Performance assessment of infrastructures exposed to windblown sand hazard

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ABSTRACT

The global economic trend is increasingly going towards the planning and construction of strategic infrastructures in Middle East and Far East countries. They comprehend pipelines, refineries, power plants, roads and railways to transport minerals and passengers, amongst others. A considerable amount of such infrastructures arise in arid and desert regions and experience windblown sand related issues. The wind blows the desert sand, and cause sand accumulation and erosion around any kind of built structure. Windblown sand affects infrastructure construction, serviceability, and undermines users' safety, leading to the so-called Sand Limit States [1]. As a result, windblown sand effects can lead to several incremental costs in infrastructure management, e.g. loss of capacity, loss of production and increased maintenance costs, but also to disastrous events, such as train derailment. A number of design solutions (i.e. Sand Mitigation Measures, SMMs), mainly born for railway applications, have been proposed in the last decade in order to mitigate windblown sand effects [1]. Among all SMM types, Path SMMs are the most employed and translate into earthworks, porous fences and solid barriers. They are located between the sand source and the protected infrastructure and are intended to trap windblown sand by promoting sedimentation far from it. However, systematic and comprehensive guidelines for windblown sand hazard evaluation, but also design and performance assessment of SMMs are still missing in both structural engineering literature and standards. Recent and remarkable exceptions are the categorization of the windblown sand action [2], and the prescriptions given by the Algerian snow and wind code.

In this study, the authors discuss the appropriate methodologies to investigate the efficiency of SMMs through both numerical (Computational Fluid Dynamics simulations) and experimental simulations (Wind Tunnel tests). Then, a probabilistic approach to assess windblown sand action and plan sand removal maintenance operation on the endangered infrastructure is proposed. The following Path SMMs are tested: a basic concrete Straight Vertical Wall (SVW), the aerodynamically shaped Shield for Sand (S4S) barrier [3], and a porous fence. Their performances are comparatively discussed in terms of frequency of and economic impact on sand maintenance operations by referring to delimited environmental conditions along the North-South railway line (Kingdom of Saudi Arabia). The obtained results can be synthetized in the following key points: (i) S4S scores overall good performance scoring the highest overall maintenance intervals; (ii) the porous fence offers maintenance intervals long enough to a high sand removal frequency around the SMM itself; (iii) SVW shows overall poor performance scoring the lowest maintenance intervals. All the SMMs pay off their own design and construction costs over about one year after completion, thanks to the dramatic reduction of sand maintenance costs.

References

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