SOCOTEC
THE POWER OF FORESIGHT

BRIDGES INSPECTION BY USING GPR STREAM D

CASE HISTORY
OLD TECHNOLOGY- STREAM C

An overview of the survey of a beam using STREAM C set on by-bridge is shown. The aim is the definition of the tracing of the prestressing cables and qualitative mapping of metallic elements corrosion.

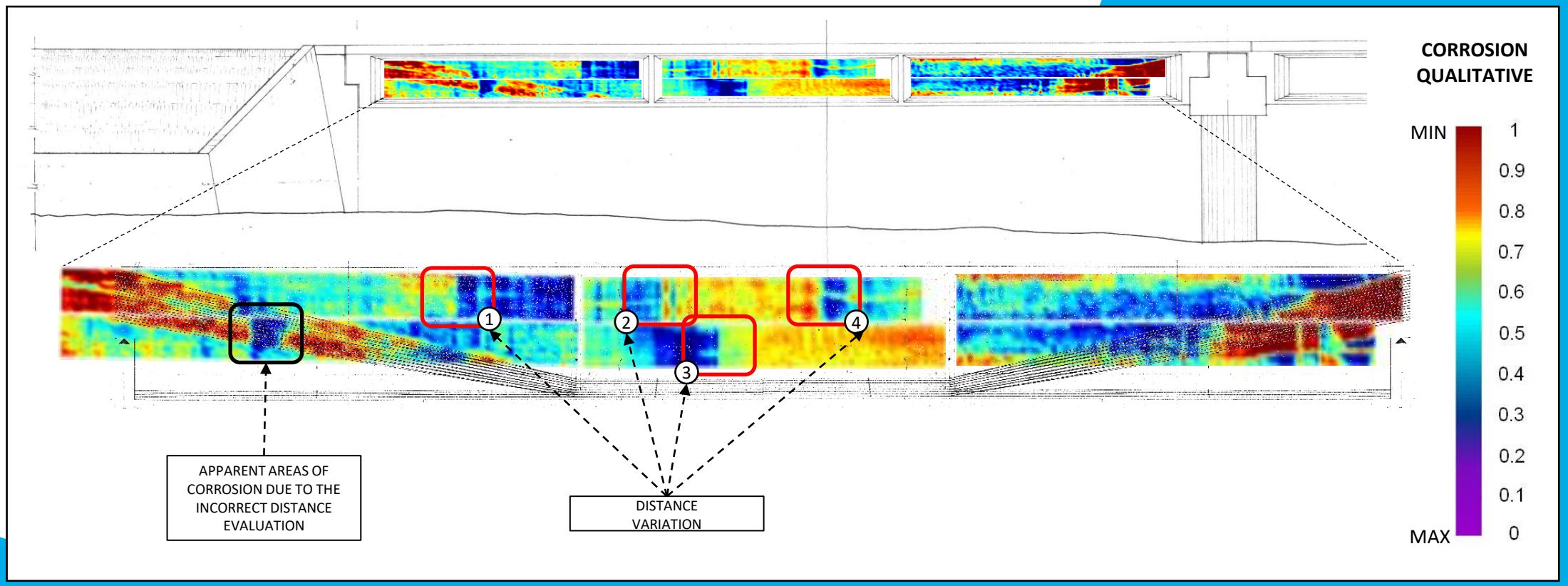
Through the acquisition by using the GPR technique, the resulting information can always be correlated to the corrosion of the investigated metal elements, providing that the acquired data are correlated throughout the acquisition phase to the distance between the instrumentation and the investigated element.

The figure shows a cable survey carried out with STREAM C technology, affected by the following problems:

A. Sudden color changes, from red to blue, show a variation in the distance of the instrumentation due to the change of direction of the by-bridge and not to a real variation in the structure properties (AREAS 1,2,3,4);

B. The obtained detail, due to the acquisition frequency, is not optimal (there is no clear distinction of the close cables);

C. Inaccurate output of corrosion detection.



TESTING THE CORROSION CALCULATION THROUGH GPR THE NEW TECHNOLOGY- STREAM D

The mapping of the metallic elements corrosion by using GPR is based on the study of the signal amplitude: greater amplitude (high return reflection) = low corrosion.

