



**FORE
SEE**
PROJECT

FIBRA

*An integrated DoE – Multi-Criteria
Decision-Making analysis applied for
experimental evaluation of fiber
reinforced porous asphalt mixtures*

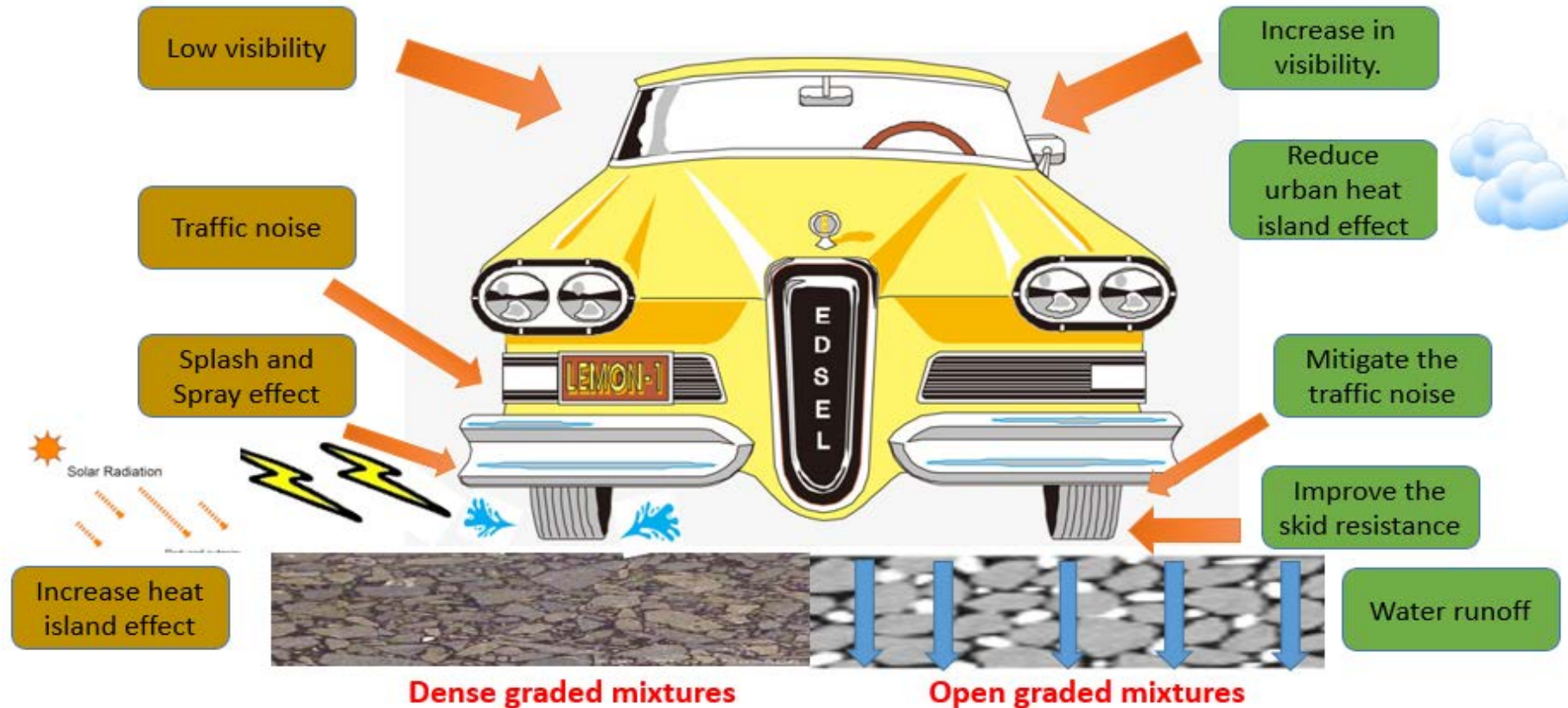
Speaker: Carlos José Slebi Acevedo

Directors: Daniel Castro Fresno

Pedro Lastra González

Porous asphalt (PA) mixture: An environmental-friendly alternative for the development of new pavement structures

Unfortunately the durability of the PA mixture is not as promising as dense-graded mixtures



