How to use GPR and ultrasound to check the seepage points of new tunnels?

Non-destructive testing techniques for efficient seepage detection

Tunnel seepage is always a common problem in new highway tunnels, which seriously threatens the safety and service life of tunnels. Traditional inspection methods face many challenges in accuracy and efficiency.

In recent years, ground penetrating radar (GPR) and ultrasonic imaging as a new type of water seepage detection technology, has been more and more widely used. These NDT techniques can provide a more accurate and rapid method for detecting and locating water seepage points in tunnels.

Structural radar: Depending on the velocity of electromagnetic wave propagating in different materials, the seepage area can be found quickly by measuring the time delay and amplitude variation.

Array Ultrasound Imaging: When the probe moves along the tunnel, the reflection of wave will be different from the incident wave if it encounters a cavity or seepage. By analyzing the difference of reflected echo in different positions, the concrete position of the seepage point can be further determined.

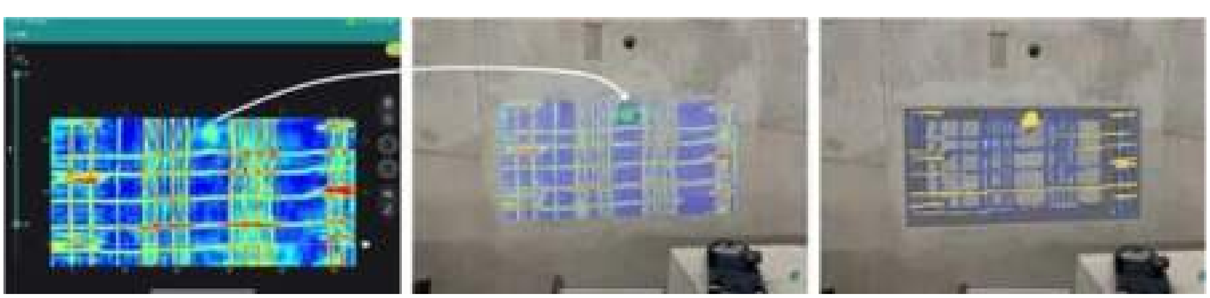
Application Case

Recently, a tunnel under construction found water seepage during the construction process. Due to safety considerations, the construction was suspended and relevant testing institutions were invited to conduct a large-scale inspection of the water seepage location in order to carry out targeted support design and construction program modification. The inspection was carried out in two areas (Area A & Area B).

Solutions

First, use the GPR to carry out a large area blind scan to find out the possible water seepage area, and then carry out a detailed inspection with the ultrasonic pulse echo instrument to determine the exact water seepage location.

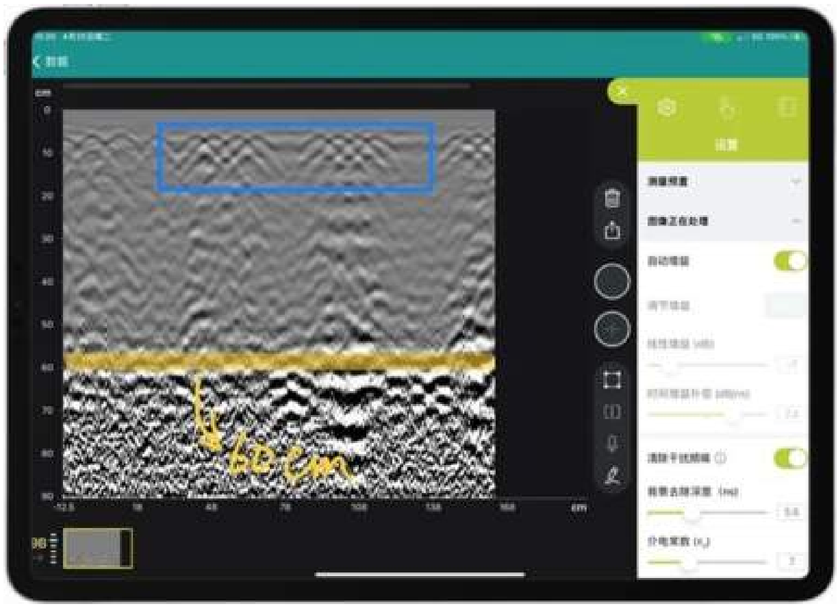
Test Results - Zone A



Area Scan Results of GP8100 GPR

On the left side of the above picture is the result of the regional scan, from which you can see that the transverse reinforcement is stirrup, arranged in approximately equal spacing in the vertical direction. Longitudinal reinforcement is the main reinforcement, in the horizontal direction, the middle area is a group of four arranged (close), in the two sides of the region is a single arrangement (sparse).