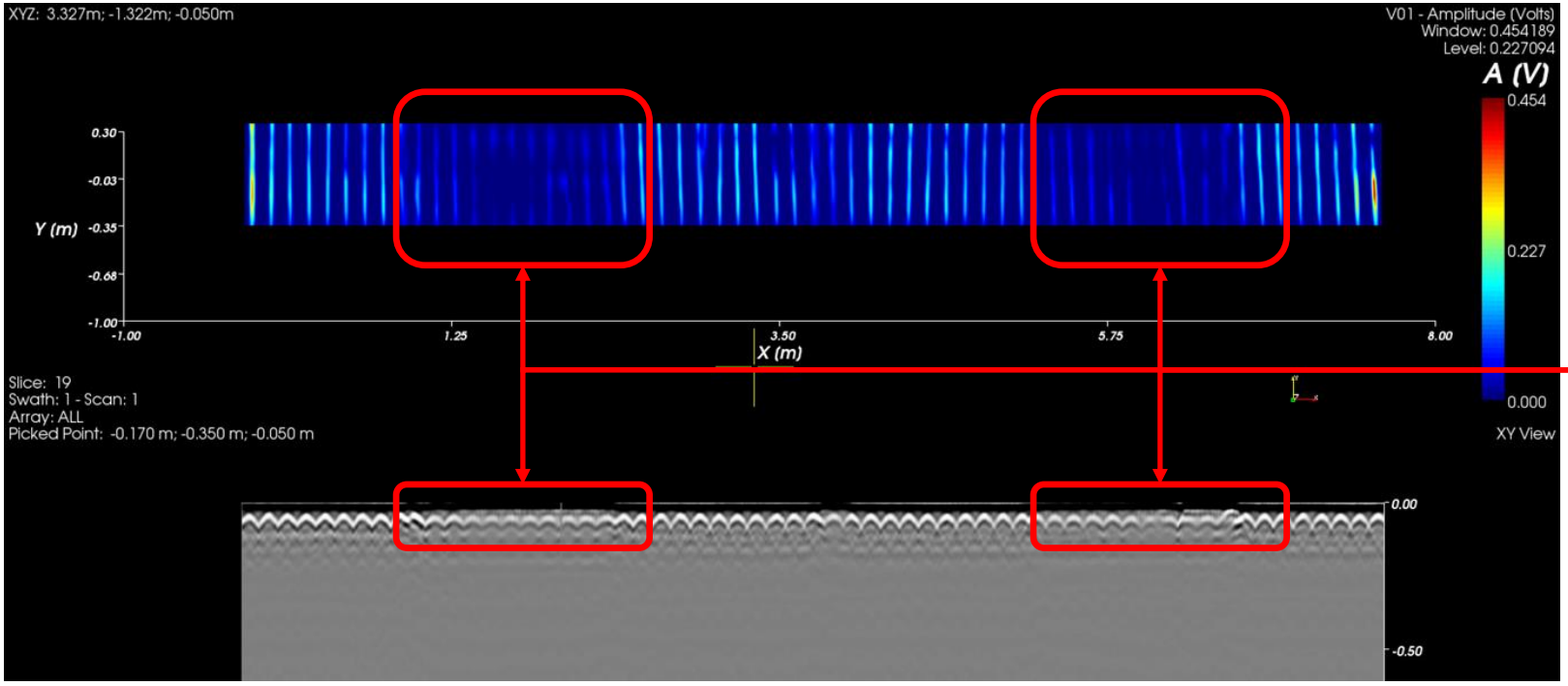
Several tests and researches were carried out on reinforced concrete samples in which the different degree of corrosion of the metallic elements were well known, first of all using the 2GHz GPR multichannel, and then the HCP method.