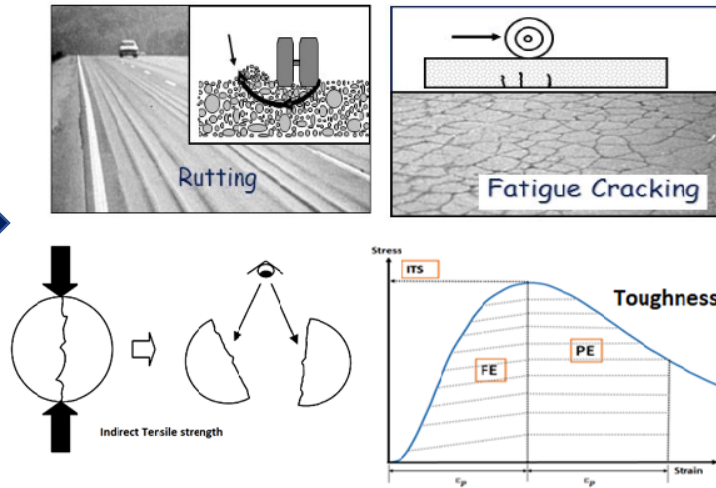
2. Background and main Aim

Numerous research studies concerning the use of fibres in dense-graded asphalt-mixtures

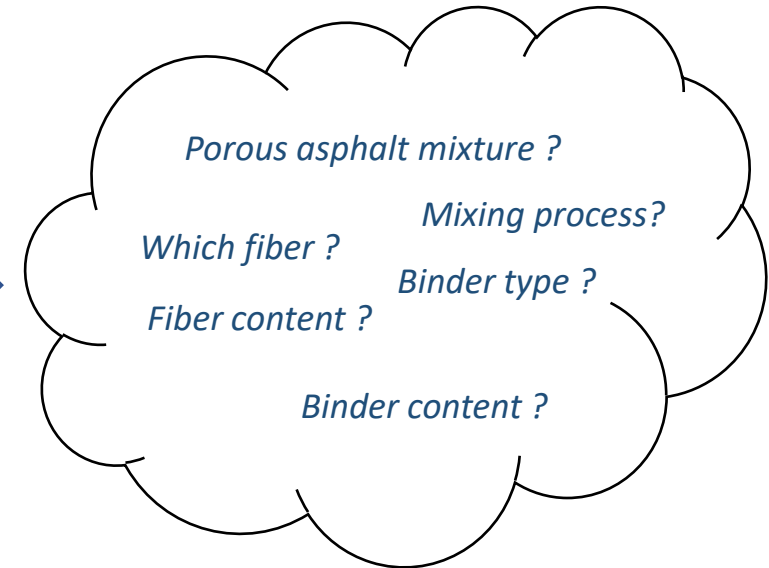
Fiber types



Improvements in different mechanical properties



Several gaps that must be solved ?





