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Overview and comparative study of GPR international standards and guidelines – COST Action TU1208

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Ground Penetrating Radar (GPR) can be effectively used for non-destructive testing of composite structures and diagnostics affecting the whole life-cycle of civil engineering works. Nevertheless, few recognised international standards exist in this field and inhomogeneous recommendations are present in different countries. Moreover, the levels of knowledge, awareness and experience regarding the use of GPR in civil engineering vary strongly across different European areas. The COST Action TU1208 is working hard on leveraging these differences, by sharing and disseminating knowledge and experience, as well as by developing guidelines and protocols for a safe and effective use of GPR in civil engineering. GPR users need to know which is the best way to conduct GPR measurements and what the quality level for the results should be. The TU1208 guidelines will ensure a higher efficiency and quality of GPR services and they will constitute a scientific basis for the introduction of European Standards on the application of GPR in civil engineering. The aim of this contribution is to present an in-depth overview and critical analysis of the existing GPR international and national standards and guidelines. The main documents considered in our work are listed and briefly described in the following.

Three standards are provided by the American Society for Testing and Materials (ASTM), to guide the GPR use for subsurface investigation, evaluation of asphalt-covered concrete bridge decks, and determination of pavement-layer thickness:

1. ASTM D6432-11, Standard Guide for Using the Surface Ground Penetrating Radar Method for Subsurface Investigation, ASTM International, West Conshohocken, PA, 2011, www.astm.org, DOI: 10.1520/D6432-11.
 2. ASTM D6087-08, Standard Test Method for Evaluating Asphalt-Covered Concrete Bridge Decks Using Ground Penetrating Radar, ASTM International, West Conshohocken, PA, 2008, www.astm.org, DOI: 10.1520/D6087-08.
 3. ASTM D4748-10, Standard Test Method for Determining the Thickness of Bound Pavement Layers Using Short-Pulse Radar, ASTM International, West Conshohocken, PA, 2010, www.astm.org, DOI: 10.1520/D4748-10.
- Further ASTM standards exist, not focused on GPR but including useful information (details are not provided here, for brevity reasons). There are no standards in Europe, instead, guiding the GPR use for subsurface prospecting and regulating the numerous applications of this non-destructive technique.

The following Radio and Telecommunications Terminal Equipment (RTTE) directive applies to GPR equipment and allows the placing of a GPR product on the European (EU) market for sale: Directive 1999/5/EC of the European Parliament and of the Council of 9 March 1999, on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity. Official Journal of the European Union, L 91, 7.4.1999, open access on ec.europa.eu. This document will be repealed, since 13 June 2016, by the following RTTE directive: Directive 2014/53/EU of the European Parliament and of the Council of 16 April 2014, on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment, repealing Directive 1999/5/EC. Official Journal of the European Union, L 153, 22.5.2014, open access on ec.europa.eu. Although conformance to the RTTE directive allows the placing of a GPR product on the market for sale, it does not give authority for its use. In order to use the equipment, in the majority of EU member countries, a license is required. The license is controlled and issued by the radio administration in each of the member countries.

The Electronic Communications Committee (ECC) of the European Conference of Postal and Telecommunications Administrations (CEPT) considers and develops policies on electronic communications activities in European context, taking account of European and international legislations and regulations. There are 48 European countries involved in the CEPT, which cooperate to regulate posts, radio spectrum and communications networks in Europe. The ECC agreed to the decision ECC/DEC/(06)08, specifically referred to GPR and Wall Penetrating Radar (WPR) systems: ECC Decision of 1 December 2006 on the conditions for use of the radio spectrum by Ground- and Wall- Probing Radar (GPR/WPR) imaging systems, 14 December 2006, open access on www.cept.org. This is not legally binding on member countries. It is currently implemented by 25 and partly

implemented by 2 of the 48 administrations; 5 further administration are considering and studying the decision. Outside Europe, different approaches exist, ranging from very formal technical approval and licensing conditions to no specific rules.

A series of standards and codes, introduced by the European Telecommunications Standards Institute (ETSI), regulate the GPR use and its emissions of electromagnetic radiation in Europe:

1. ETSI EN 301 489-1 v1.9.2, Electromagnetic compatibility and Radio spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements, Sept. 2011, open access on www.etsi.org, Ref. DEN/ERM-EMC-230-32, 45 pp. [7]. This document is a Harmonized European Standard.
2. ETSI EN 301 489-32 v1.1.1, Electromagnetic compatibility and Radio spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 32: Specific conditions for Ground and Wall Probing Radar applications, Sept. 2009, open access on www.etsi.org, Ref. DEN/ERM-EMC-230-32, 12 pp. [8]. This document is currently (May 2015) a Candidate Harmonized European Standard (Telecommunication Series).
3. ETSI EN 302/066-1 v1.2.1, Electromagnetic compatibility and Radio spectrum Matters (ERM); Ground- and Wall- Probing Radar applications (GPR/WPR) imaging systems; Part 1: Technical characteristics and test methods, Dec. 2007, open access on www.etsi.org, Ref. REN/ERM-TG31A-0113-1, 25 pp. [9]. This document is a Harmonized European Standard (Telecommunications series).
4. ETSI EN 302/066-2 v1.2.1, Electromagnetic compatibility and Radio spectrum Matters (ERM); Ground- and Wall- Probing Radar applications (GPR/WPR) imaging systems; Part 2: Harmonized EN covering essential requirements of article 3.2 of the RTTE Directive, Dec. 2007, open access on www.etsi.org, Ref. REN/ERM-TG31A-0113-2, 12 pp. [10]. This document is a Harmonized European Standard (Telecommunications series).
5. ETSI EG 202 730 v1.1.1, Electromagnetic compatibility and Radio spectrum Matters (ERM); Code of Practice in respect of the control, use and application of Ground Probing Radar (GPR) and Wall Probing Radar (WPR) systems and equipment, Sept. 2009, open access on www.etsi.org, Ref. DEG/ERM-TGUWB-010, 11 pp. [11]. This document is currently (May 2015) an ETSI guide.

Few National GPR Guidelines and Standards exist in Europe. In France, the National standard NF S 70-003, Parts 1-3, is concerned with the use of GPR to detect buried utilities. Still in France, Cerema/Ifsttar produced protocols for road inspection. In Germany, the DGZfP e.V. (German Society for Non-Destructive Testing) published a fact sheet called "Merkblatt B10" on the radar method for non-destructive testing in civil engineering (2008). Still in Germany, there is a BASt (Federal Highway Administration) instruction sheet on the use of GPR to gain inventory data of road structure (2003). In Poland, the national regulation of September 24, 1998 (Dz.U. Nr 126 poz. 839) cites 'georadar testing' as a method to investigate the soil structure. In Scandinavia, recommendations for guidelines were developed during the MARA NORD Project (2010-2012) on the use of GPR in asphalt air voids content measurements, in road construction quality control, in bridge deck surveys, in road rehabilitation projects and in site investigations.

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