The middle and right pictures are the corresponding projection of the scanning results of the internal structure of the tunnel on the real scene. The real location and the corresponding scanning structure are completely integrated, which is convenient for data management and recording, and can provide fast and accurate positioning guidance for subsequent tunnel maintenance work.

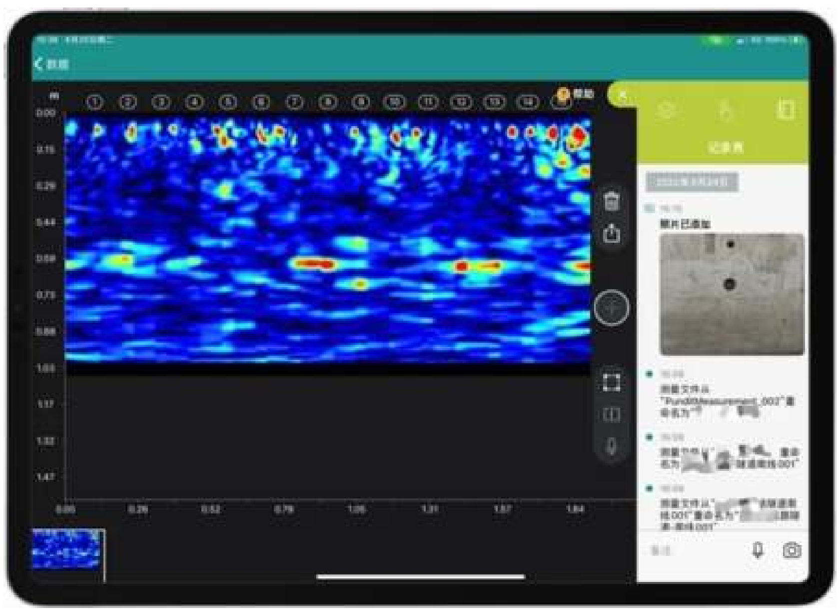


GP8100 radar cross section diagram

Judging from the radar cross section diagram, the inverted hyperbolic shape in the depth of 7 ~ 13 cm (blue frame) is mainly caused by the reflection of the double layer steel mesh signal. At the depth of about 60 cm (yellow mark line), the continuous plate reflection signal is mainly caused by the signal reflection of the initial branch of concrete (slab thickness). There is no obvious water-rich signal between the depth of steel bar and the base plate.

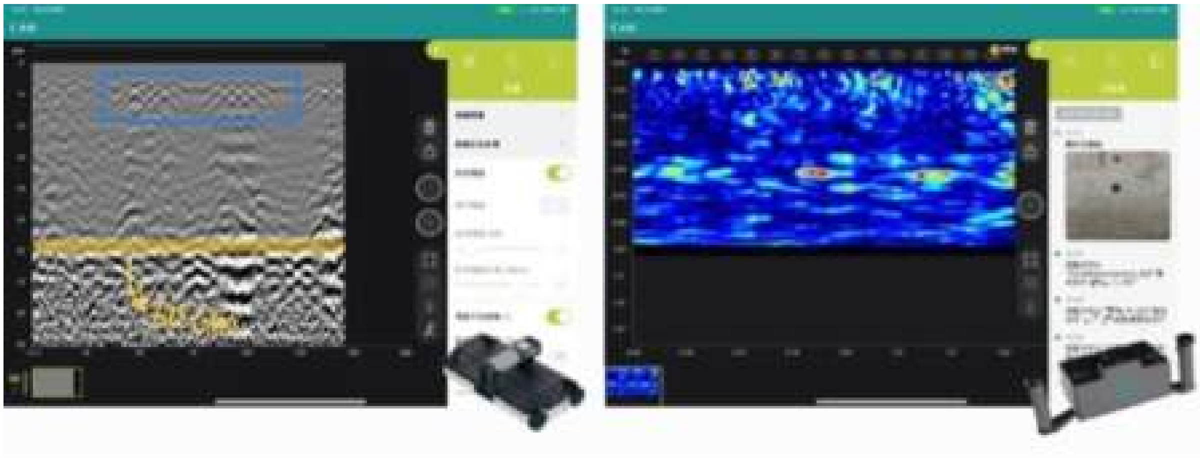
Scanning in the direction of the yellow arrow with ultrasonic imaging

Next, we used PD8050 array ultrasound imaging, scanning in the direction of the yellow arrow.