The carried out experimentation has highlight the good ability of the GPR methodology in detecting the corrosion degree of metallic elements in reinforced concrete but, at the same time, has shown the negative aspects of the existing instrumentation.

More specifically, the following aspects are critical:

- the penetration capacity of the antennas for the high frequency;
- the complex logistics related to the inspection of viaducts, where the instrumentation can continuously wobble impeding the equidistance from the investigated surface during the entire acquisition phase.

SOCOTEC Italia, basing on its experiences and researches, has created the GPR STREAM D: array of 34 antennas of 1 GHz equipped with position sensors and, thus, it is not necessary to work equidistant from the surface. This allows a high acquisition speed never experienced and very accurate data return, thanks to the use of latest generation software, related to excellent diagnostic skills.



GPR STREAM D

HIGH QUALITY, HIGH PRODUCTIVITY, HIGH VELOCITY RADAR SYSTEM FOR REAL–TIME INVESTIGATION

GPR STREAM D ALLOW, WITH HIGH PRECISION AND VELOCITY, TO MAP:

> THE CONCRETE THICKNESSES AND BITUMINOUS CONGLOMERATE
> THE REBAR
> CORRODED AREAS
> CONCRETE COVER DETERIORATION
> DELAMINATION

DETAIL – Stream D provides very high details and it is also characterized by an excellent penetration capacity; the type V antennas inside, with a dedicated electric power supply, allow, with the same frequency, a greater penetration than the old standards.

PRECISION – Stream D system is equipped with a series of laser sensors that, at any time, define the position, distance and inclination of the antenna array with respect to the investigated structure; the result is an effective, precise and easily usable 3D map.

PRODUCTIVITY – The type V antennas allow GPR to work even at a certain distance from the structure, assisted by sensors that constantly monitor the positioning; for this reason, the survey, especially in complex environment such as on the beam side, can be much faster since the operator could not monitor distance of the antenna array from the surface.

USED SOFTWARE – The supplied software, versatile and speed, allows direct data management and normalization, obtaining high quality data also in case of vibrations and strong oscillations in the acquisition phase (eg. survey with by-bridge). The processed and normalized data are optimal to measure the concrete degradation and the reinforcements and prestressed cables corrosion.

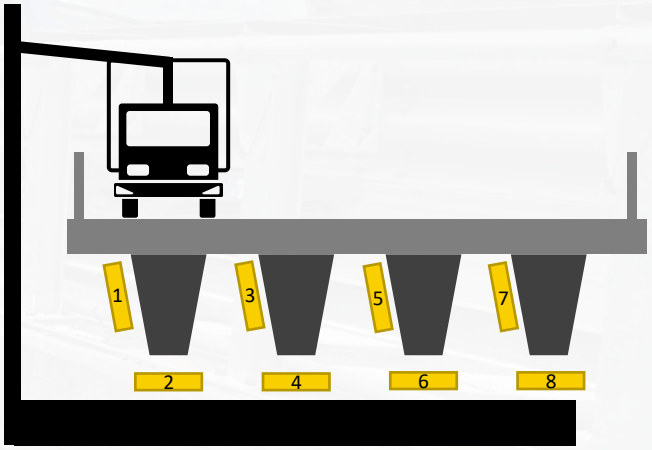
STREAM D CHARACTERISTICS

Total weight	based on the configuration from 75 kg to 95 kg
Maximum acquisition velocity	10 km/h
Radar power consumption	55 W
Placement	• magnetic encoder and/or integrated laser • dGPS and/or total station • 4 laser disto for defining the inclination and distance from the surface
Operation	up to 20 cm away from the investigated surface
Radar power supply	SLA battery 12VDC 24 Ah
Antenna total size	120 x 57 cm
Number of channels	34 VV
Antennas frequency	1 GHz
Antennas polarization	VV
Scan width	96 cm
Certification	EC, FCC, IC