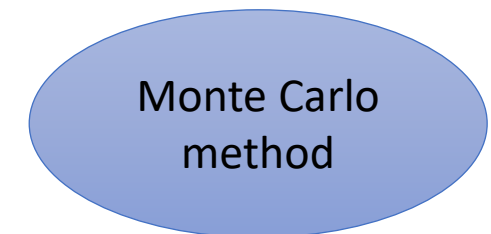
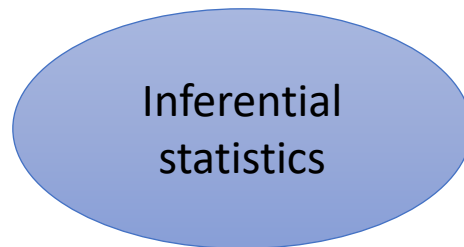
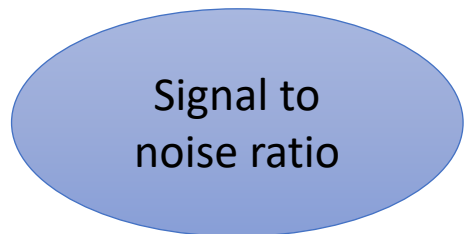
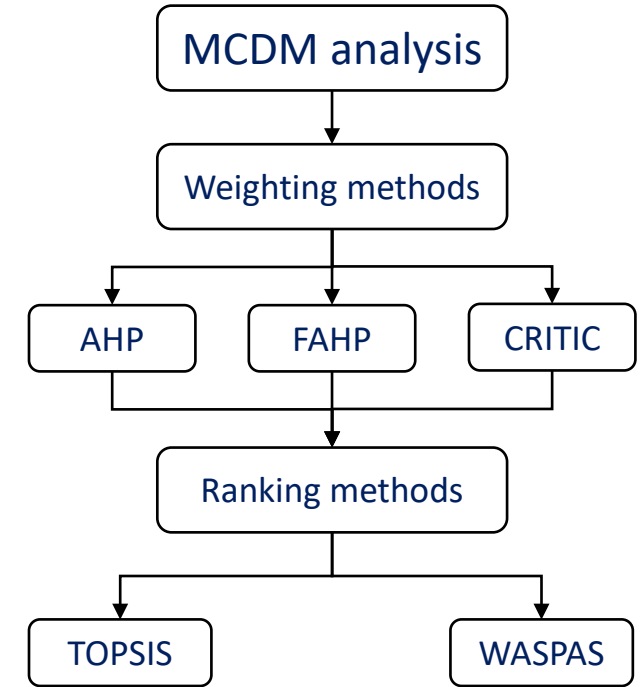
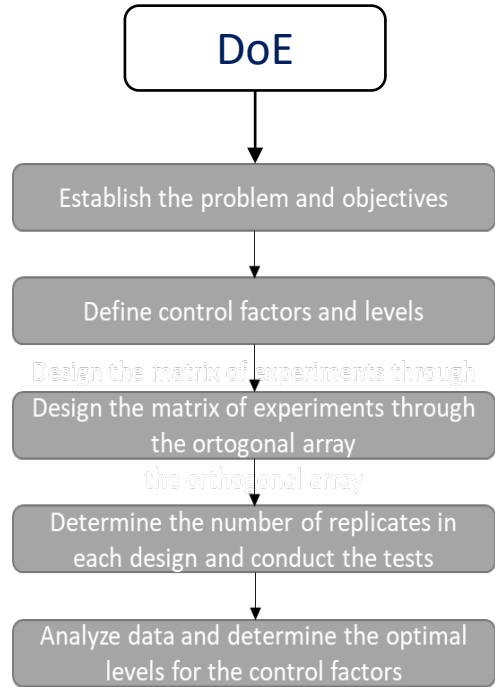
Basic skills

- Systematic understanding of a field of study and command of the skills and research methods related to the field CB11
- Skill to conceive, design or create, implement and adopt a substantial process of research or creation CB12
- Skill to contribute to the enlargement of the knowledge limits through an original research. CB13
- Skill to carry out a critical analysis and assessment and synthesis of new and complex ideas CB14
- Skill to communicate with the academic and scientific community and with society in general about the scope of knowledge in the ways and languages of common use in the international scientific community. CB15
- Skills to encourage [...] the scientific, technological, social, artistic or cultural progress in a society based on knowledge. CB16

Capacities and personal abilities

- Cope in contexts in which there is little specific information. CA01
- Find the key questions to be answered to solve a complex problem. CA02
- Design, create, develop and undertake new and innovative projects in the knowledge scope. CA03
- Work both in teams and individually in an international or multidisciplinary context. CA04
- Integrate knowledges, face complexity and formulate judgements with limited information. CA05
- Intellectual criticism and defence of solutions. CA06

4. Development of the research



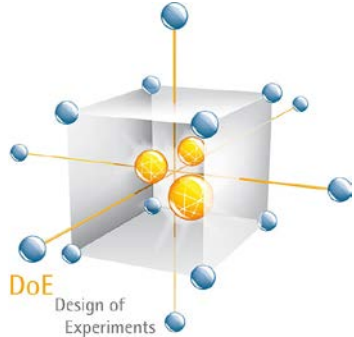
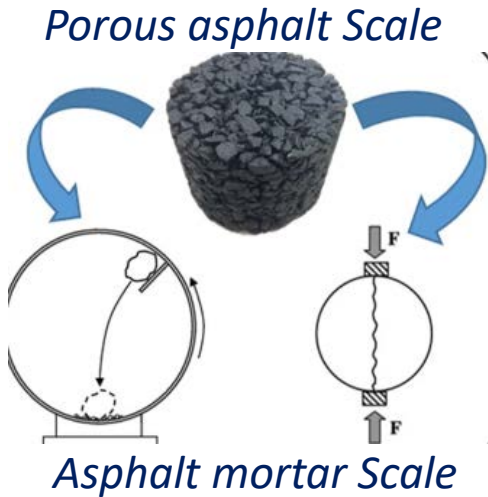
4. Development of the research

