Ground Penetrating Radar (GPR) Survey for Identifying Underground Voids in Zanjan, Iran.

Purpose of the Project

This project aimed to conduct a high-resolution Ground Penetrating Radar (GPR) survey to detect potential subsurface cavities, voids, and abandoned qanat pathways beneath an excavated construction site in Zanjan, Iran. The primary motivation for the survey was to assess and mitigate the risk of ground subsidence, which poses serious threats to the structural safety of the future development. Pre-existing evidence of old wells in the area further emphasized the importance of this investigation.

Methodology

Field data acquisition was carried out using the **PinPointR GPR system**, a cutting-edge dual-frequency radar developed by **ImpulseRadar (Sweden)**. Operating simultaneously at 400 MHz and 800 MHz, this system offers a superior balance between penetration depth and spatial resolution, compared to conventional single-frequency GPR units.

Data were collected by scanning the site surface and capturing reflected electromagnetic signals. The recorded raw data were subsequently processed using **Geolitix**, an advanced GPR processing and visualization software that enables precise three-dimensional modeling of subsurface structures.
The integrated **multi-frequency GPS** module allowed for high-accuracy georeferencing, ensuring all survey data could be precisely mapped and spatially analyzed.

Figure 1 - Overall view of the project site.

Figure 2 - The ImpulseRadar GPR device, PinPointR model, along with the multi-frequency GPS.

Design and Implementation

To achieve high analytical accuracy, a dense grid consisting of **70 GPR profiles** was designed and implemented in two **orthogonal directions** (north–south and east–west) with **0.5-meter spacing** between the lines. This layout enabled the construction of **a high-resolution 3D model** of the subsurface structures.
In this project, the **north–south profiles** had an **average length of approximately 19 meters**, while the **east–west profiles** were **about 15 meters long**.

Figure 3 – Field Deployment of GPR System: field specialist conducts a grid-based GPR survey using the PinPointR dual-frequency antenna system *(ImpulseRadar)*.

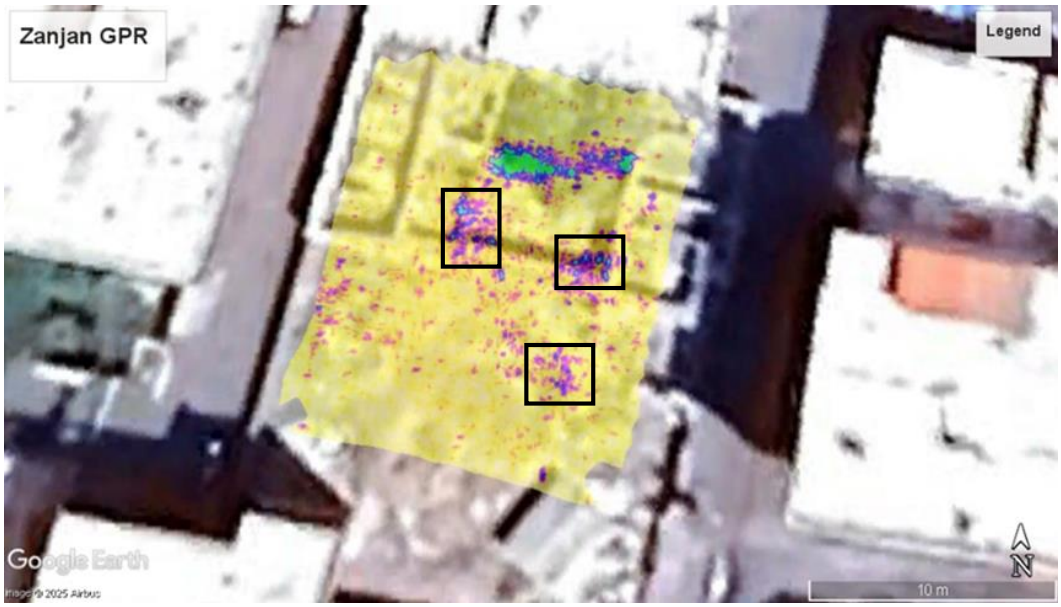

Figure 4 - A cross-sectional view of the 3D model generated using the 400 MHz antenna is overlaid on a satellite image. The northern anomalies, highlighted with black rectangles in the image, show a high degree of alignment with the foundation walls of a pre-existing structure at the project site.

conclusion

Based on data analysis and 3D modeling, **over 150 point anomalies** were identified within the surveyed area, most of which could be grouped into **11 distinct anomalous zones**. These anomalies may indicate the presence of **subsurface voids**, **variations in soil composition**, or other forms of **geotechnical discontinuities**.
The strong spatial correlation between the anomaly locations, satellite imagery, and field observations significantly enhances the reliability of the interpretations.
As a follow-up, it is recommended that **exploratory boreholes** be drilled at **three of the most prominent anomalies** to allow for further investigation and validation.