LOGISTICS AND TRAFFIC STOP

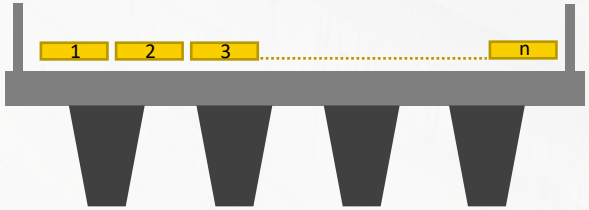
Through the use of appropriate by-bridge, it will be possible to work with the closing of a single lane (from just one side) of the roadway (for viaducts with adjacent roadways) and operate on all external or internal beams without excessive traffic restrictions.

EXAMPLE SCHEME OF ACQUISITION WITH THE USE OF BY-BRIDGE ON THE BEAMS



In yellow, the positions of the GPR STREAM D during the acquisition phase.

EXAMPLE SCHEME OF ACQUISITION FOR THE SCANNING OF THE SLAB



The equipment can be pulled by car, without the traffic partialisation, but with the aid of a support vehicle with adequate road signs.

STAFF AND EQUIPMENT

3 TECHNICIANS FOR DATA ACQUISITION

STREAM D

GPR STRUMENTATION STREAM D

MACROGRAPHY

EXTRACTION OF BAR AND TESTS FOR CALIBRATION

PULSED ECHO

STRUMENTATION FOR PULSED ECHO

BYBRIDGE

BYBRIDGE FOR SURVEYS

MOBILE WORKSHOP FOR EQUIPMENT TRANSPORT AND TECHNICIANS AND PRELIMINARY DATA PROCESSING

5 TECHNICIANS FOR ACQUIRED DATA ELABORATION AND ANALYSIS

AVAILABILITY TO SET UP A TECHNICAL OFFICE AT THE CUSTOMER'S SEAT