Literature review

MCDM analysis

Experimental evaluation of FRPA mixtures

Additive Evaluation through DoE – MCDM analysis



More than 100 scientific papers reviewed

Select the most promising fibers



CB11 CB12 CB14 CA01 CA05

Literature review

- *Approximately 140 scientific papers were reviewed.*
- *The reinforcing effect was analyzed in a quantitative and qualitative manner*
- *Fiber properties and characterization tests were discussed as well as blending procedures*
- *Different types of fibers have been used in hot mix asphalt*
- *Fibers improve the mechanical properties of hot mix asphalt*
- *In PA mixtures, fibers are commonly used as stabilizer additive*

MCDM analysis

- *Two MCDM analysis methodologies were introduced. (TOPSIS and WASPAS)*
- *AHP and FAHP were introduced for criterio elicitation*
- *Given the uncertainty involved, Monte – Carlo Stochastic simulation were proposed*
- *Statistical analysis was done to verify the results obtained*
- *Synthetic fibers proved to be a suitable option as did fibers with high tensile strength and elastic modulus.*

Experimental evaluation of FRPA mixtures

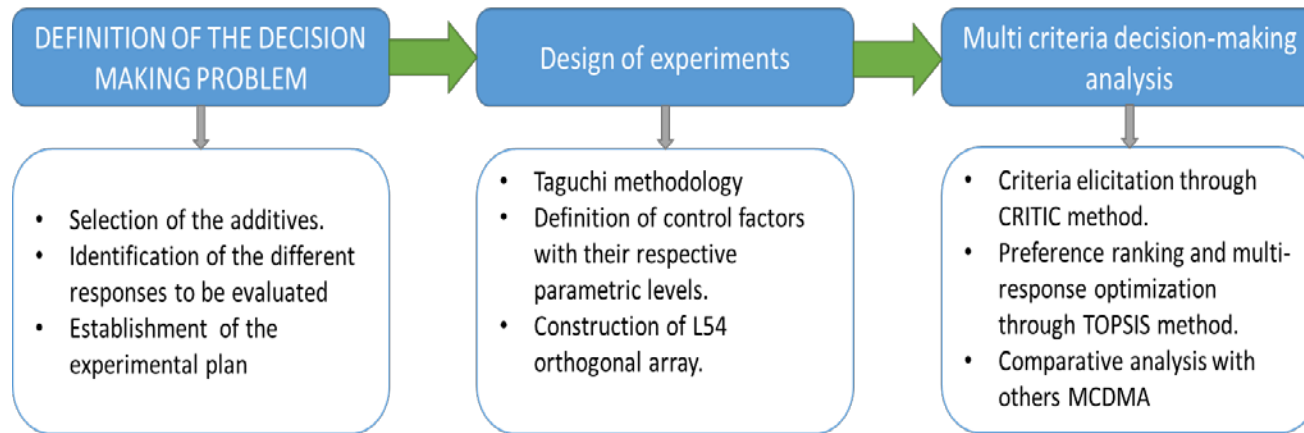
Porous asphalt scale

- *The reinforcing effect of FRPA mixtures with POA and PAN fibers were studied.*
- *A total of 8 experimental designs were proposed.*
- *14 replicates per each design were manufactured.*
- *Total samples 112.*

