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Ground-penetrating radar (GPR) is being increasingly used for pavements maintenance due to the wide range of applications spanning from physical to geometrical inspections, thereby allowing for a reliable diagnosis of the main causes of road structural damages.

In this work, an off-ground GPR system was used to investigate a large-scale rural road network. Two sets of surveys were carried out in different time periods, with the main goals to *i*) localize the most critical sections; *ii)* monitor the evolution of previous damages and localize newborn deep faults, although not revealed at the pavement surface level; *iii)* analyze the causes of both evolution and emergence of faults by considering environmental and human factors.

A 1-GHz GPR air-launched antenna was linked to an instrumented van for collecting data at traffic speed. Other support techniques (e.g. GPS data logger, odometer, HD video camera) were used for cross-checking,. Such centre frequency of investigation along with a 25-ns time window allow for a signal penetration of 900 mm, consistent with the deepest layer interfaces. The bottom of the array was 400 mm over the surface, with a minimum distance of 1200 mm from the van body. Scan length of maximum 10 km were provided for avoiding heavy computational loads.

The rural road network was located in the District of Rieti, 100 km north from Rome, Italy, and mostly develops in a hilly and mountainous landscape. In most of the investigated roads, the carriageway consists in two lanes of 3.75 meters wide and two shoulders of 0.50 meters wide. A typical road section includes a HMA layer (65 mm average thickness), a base layer (100 mm average thickness), and a subbase layer (300 mm average thickness), as described by pavement design charts.

The first set of surveys was carried out in two days at the beginning of spring in moderately dry conditions. Overall, 320-km-long inspections were performed in both travel directions, thereby showing a productivity of approximately 160 km/day at 40 km/h speed, on the average.

After processing and first-checking, GPR profiles were divided into homogeneous sections according to the combination of different parameters (e.g. route analyzed, long distance conditions of regularity/irregularity in layers arrangement). In such context, a high consistency between surface damages, mismatches from the GPR scans, and boundary environmental conditions was demonstrated. In addition, deep mismatches were detected even for early-stage or unrevealed faults.

The second set of surveys was carried out in autumn in high humidity conditions, due to recent rainfalls. 160 km of relevant routes from the same road network were investigated.

Results showed a high consistency with those collected during the first-stage of surveys. Minor changes were found in those sections with low traffic loads (e.g. farther away from the biggest town of Rieti), whereas major mismatches were detected in wetlands (e.g. close to rivers), work zones, and nearby those sections already deeply damaged in the past.

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