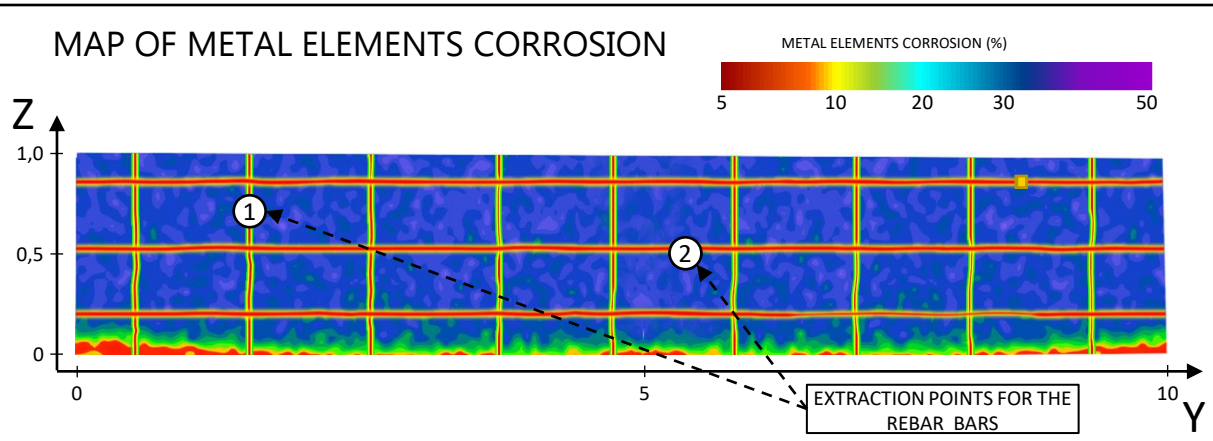
PROVIDING OF ACQUIRED DATA

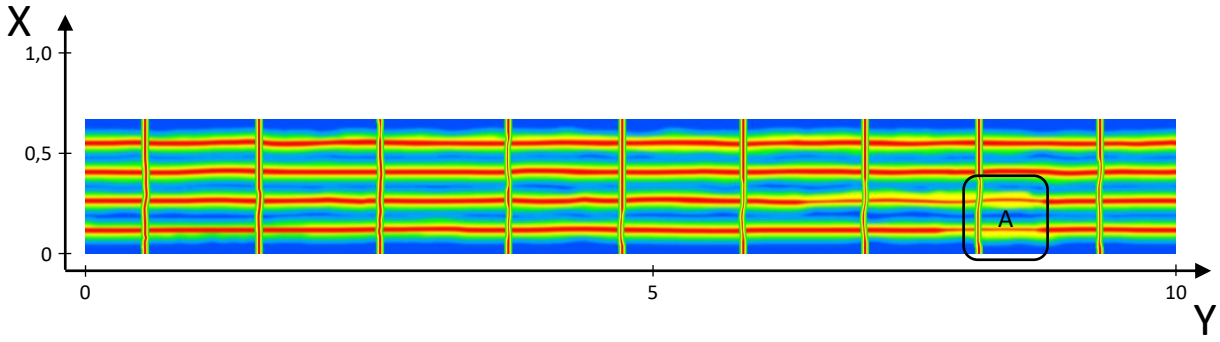
A Identification of the prestressing cables tracing and qualitative mapping of their corrosion

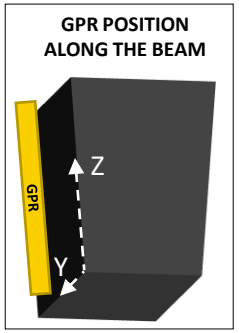
B Mapping of rebar and relative qualitative corrosion

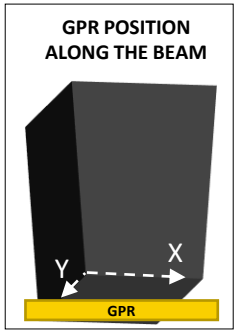
C **Quantitative conversion**, in percentage (reduction of the equivalent section), of the corrosion degree by laboratory analysis with macrographic technique on representative bar samples taken from the structure

EXAMPLE OUTPUT OF ACQUIRED DATA









A **B** **C**

① SAMPLING OF DETERIORATED BAR, THEN SUBJECT TO LABORATORY TESTS

② SAMPLING OF LESS DETERIORATED BAR, THEN SUBJECT TO LABORATORY TESTS

	QUALITY	CORROSION % (equivalent section reduction)
	EXCELLENT	0/5 %
	MEDIUM	10/15%
	LOW	20/25%
	BAD	>30%

CONCLUSION
In this example, the average value of corrosion is about 5% with peaks between 10-15% in the area called "A"

PROVIDING OF ACQUIRED DATA

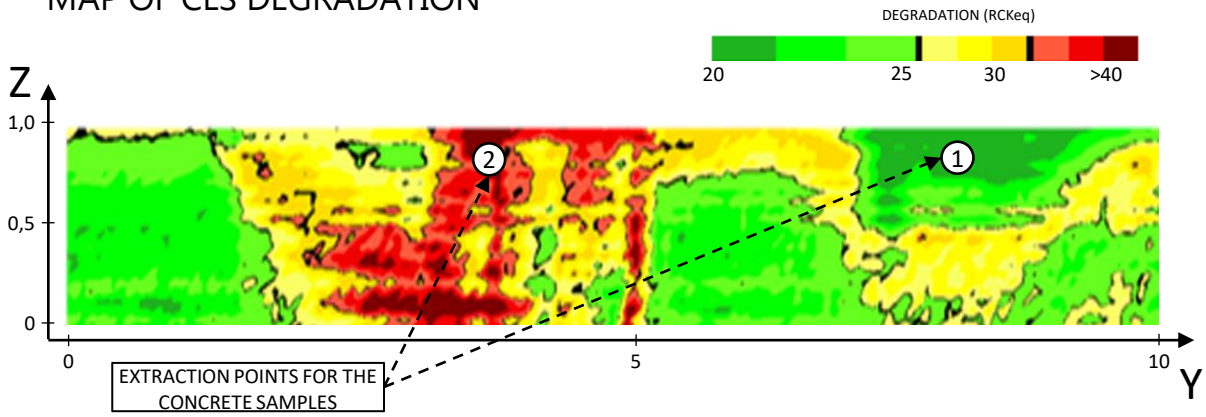
D Mapping of the concrete degradation areas