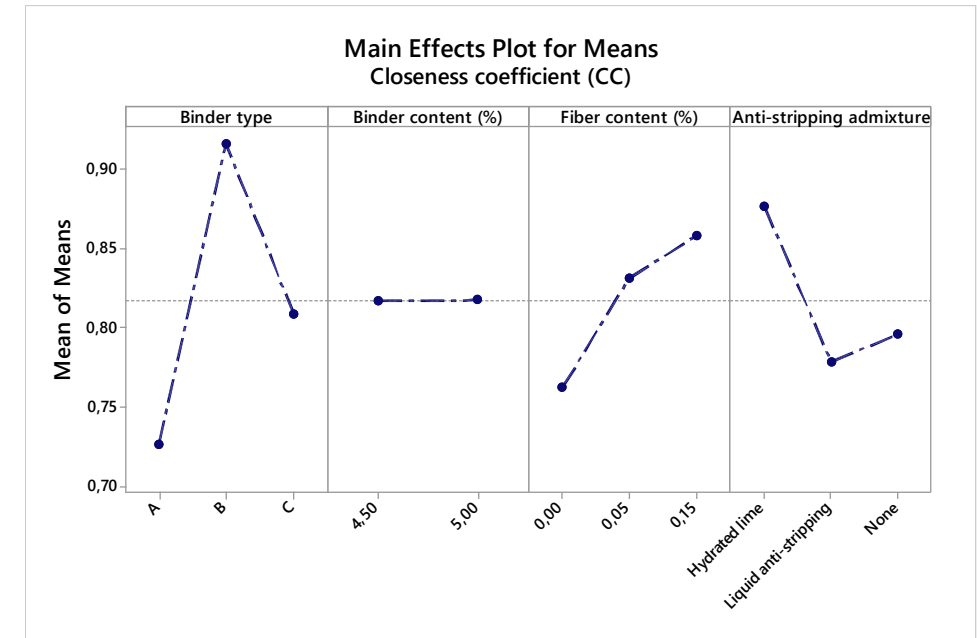
Asphalt mortar scale

- *The reinforcing effect of FRPA mixtures with POA and PAN fibers were studied at asphalt mortar scale through the indirect tensile test.*
- *21 mixture designs and 3 replicates per each designs. A total of 63 specimens. Indirect tensile strength and fracture parameters were recorded.*

Additives evaluations through a combinations of DoE and MCDM analysis



Control factors	Notation	Level 1	Level 2	Level 3
Binder type	BT	A	B	C
Binder content (%)	BC	4.50	5.00	-
Fiber content (%)	FC	0	0.05	0.15
Anti-stripping admixture	ASA	none	HL	Liquid anti-stripping



An orthogonal array with 54 mixture designs were performed. A total of 324 specimens were manufactured.

SWOT



Training courses

Organiser: Doctoral school of the University of Cantabria

- Marco general del doctorado – el método de la ciencia – 6 hours
- El futuro profesional – 3 hours
- Instrumentos de ayuda en la preparación de artículos científicos – 9 hours
- ¿Qué es la ciencia? El falsacionismo de Popper – 8 hours
- La Fundación Alexander von Humboldt y sus programas de investigación – 2 hours
- Proyectos Europeos e Internacionales de Investigación en las áreas de Ciencias e ingeniería – 20 hours
- La relevancia de las competencias personales y profesionales en el contexto actual – 3 hours
- Iniciación de proyectos europeos – 3 hours
- La colaboración universidad-empresa – 3 hours
- Taller de técnicas de creatividad – 10 hours
- Creación de líneas de investigación multidisciplinar y presentación de resultados – 2 hours
- La comunicación científica en Internet 1: redes sociales, agregadores y curación de contenidos – 20 hours
- Propiedad intelectual y propiedad industrial – 3 hours
- Tips for getting published - 2 hours
- Sacar partido a tu doctorado para llegar a ser un investigador independiente – 5 hours

Total hours = 99

Organiser: the University of Cantabria

- Curso básico de seguridad de laboratorios 2019 sexta edición – 10 hours

Organiser: INGEOEXPERT – Online course

- Programación en MATLAB aplicado a geotecnia – 50 hours

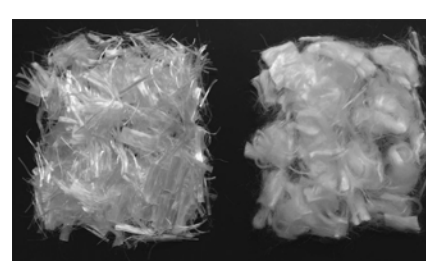
Organiser: Online course taken in Coursera by the École des Ponts Paris Tech

- Mastering bitumen for better roads and innovative applications – 50 hours

Mobility

International stay at the **Catholic University of Colombia**. From the end of September to the end of December. Three month duration.

The novel combination of DoE-MCDM technique learned and developed in the GITECO research group is applied to analyze the reinforcing effect of other fibers as nylon and polypropylene in Open graded friction courses. Different virgin binder and raw materials extracted from Colombia were used to manufacture the sample and carry out the experiments.



