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# Evaluating Roadway Integrity After a Hurricane

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Mountains of rubble replacing neighborhood homes and large pools of standing water left over from waist-high flooding characterize the landscape of communities following devastating hurricanes. States like Florida are no stranger to tropical cyclones and the destruction they leave behind. Since U.S. record keeping began in 1869, the state has seen at least 120 hurricanes make landfall.

In September 2022, the deadliest hurricane in nearly one hundred years, Hurricane Ian, hit the western coast of Florida. The National Weather Service recorded more than 20 inches of rainfall during the storm, causing major flooding across the state from the Gulf to the Atlantic coast. Floodwaters such as these are considered the most destructive result of a hurricane. According to FEMA, "...just a few inches of water can cause tens of thousands of dollars in damage." In the case of Hurricane Ian, flooding caused the majority of the tens of billions of dollars in damage across Florida.

After standing water recedes and debris is cleared, an initial step of emergency workers undertaking hurricane-recovery efforts is to assess and open critical infrastructure. It is the responsibility of state governments and localities to clearly communicate to the public which roads and bridges are accessible. Vulnerabilities in pavement, sidewalks, and the soil below must be considered following a storm such as Ian to ensure safety for returning residents as well as recovery teams.

Predisposition to extreme weather conditions combined with Floridian soil that is prone to instability and erosion can

make ground hazards a pervasive challenge over the state's nearly 274 thousand miles of roadway. While some hazards are obvious, such as cracked pavement, potholes or sinkholes, some roadway weaknesses may be hidden hazards.

## NDT-E Methodologies

Following destructive weather events, it is crucial to gather data on the visible and invisible status of roadways and subsurface infrastructure, including utility pipelines beneath roads, in a timely manner. Heavy vehicles bringing emergency aid and vital supplies into hard-hit communities can exacerbate the condition of compromised pavement. Reliable information on the integrity of roads can be collected effectively and quickly by using nondestructive testing and evaluation (NDT-E) methodologies to check for vulnerabilities.

NDT-E is the process of assessing an asset to determine its material and/or structural integrity without impeding its serviceability or affecting its safety. NDT-E technology helps identify where infrastructure is stable and where repairs and improvements should be made to prevent potential failure. Today, there are many types of NDT-E methods that not only are used to discover potential defects and hazards in roadway infrastructure, but also can be applied to innumerable other structures and materials.

In the case of roadways, there are several different NDT-E methods that can be used, each of which has its own benefits and limitations. The most commonly used method is visual inspection, which involves an experienced technician simply looking at the surface of the road to identify any obvious defects or damage. Visual inspection can be conducted by an inspector or by using cameras and other imaging equipment. One of the most effective evaluation methods for determining the integrity of roads and pavement, however, is ground penetrating radar (GPR). This technology uses electromagnetic waves (light waves) to scan the roadway material and subsurface material to identify areas of moisture, buried objects or voids, among other physical properties. GPR evaluations achieve a number of important objectives, including measuring the thickness of pavement, ensuring that its integrity hasn't been compromised or altered and identifying subsurface voids and worrisome characteristics such as excess moisture in the material. This can be additionally useful for identifying underground utilities or other objects that may be damaged during roadway collapse or repair.

The capability exists to outfit vehicles with GPR systems that can operate at the posted speed limit to reduce the impedance on the traveling public. Additionally, step-frequency continuous wave GPR can be utilized to inspect nearly a lane-width of data at a time while simultaneously utilizing multiple frequencies to inspect the roadway material and the subsurface.

In 2014, the Minnesota Department of Transportation utilized highway-speed GPR to gather data on the network of roads within the state. A study conducted by the University of Minnesota Center of Transportation Studies found that using this vehicle-mounted GPR was straightforward and increased the speed and accuracy of data collection, improving the ability to quickly determine the uniformity of large swaths of road. Multiple other studies performed by the Strategic Highway Research Partnership 2 (SHRP 2) program also utilized these types of antennas to inspect and validate pavement NDT-E data. These types of assessment would not have been possible using conventional visual inspection. Following Hurricane Ian, municipalities in Florida received proposals to begin similar investigations over approximately 400 miles of roadway. This process, however, was not mandated by state regulations.

## Prevention Before, Response After

When hurricanes hit, emergency inspection is conducted on an ad hoc basis. If an ounce of prevention is worth a pound of cure, standards requiring regular inspection and monitoring should be put in place not only when times are good but immediately following extreme storms.

Pavement inspection data is crucial to help a state's department of transportation make data-driven post-storm decisions about repairs prior to further degradation and potential collapse. Typically, roadways across the United States are managed well, with annual and biannual evaluation, inspection and monitoring requirements set forth in the National Bridge Inspection Standards (NBIS) and the National Tunnel Inspection Standards (NTIS). Taking the additional step of performing testing and analysis of pavement as a fundamental element of emergency response to destructive storms should also be performed. Layering on the reality that visual inspection cannot detect erosion or loss of substructures as a result of floodwater damage, there is a high potential for structural disaster following the natural disaster, and NDT-E methodologies could assist in mitigating that risk.

Overall, NDT-E is an important tool for ensuring the safety and integrity of roads and other infrastructure. By regularly testing and evaluating the condition of roads, maintenance workers can identify and address problems before they become more serious, helping to keep the roads we use every day safe and reliable, and saving precious stakeholder resources with proactive maintenance and preservation.

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## About the Article

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