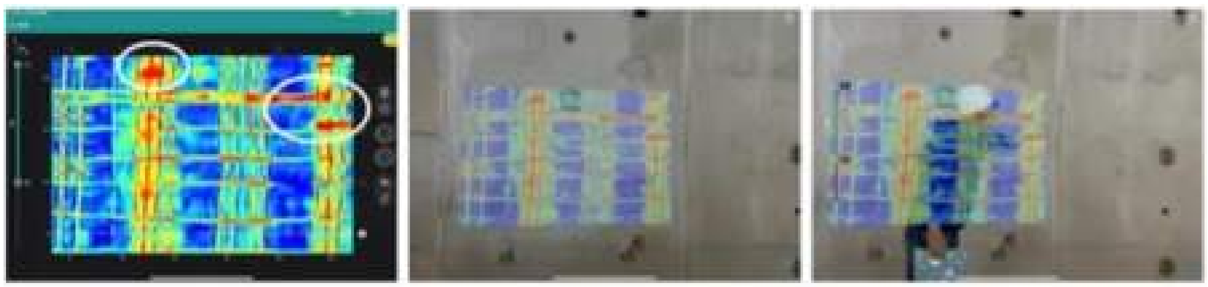
PD8050 Linear Scan Results

According to the results, the periodic steel bar distribution signal can be seen at the depth of about 7 cm in the shallow layer above, and the clear bottom plate reflection signal can be seen at about 59 cm in the 1-15 measuring line area. There is a part of discontinuity in the middle, which is due to the fact that the surface steel bar reflects a part of the ultrasonic signal, which leads to the deep target can not be detected. On the whole, the signal of the base plate can be reflected clearly (when ultrasonic imaging, it is not advisable to adjust the signal gain too much, otherwise it is easy to misjudge the hole or defect). Analysis of GP8100 and PD8050 results.



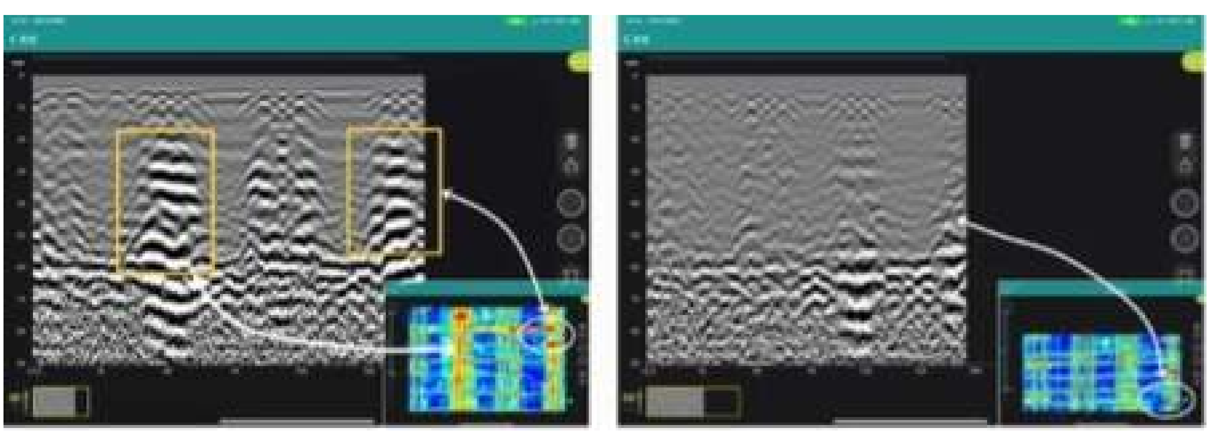
By analyzing the GP8100 linear view (left) and PD8050 linear view (right), we can see the shallow reinforcement signal and the continuous signal of the initial support base plate at the depth of 60 cm, and there is no obvious water-rich area between the reinforcement and the base plate. In summary, the construction quality of A area can be preliminarily judged, and there is no obvious water seepage.