CB12

CB15

CA04

International conferences, posters and communications

- Participation in the **1st International Congress of Civil Engineering and IV Innovation to Grow Symposium**. Organized by: Bolivarian Pontifical University; Bucaramanga sectional (October 2019). Title of the presentation: Optimización de respuesta múltiple de mezclas de gradación abierta reforzadas con fibras a través de CRITIC-WASPAS basado en la metodología Taguchi. Bucaramanga, Colombia
- Participation in the **Congress of Innovation and Trends in Engineering CONIITI 2019**. Organized by: Catholic University of Colombia (October 2019). Title of the presentation: Desarrollo de mezclas porosas reforzadas con fibras empleando técnicas multi-criterio de toma de decisiones. Bogotá, Colombia
- Participation in the **Transportation research board (TRB) – 99th annual meeting**. (January 2020) Title of the poster: A decision support model applied to additive selection in porous hot mix asphalt. Washington D.C. United States.
- Participation in the **Transportation research board (TRB) – 99th annual meeting**. (January 2020) Title of the poster: Study of the effect of polyolefin-aramid fibers on PA mixture. Washington D.C. United States.
- A communication was sent to **Transport Research Arena (TRA)**. (Abril 2020). Title of the communication: FIBRA -Fostering the implementation of fibre reinforced asphalt mixtures by ensuring its safe, optimized and cost-efficient use. Preliminary results. Helsinki, Finland. **The conference was cancelled due to the restrictions imposed by the COVID – 19 situation.**

Published Papers

- **C.J. Slebi-Acevedo**, P. Lastra-gonzález, P. Pascual-Muñoz, D. Castro-Fresno, Mechanical performance of fibers in hot mix asphalt : A review, *Constr. Build. Mater.* 200 (2019) 756–769. doi:10.1016/j.conbuildmat.2018.12.171. **(IF 2018: 4.046 Q1 in the civil engineering category)**
- **C.J. Slebi-Acevedo**, P. Pascual-Muñoz, P. Lastra-González, D. Castro-Fresno, A multi-criteria decision-making analysis for the selection of fibres aimed at reinforcing asphalt concrete mixtures, *Int. J. Pavement Eng.* 0 (2019) 1–17. doi:10.1080/10298436.2019.1645848. **(IF 2018: 2.298 Q1 in the Materials science, and characterization test category)**
- **C.J. Slebi-Acevedo**, P. Lastra-gonzález, I. Indacochea-vega, D. Castro-fresno, Laboratory assessment of porous asphalt mixtures reinforced with synthetic fibers, *Constr. Build. Mater.* 234 (2020). doi:10.1016/j.conbuildmat.2019.117224. **(IF 2018: 4.046 Q1 in the civil engineering category)**
- **C.J. Slebi-Acevedo**, P. Lastra-González, D. Castro-Fresno, M. Bueno, An experimental laboratory study of fiber-reinforced asphalt mortars with polyolefin-aramid and polyacrylonitrile fibers, *Constr. Build. Mater.* 248 (2020) 118622. doi:10.1016/j.conbuildmat.2020.118622. **(IF 2018: 4.046 Q1 in the civil engineering category)**
- **C.J. Slebi-Acevedo**, P. Pascual-Muñoz, P. Lastra-González, D. Castro-Fresno, Multi-Response Optimization of Porous Asphalt Mixtures Reinforced with Aramid and Polyolefin Fibers Employing the CRITIC-TOPSIS Based on Taguchi Methodology, *Materials (Basel)*. (2019). doi:10.3390/ma12223789. **(IF 2018: 2.2972 Q2 in the materials, science, multidisciplinary category)**
- **C.J. Slebi-Acevedo**, P. Lastra-González, M.A. Calzada-Pérez, D. Castro-Fresno, Effect of Synthetic Fibers and Hydrated Lime in Porous Asphalt Mixture Using Multi-Criteria Decision-Making Techniques, *Materials (Basel)*. 13 (2020) 675. doi:10.3390/ma13030675. **(IF 2018: 2.972 Q2 in the materials, science, multidisciplinary category)**
- **C.J. Slebi-Acevedo**, I.M. Silva-rojas, P. Lastra-gonzález, P. Pascual-muñoz, D. Castro-fresno, Multiple-response optimization of open graded friction course reinforced with fibers through CRITIC-WASPAS based on Taguchi methodology, *Constr. Build. Mater.* 233 (2020) 117274. doi:10.1016/j.conbuildmat.2019.117274. **(IF 2018: 4.046 Q1 in the civil engineering category)**
- **C.J. Slebi-Acevedo**, J.C. Ruge-Cárdenas, D. Castro-Fresno, An integrated DoE – Stochastic multi criteria decision-making analysis applied for experimental evaluation of fiber reinforced porous asphalt mixtures, *Constr. Build. Mater.* 255 (2020) 119330. doi:10.1016/j.conbuildmat.2020.119330. **(IF 2018: 4.046 Q1 in the civil engineering category)**

THANK YOU!

*Research has no limits. This research probably leads to more questions than answers.
Once you have solved one. Then, you realize that you have created a couple more.*

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