GPR Application	Methodology			Processing		Results		Complementary Tests (NDT, coring, etc.)	Ref.
	Antennas & Acquisition parameters	Testing Set-up	Equipment	Filters & Algorithms	Software	Achievements	Inconveniences & Limits		
[Concrete retaining walls in roads] Description of data processing, use of a device developed to acquire data in walls and processing strategies. Two case studies	Case study: large retaining wall in a motorway: 400 MHz: 40 ns time length & 512 samples per scan 900 MHz: 25 ns time length & 512 samples per scan 1.5 GHz: 30 ns time length & 1024 samples per scan Case study: test in a small retaining wall: two perpendicular 1.5 GHz antennas (distance between centres 0.197 m) with a time length 15 ns and 512 samples per scan	Study of a large motorway wall: 0.1 m line spacing with 900 MHz and 400 MHz antennas, and 0.005 m line spacing with 1.5 GHz antenna Study of a small retaining wall: testing strategies for the reduction of the polarization dependence of GPR results using two perpendicular antennas, with a 0.01 m line spacing	GSSI and a semiautomatic survey apparatus for GPR acquisition in vertical lines on walls	1.5 GHz: Band-pass filter (lower cut-off 200 MHz, lower plateau 400 MHz, upper plateau 2700 MHz, upper cut-off 2900 MHz); Static correction of picked direct wave; Kirchhoff migration (v=0.11m/ns); Gain (linear function: 0 dB at 0 ns and 20 dB at 20 ns); Time cut to 12 ns; Resampling to 0.04 ns; Background Removal (3D was built using 2D datasets with and without Background Removal); 3D images Other antenna: NP Test in the small wall: Time shift; Dewow; Linear gain (0 dB at 0 ns and 20 dB at 15 ns); Background removal; Spiking deconvolution; F–K filter; Built 3D images; 3D deconvolution with Stolt's algorithm (v=0.105 m/ns)	ReflexW Matlab	(i) The apparatus designed for data acquisition is efficient in large and small retaining walls, being possible acquire data along 30/40 radar lines per hour; (ii) 900 MHz and 1.5 GHz allow mapping several layers of rebar and other structures (e.g. dowels); (iii) the fusion of datasets acquired with antennas with perpendicular orientations (test in the small wall) can significantly reduce the directionality of radar data	(i) The 400 MHz antenna penetration depth the same than the penetration depth obtained with higher frequencies as consequence of the dense rebar; (ii) GPR data is not enough to distinguish between anomalies as consequence of rock anchor and other targets; (iii) not analysed deeper structures and the back wall reflection. More development of algorithms are required	NP	[116]

Study of benefits and limits of innovative processing strategies compared with classical methods. Application in concrete retaining wall with two rebar layers	Two perpendicular 1.5 GHz antennas in the same box Time window: 15 ns Samples per trace: 512 Traces per meter: 400 Transmitter-receiver offset: 0.06 m	Data acquired with a multi-sensor and multi-polarization GPR, along vertical lines using an apparatus designed for the semi-automatic radar data acquisition in walls. Line spacing: 0.01 m	GSSI SIR-20 Data acquisition apparatus (rail system with an electric motor to move and support the antenna on the vertical wall) Survey wheel	A window spectral analysis was applied to the datasets. FFT Classical 2D processing: band-pass filter; time-zero correction; Kirchhoff migration (ε_r=6.25); background removal; Gain Full 3D processing: built 3D datasets from the two antenna polarization separately, after the 2D processing of each B-scan (time shift; dewow; gain; background removal; spiking-deconvolution; F-K filter); 3D migration with a Stolt's algorithm (v= 0.105 m/ns) Fusion of data from each polarization and inverse scattering followed by data fusion using three strategies	ReflexW	(i) The 2D processing using data from one antenna provides a detailed mapping of the horizontal first layer rebar; (ii) the 3D processing followed by data fusion provides a complete map of both, horizontal and vertical rebar for the top layer of rebar; (iii) the inverse scattering approach followed by data fusion provides a complete map of both, horizontal and vertical rebar of the top layer of rebar	(i) Decay of higher amplitudes (the concrete act as a low pass filter); (ii) the 2D processing using data from one antenna provides a low amplitude and low focus result for the vertical bars; (iii) all three tested processing methods produce a result of lower quality for the second layer of rebar. This result is due to the limits of the GPR dataset	NP	[117]