Test Results - Zone B



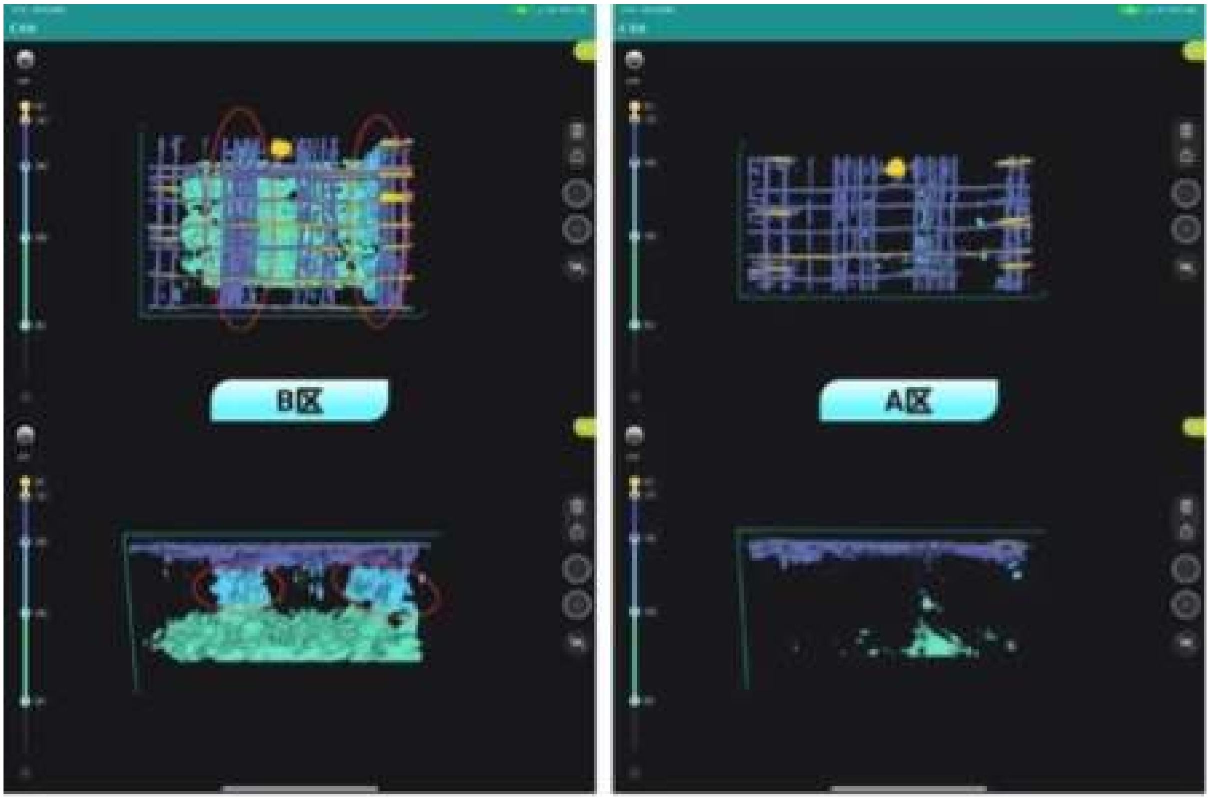
GP8100 Area Scan Results

First, the GP8100 is used for large area scanning. The left picture is the scan result of the area. The horizontal and vertical reinforcement distribution in the picture is similar to that in the A area, but in the area shown by the white circle, there is an obvious signal enhancement area after the reinforcement, which is suspected to be caused by water seepage. The middle and right images are AR structural projections of the scan results. By reducing the transparency of the structure image, the right engineer marks the suspected area for the later PD8050 test. To further verify why there is water seepage in the area, we select the 8th line in the radar area scan in the B area and the 9th line in the radar region scan in the A area for comparative analysis.