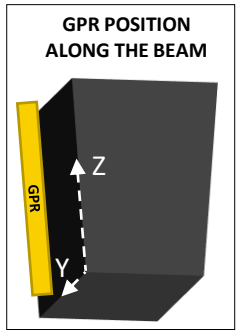
E Mapping damp areas

EXAMPLE OUTPUT OF ACQUIRED DATA

D

MAP OF CLS DEGRADATION





① EXTRACTION OF CONCRETE SAMPLE IN THE MOST DEGRADED AREA, THEN SUBJECT TO LABORATORY TESTS

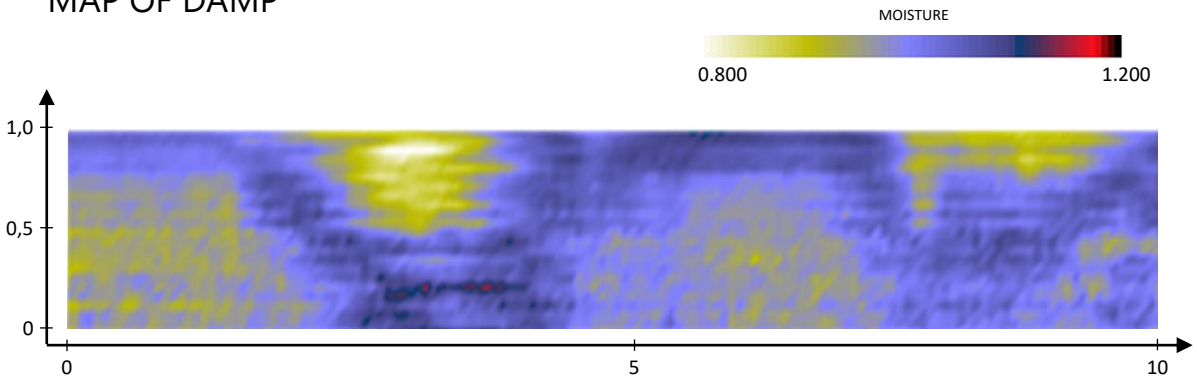
② EXTRACTION OF CONCRETE SAMPLE IN THE LESS DEGRADED AREA, THEN SUBJECT TO LABORATORY TESTS

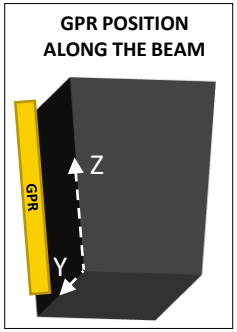
QUALITY	RCK MPa* (Project value 37Mpa)
EXCELLENT	>40
MEDIUM	30
LOW	25
BAD	20

