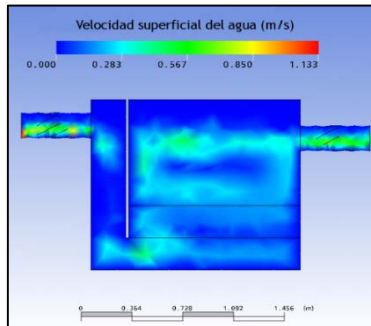
## MAIN RESULTS FROM THE PROJECT

- ❑ After two years of monitoring water quality parameters in the stored water showed to be generally in a range that allows the water reuse. The main drawbacks were the high values of EC and pH observed in the outflow.
- ❑ BOF-Slag aggregates should be treated previously to be placed in PPS in order to reduce EC and pH.
- ❑ According to the results obtained, BOF-Slag may be more useful if used in a base layer, where the water contact is lower than in reservoir layer.

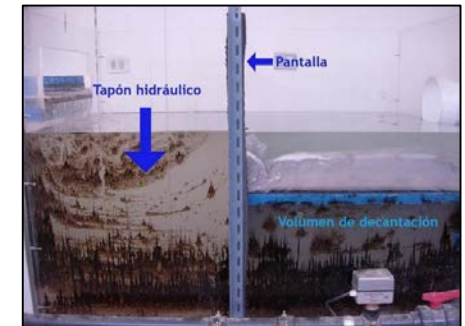
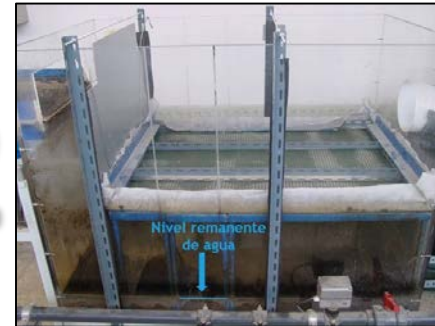
## AIMS

- 1 Design of systems for catchment and treatment of runoff with hydrocarbons
- 2 Investigation of the real-scale performance of the designed systems
- 3 Analysis of the physical aspects affecting the hydraulic and depuration behaviour
- 4 Study of the influence of microbial biodegradation on hydrocarbon depuration

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## MAIN RESULTS FROM THE PROJECT

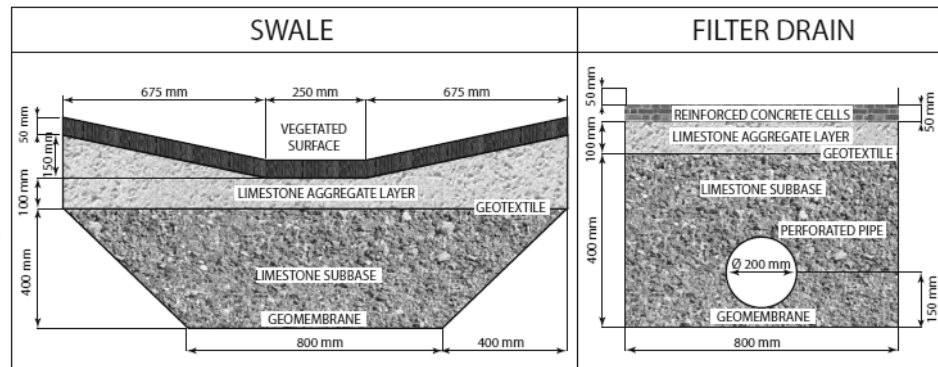
- ❑ The System for Collection, Pre-Treatment and Treatment (SCPT) was designed for being installed in impervious park areas for manage polluted surface runoff. The system consists in three different chambers divided by a vertical wall and horizontal geotextile which filter the inflow water.
- ❑ The SCPT was capable of reducing pollution EMC up to 90% for both TSS and TPH independently of the hydraulic conductivity of the geotextile. The number of geotextile layers showed to be the mos influencing parameter in the pollutants removal efficiency.



## AIMS

- 1 Design of sustainable drainage stretches in the roadside of a parking area
- 2 Monitoring of water quality parameters in the outflow of the stretches
- 3 Analysis of the influence of climate conditions on water quality parameters
- 4 Comparison of the stretches capacity to improve runoff water quality

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## MAIN RESULTS FROM THE PROJECT

- ❑ After two years of continuous use and monitoring, outflow from Swale and Filter Drain systems showed to be significantly less polluted than in conventional concrete ditch system during the whole monitoring period.
- ❑ According to water quality results outflow water from both SuDS can be reused for street washing, industrial uses and irrigation purposes according to Spanish law, reaching TSS concentration in the outflow of 10 mg/L.
- ❑ Outflow from filter drain system showed more to be less polluted than the outflow from the swale during the whole experimental period.