Assessment of a crushed stone and lime mortar retaining wall in order to determine the shape, stability and foundations	Shielded antenna with a dual frequency operation (200 MHz and 600 MHz) and 80 MHz antenna	3 Horizontal radar lines on the wall and on the bank	RIS Hi-MOD and RIS ONE GPR (IDS) Survey wheel	Time-zero correction; background removal; vertical band-pass filter (for the 80 MHz antenna: from 50 to 150 MHz; for the 200 MHz antenna: from 100 to 300 MHz; for the 600 MHz antenna: from 400 to 800 MHz); Linear gain; Smoothed gain	GRED 30 Utilities software	(i) The thickness of the wall was determined; (ii) detection of the level of bedrock behind the wall; (iii) anomalies produced by the anchors installed during previous repairing works	(i) Accuracy depends on the selection of radar-waves velocities	NP	[118]
Analysis of a retaining wall built in an unknown ground. The objective is to determine the geometry of the masonry wall and its foundations	Dual frequency of 200/600 MHz antenna 80 MHz antenna	Three longitudinal and three transverse scans	RIS Hi-MOD and RIS ONE (IDS)	Time-zero correction; background removal; vertical band-pass filter (80 MHz antenna: from 50 to 150 MHz; 200 MHz antenna: from 100 to 300 MHz; 600 MHz antenna: from 400 to 800 MHz); Linear gain; Smoothed gain	GRED 30 Utilities software	(i) Detection of several geological layers under the wall; (ii) detection of the foundations; (iii) determined thickness and height from radar data; (iv) anomalies associated to possible anchors	NP	Tests excavations	[119]
Assessment of a masonry (stone blocks) wall	1 GHz antenna: 2 cm trace-interval with 40 ns time window and 1024 samples per trace	Radar lines along the top of the wall	RAMAC/GPR system from MALÅ Geoscience Survey wheel	Time-zero correction; 2 Dewow; Gain function (linear 0.47 & exponential 0.47); Subtracting average (450 average traces); Band-pass Butterworth (low cut-off: 300 MHz n & upper cut-off: 1500 MHz); Kirchhoff migration based on velocity = 0.14 m/ns	Reflex W	(i) Metrical analysis of masonry ashlars (ii) Identification of edges of blocks and layers of blocks	(i) The confluence of many diffractions made difficult the identification of the true ashlar edges in the horizontal direction; (ii) irregularities in the geometry could produce inaccuracies in the spatial trace positioning; iii) the data showed complex pattern of reflections such as multiple reflections and hyperbolic diffractions that makes difficult the interpretation of the data; (iv) careful filtering of raw data is required to diminish clutter and improve the signal-to-noise ratio	FDTD modelling Laser scanning	[120]

Study of stone retaining walls in a subterranean tomb	500 MHz antenna (time window: 40 ns) 800 MHz antenna (time window: 45 ns and 512 samples per scan) 1 GHz antenna 2.3 GHz antenna	Corridor: horizontal radar lines (10 cm between lines) Walls inside the tomb: circular and parallel radar lines	NP	Background removal; band-pass filter between 400 MHz and 1200 MHz; manual gain; built 3D circular pseudo-radar images	GPRSlice	(i) Identification of the two layers of irregular stones of the walls and the thickness of each layer; (ii) detection of the contact with the natural soil; (iii) detection of zones affected by humidity and salt (comparing amplitudes)	(i) The irregular structure makes difficult the identification of specific damage; (ii) required the use of scaffolding due to the height and shape; (iii) the irregular surface makes difficult the survey and covering the stones with a polyurethane sheet was required. It was difficult to draw and follow regular radar lines (a laser was used to mark the lines)	NP	[121]

Table S4. Retaining walls: relevant on-site GPR surveys (NP = Not Provided; Ref. = Reference).