Experimental Modelling of Washboard Phenomenon in Unpaved Roads.

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**Extended Abstract**

The washboard phenomenon is identified by the presence of ripples on unpaved roads, emerging as vehicles traverse surfaces composed of sand, gravel, or mud. These undulating patterns not only cause discomfort but also pose potential hazards to drivers by disrupting tire-road contact. Despite its significance, limited research has been conducted on ripple phenomena, and the primary cause of their formation remains uncertain. This study aims to unravel some mechanisms of these patterns by analysing key factors such as vehicle speed, weight, and granular material properties. The research draws inspiration from the foundational work of [1-6].

To investigate unpaved road ripples, experimental devices with rotating wheels at constant speeds have been employed. Previous observations suggest that ripples initiate as small waves, gradually growing to heights of up to 20 cm, with wavelengths ranging from 1 to 30 cm. Wave amplitude is influenced by factors such as vehicle speed, mass, shock absorbers, and tire inflation pressure [1-6]. Field studies indicate that ripples predominantly occur in turning zones and on inclined roads, where additional stresses from vehicles impact the road material [7,8].

Experiments conducted by [1-6] propose that unpaved road ripples result from repetitive vehicle passage at a critical speed, creating two distinguishable states: an apparently flat road and a road with ripples. Research findings suggest categorizing ripple phenomena into four modes based on vehicle speeds [4]. At low speeds, small deformations dissipate with vehicle transit. At speeds higher than the critical speed, ripples emerge while the wheel remains in contact with the road. Higher speeds lead to continuous ripple growth until the wheel jumps, and at extremely high speeds, vehicle instability causes the wheel to leap from crest to crest.

This research evaluates physical variables that influences ripple formation using an experimental multi-pass system. The system comprises an instrumented rotating wheel over a sandy path, revealing the evolution of soil ripples as the wheel passes over the track, which is the same device [9] used. Experimental simulations for various scenarios, including different wheel velocities, masses, and soil densities, were conducted. This device enables the assessment of soil plastic deformations, wheel trajectories, and dynamic forces.

Furthermore, the research provides insights into potential mitigation strategies for washboard roads. It suggests that controlling vehicle speed and improving road material properties could effectively mitigate the formation and severity of these patterns, aligning with theories proposed by [3, 10, 11]. The experiments confirm that speed defines ripple properties, such as amplitude and wavelength.

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