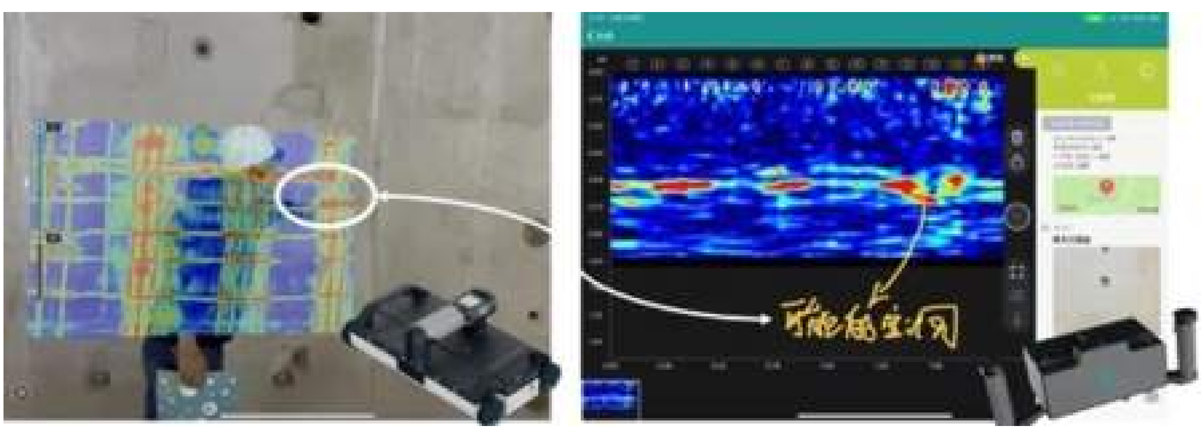


Comparison of Radar Line Scanning in Zone A and Zone B

Left is a section view of the 8th line in Area B and right is a section view of the 9th line in Area A. From the comparison of the two maps, there is no water enrichment or seepage in area A, and there is obvious water enrichment signal between steel bar and floor in area B.



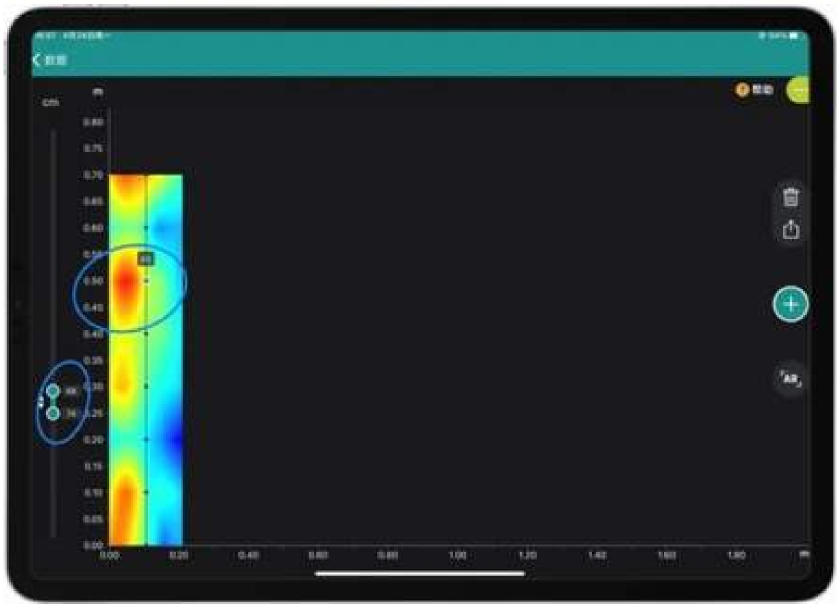
Through the radar AR structure observation in Zone B, it is also found that there is an obvious water rich signal and the possibility of water seepage between the steel bar and the bottom plate (shown in the red circle on the left). We then use PD8050 to find the reason of water seepage in this area.



Linear Scan Results for PD8050

Above (right) is a linear scan view of the PD8050. At about 1.4m in the horizontal direction, there is a clear cavity reflection signal behind the initial support floor (about 65-73cm depth), and its actual position also corresponds to the previous radar scanning results (left), which further determines that there may be a cavity here, resulting in water seepage.

In response to the above results, we continued to perform a full 3D matrix scan of the area using the PD8050, and reconfirmed the results of the presence of voids at the depth of 68-74 cm.



The void position behind the base plate, with a depth of about
68-74 cm (shown by the blue circle in the figure)

According to our test feedback, the construction team saved and shared all the electronic data to the reporting objects, and formulated a correction plan for Area B on the spot.

See more application notes for the use of GPR and ultrasonics on our [Tech Hub.]