# DEVELOPMENT OF RAINWATER STORAGE PAVEMENTS FOR NON-POTABLE USES

## AIMS

1 Study of the rainwater catchment methods by permeable pavement systems

2 Analysis of the rainwater storage capacity of permeable pavement systems

3 Development of water storage systems to be used with geothermal purposes

4 Investigation of systems that allows catchment and exploitation of rainfall water

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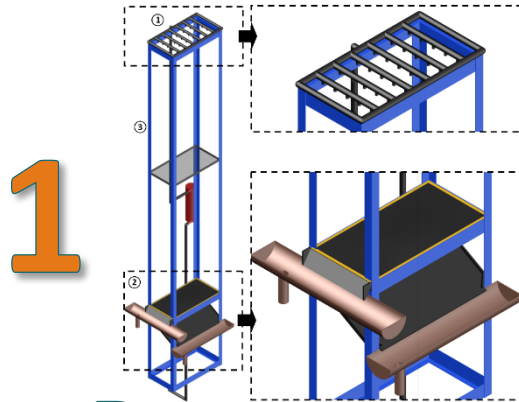


## MAIN RESULTS FROM THE PROJECT

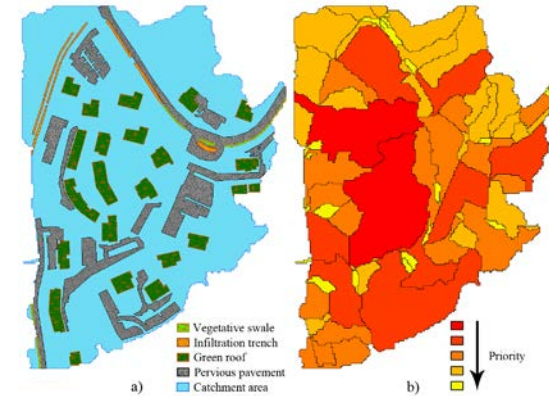
- ❑ The combination of a porous asphalt surface and a limestone gravel sub-base provided the best insulation from the ambient air conditions, while interlocked concrete block pavement surface and plastic cell sub-base dissipated the heat better than the other systems.
- ❑ All the permeable pavements presented a high capacity of catchment and infiltration, and can be used as attenuation elements for the superficial runoff peak-flow and to decrease flooding problems.
- ❑ It was demonstrated that vehicles parked on a car park bay made of a porous mixture of porous concrete influenced the infiltration capacity of this surface after observing the existence of a zoning effect in these bays.

## AIMS

- 1 Mechanical and hydrological analysis of different permeable pavement materials
- 2 Design of permeable pavements adapted to urban environments
- 3 Identification of urban road sections sensitive to flooding using GIS and SWSM
- 4 Development of a MCDM methodology to compare different drainage strategies



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## MAIN RESULTS FROM THE PROJECT

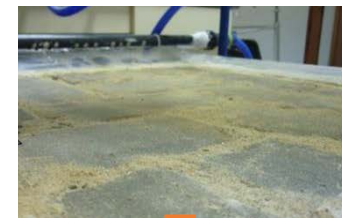
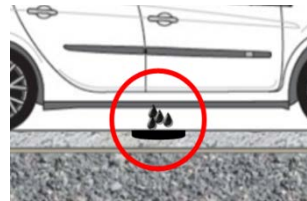
- ❑ The type of aggregate in the sub-base layer was found to influence the storm water retention capacity of PPS mainly in the first time after construction, being the surface layer which conditioned the long-term hydrological performance of PPS. Among continuous surfaces, porous concrete showed less clogging potential, more infiltration capacity and more self cleaning capabilities than porous asphalt.
- ❑ Based on the combination of the AHP and MIVES methods a multi-criteria decision-making model was developed to select PPS according to the three pillars of sustainability. The results showed that continuous pavements outperformed paver-based systems. In addition, several GIS-based stormwater simulations proved that PPS reached the best ratio between runoff volume reduction and required area.

# FUTURE RESEARCH:

## PERMEABLE, RESILIENT, SUSTAINABLE AND SMART URBAN SURFACES (SUPRIS)

### AIMS

- 1 Identification of the main risks related to urban surfaces
- 2 Analyse the resilience and sustainability of urban surfaces
- 3 Assess the effectiveness of maintenance techniques and methods
- 4 Development of MCDM methods for designing adapted solutions



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## 4. MAIN CONCLUSIONS FROM 14 YEARS OF RESEARCH IN NORTHERN SPAIN

*UC research helped to demonstrated that the application of SUDS in Spain was possible and that design considerations such as the climatic regions were decisive to overcome the initial problems in the northern regions. 26 JCR journal articles, 2 books, 35 conference presentations, 5 doctoral theses and 2 patents have concentered the influence of the UC as the main reference in SUDS in Spain.*

*SuDS-based research in these regions has been mainly focused on the analysis of PPS in terms of both their hydraulic performance and their influence on water quality. Other systems such as swales and filter drains have been analysed from a similar perspective, whereas alternative approaches for water collection and treatment such as the SCPT device were also designed and assessed.*

*The last research lines have been oriented to the development of GIS-based stormwater simulation models and decision support tools to improve urban water management, two topics which will be further studied in the future, along with porous concrete, flood risk analyses and Climate Change modelling.*

# watwaf



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