*Reference table for a RCK project of 37 MPa

E

MAP OF DAMP





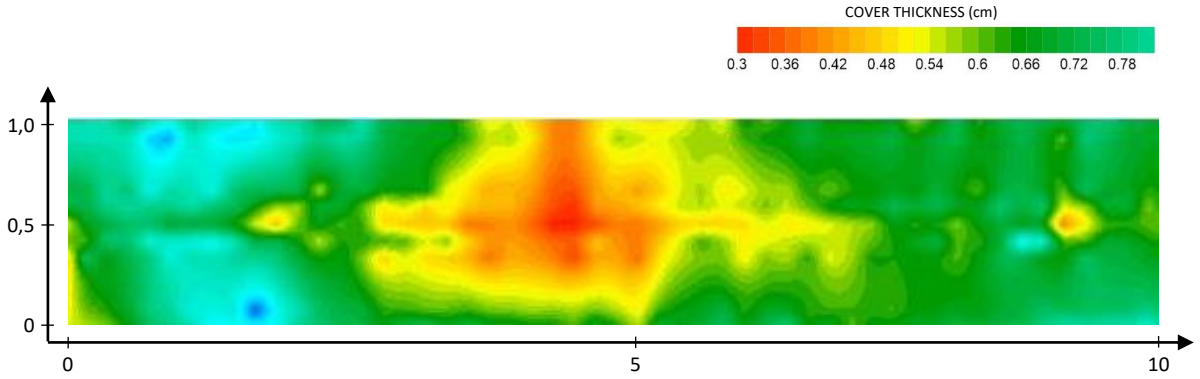
PROVIDING OF ACQUIRED DATA

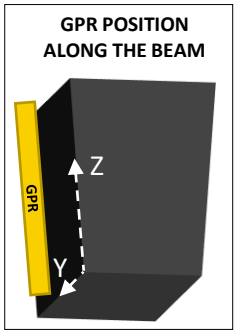
F Mapping of the concrete cover substrates

EXAMPLE OUTPUT OF ACQUIRED DATA

F

MAP OF THE CONCRETE COVER SUBSTRATES





COMPARATIVE TABLE OF INSPECTION METHODOLOGIES

SURVEY	TYPE	TESTED AREA	MAP DIMENSIONALITY	SURVEY SPEED	METAL ELEMENTS CORROSION	CONCRETE DETERIORATION	DUMP'	COVER THICKNESS	NOTE
ULTRASOUND	NON DESTRUCTIVE	CONFINED	1D	LOW	NO	QUALI TATIVE	NO	QUALI TATIVE	Confined surveys Discontinuity point valuation
HALF-CELL POTENTIAL MAPPING	NON DESTRUCTIVE	CONFINED	1D	LOW	QUALI TATIVE	NO	NO	NO	Used for rebar and not applicable (due to inaccessibility) to pre and post compression reinforcements Confined surveys
IMPACT-ECHO	NON DESTRUCTIVE	CONFINED	1D	MEDIUM	NO	QUALI TATIVE	NO	QUANTI TATIVE	Disturbance of the acquired signals due to the presence of geometric effects of the element Signal disturbance due to the presence of water in the prestressed cable Confined surveys
CARBONATION FROM CONCRETE SALMPLE	SEMI DESTRUCTIVE	CONFINED	1D		NO	QUANTI TATIVE	NO	NO	Evaluation of alkaline protection of concrete
MACROGRAPHY FROM REBAR SAMPLE	SEMI DESTRUCTIVE	CONFINED	1D		QUANTI TATIVE	NO	NO	NO	Very confined evaluation of the oxidation state of the rebar
CHLORIDE FROM REBAR SAMPLE	SEMI DESTRUCTIVE	CONFINED	1D		QUANTI TATIVE	NO	NO	NO	Evaluation of steel depassivation for high concentration of chlorides
REFLECTOMETRY	NON DESTRUCTIVE	CONFINED	1D	MEDIUM	QUALI TATIVE	NO	NO	NO	Complex data interpretation Methodology usable just for a qualitative evaluation of deterioration degree
TRADITIONAL GPR	NON DESTRUCTIVE	WIDE	2D	MEDIUM	NO	NO	NO	QUANTI TATIVE	Limited use in standard conditions Logistic limitations
MULTI ARRAY GPR	NON DESTRUCTIVE	WIDE	3D	HIGH	QUALI TATIVE	QUALI TATIVE	QUALI TATIVE	QUANTI TATIVE	Qualitative evaluation of deterioration and corrosion degrees Logistic limitations
2019									
GPR STREAM D	NON DESTRUCTIVE	WIDE	3D	HIGH	QUANTI TATIVE	QUANTI TATIVE	QUANTI TATIVE	QUANTI TATIVE	Result deriving from years of experimentation aimed at connecting point analytical tests to extensive mapping