

PhD thesis proposal – Title:

**Improvement of the knowledge of complex media composed of cracks
by electromagnetic scattering simulation**

Starting date: ASAP (January 2019 at the latest)

Duration: 36 months

Location: ICAM School of Engineering – Nantes campus

Context: The French road network consists mainly of national roads, most of which being built about 40 years ago. Road surface defects are caused mainly by underground defects (horizontal or vertical cracks which are defects that appear within the pavement, like debondings) that can occur long before visible degradations appear on the surface. The structural pavement diagnosis is hence necessary in order to prevent disasters. The geometrical characteristics of these defects (their shape, width, length, depth of occurrence etc.) as well as the extent and paths of water induced by these defects is a very important indicator of durability of these structures. In the context of the detection of embedded cracks, in order to help in the detection, there is a need for understanding the physical mechanisms of scattering and propagation that occur.

Subject and objectives: This work focuses on the propagation of electromagnetic waves to physically and geometrically characterize civil engineering media. This is made by improving the understanding of the scattering mechanisms inside a stratified medium of rough interfaces containing cracks for a large band of frequencies. Thus, the PhD student will develop rigorous and asymptotic (fast) electromagnetic models in order to better predict and understand the propagation phenomena occurring in this complex configuration. This study will first focus on the simple case of horizontal cracks for which preliminary work has been conducted (rigorous model, for the simple case of a medium made up of 3 layers). After generalization, this work will make it possible to develop and validate a fast asymptotic model, as well as to extend the modeling to a larger number of interfaces, allowing us to deal with more realistic scenarios. Then, the novel case of vertical cracks will be analyzed by both rigorous and asymptotic modeling, which represents a real innovation in terms of electromagnetic modeling. The work of the PhD student may follow the following schedule:

- 1st year: Bibliographical study on the electromagnetic models of scattering from layered structures, for both flat and rough interfaces, and by using rigorous as well as asymptotic approaches. Focus will be made on numerical resolution models.
- 2nd year: It will mainly be devoted to the resolution of horizontal cracks, which raises the problem of the resolution of very thin layers by a numerical approach. Fortunately, existing analytical approaches will be used to validate new numerical approaches. Besides, the thickness variation of the crack will be handled more easily by the numerical approach.
- 3rd year: The novel case of vertical cracks will be handled. This time, it will mainly be the numerical method which will be used to validate the developed asymptotic approach. He/she will submit a paper to a journal and will write the PhD manuscript for the PhD defence.

Education and skills: 2nd year Master or Engineering school diploma with specialization in electromagnetic scattering and/or applied mathematics for electromagnetics. An appetite for applied mathematics and electromagnetic modelling is highly appreciated.

For applying: There is no constraint about your nationality. Send the following documents to the two advisors below: a detailed CV, the transcript of marks of the last 3 years (Bachelor's degree, 2 years of Master's degree), a covering letter, and a reference letter from your Master traineeship advisor.

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