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# A Review on Non-destructive Methods for Testing the Concrete Cubes for Analysing the Material Composition

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**ABSTRACT:** The main goal of this study is to discover the properties of soil using Vis-NIR spectroscopy with the help of ASD FieldSpec4 instrument. The instrument ASD FieldSpec4 Spectroradiometer is utilized for capturing spectral signature of concrete cube samples. In the Vis-NIR wavelength range utilized Partial Least Squares Regression (PLSR) method to estimate the properties present in the samples of soil. Also, few pre-processing methods were applied such as savitzkygolay and first derivative preprocessing. The outcomes were assessed by root mean square error (RMSE) and coefficients of determination (R<sup>2</sup>).

**KEYWORDS:** concrete, spectroradiometer.

## I. INTRODUCTION

An increase in the number of buildings in urban areas, when poorly planned, causes structural and spatial problems that directly affect people and the surrounding environment (Ben-Dor 2003). With respect to structural problems, various studies have been performed to monitor the quality of engineering works such as control of strength of structural materials. Cement materials such as paste and mortar are some of the most frequently used materials in the construction market. The intensive use of these products encourages further research on technology of cement materials, fosters multidisciplinary approaches, and enables broader and more efficient evaluations. Most quality inspections of structures made of cement materials are associated with destructive testing. Non-destructive techniques are technologies that assist destructive methods in evaluating a building as for the condition of the material used as well as the presence of cracks, voids, and corrosion of steel bars. In this context, remote sensing offers several resources that collect data from an object. It is used to gather information about the target without the need to destroy it. Several research studies on non-destructive methods for inspection of structural concrete have emerged in Europe, as well as in the USA and Far East. The study of construction materials with proximal remote-sensing techniques has been underway for mapping and monitoring the quality of such materials. Depending on the type of evaluation, this inspection can be directly performed on site during construction, in a quick and cost-effective manner, without damage to the finish of the structure. Methods that use electromagnetic radiation (radiometers) have well-defined investigative principles and only require access to the surface of the material (Ghosh 2001; Ylmén et al. 2009). Remote sensing registers the electromagnetic radiation reflected, absorbed, transmitted, or emitted by a target, which is associated with the response obtained with the physicochemical properties of the target (Hunt and Salisbury 1970, Goetz et al. 1985). The sensors, ranging from orbital to proximal, have many applications in the fields of engineering, medicine, natural resources, environment, urban planning, and among others.

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Table1: Difference between Destructive and Non Destructive methods

Destructive method	Non-Destructive method
Application of load	No load application
Damage due to load	No damage
Special equipment is required	No Special equipment is required
Heavy machinery	Light weight machinery
High power consumption	Low power consumption
Test conduction is only at laboratories	Test can be conducted any where

**II. OVERVIEW OF REMOTE SENSING METHODS**

The Sun is the primary source of energy for the Earth. This energy, or electromagnetic (EM) radiation, travels through space in the form of waves which are absorbed, reflected, or scattered by the Earth’s atmosphere and its surface. The amount of energy emitted or absorbed by an object is a function of temperature, and every object with a temperature above 0 degrees Kelvin emits EM radiation. Plank’s equation defines a theoretical relationship between temperature and EM energy emitted, which is used to define blackbodies. Stars most closely approximate the theoretical blackbody emission, whereas all other objects, called grey bodies, have emissions lower than this theoretical maximum. Peak emission is a function of temperature, with wavelength decreasing as temperature increases. Therefore, the sun which has an approximate temperature of 6000 degrees Kelvin peaks in the visible region of the EM spectrum, whereas the Earth, with an average temperature of about 300 degrees Kelvin peaks in the thermal infrared region. This relationship is governed by the Wien law.

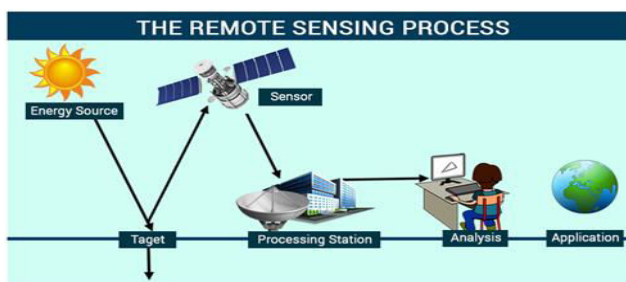


Fig 1. Remote sensing Process

**III. LITERATURE REVIEW**

**Field Spectroradiometers**

First field sensors emerged in the 1960’s. They were usually modified laboratory instruments and had limited spectral coverage in the range of 400-1100nm. Specifically developed, portable field spectroradiometers appeared in the late 1980’s. The PIDAS (Portable Instant Display and Analysis Spectrometer) instrument was completed in 1987. It sampled 833 bands in less than 2 seconds, covering a wavelength region from 450nm to 2500nm. Field and library spectra could be displayed simultaneously (Vane and Goetz, 1988). The IRIS instrument covered wavelengths from 360 – 3000nm (Hutsinpillier, 1988). For both of these instruments, spectral resolutions were not uniform over the whole

spectral range. Modern day field spectroradiometers still cover the same wavelength region as their predecessors. However, the spectral resolution tends to be uniform; around 1nm over the whole bandwidth and the integration times have increased by about factor 10. As well, the use of portable field computers with some instruments facilitates their operation and the subsequent data transfer to other systems. Field spectroradiometers can be divided into two classes: single beam and dual beam instruments. Dual beam instruments are capable of measuring two energy sources simultaneously, i.e. incident energy and reflected energy can be recorded at the same time. This gives the dual beam instruments an advantage over single beam instruments, as the latter have to acquire these data consecutively, i.e. there is a time delay during which the incident energy level can change.



Fig 2. Spectroradiometer

**Lisa Ptacek., et al (2021) [1]:** This paper presents a non-destructive measurement method for the determination of the curing quality of young concrete. Test series were carried out on concrete samples with composition and properties. Strength class Cement: 320 kg/m<sup>3</sup>, Water 170 kg/m<sup>3</sup>, w/c-ratio 0.48, Stone Round gravel 451 kg/m<sup>3</sup> Round gravel 289 kg/m<sup>3</sup> Round 307 kg/m<sup>3</sup> Sand 761 kg/m<sup>3</sup> Aggregates 40 kg/m<sup>3</sup> Additives Air entraining agent: 0.25–0.50 m%-Cement (super)plasticizer: 0.20–0.33 m%-Cement Air content (fresh concrete) 2.5–3.6% Density (fresh concrete) 2383–2442 kg/m<sup>3</sup> Fresh concrete temperature 21.8–23.3 °C. The dimensions of the samples (10 cm × 10 cm × 10 cm) were chosen. Laboratory tests were carried out with samples with three different curing types at the age of 1, 7, and 27 days. This method showed a high level of reliability for the differentiation between the different curing types and concrete ages. A recommendation for hyperspectral measurement and the evaluation of the curing quality of concrete could be made. This method showed a high level of reliability for the differentiation between the different curing types and concrete ages.

**Rochelle Schneider dos Santos., et al (2015) [2]:** In this paper, remote sensing can contribute to mapping and monitoring construction materials, allowing investigation and identification of various properties such as mechanical strength and water content in a non-destructive manner. The spectral behavior of four different mechanical strengths of two cement materials based on Portland cement, cement paste, and mortar was observed using a Field Spec 3 spectroradiometer. The spectral curves generated by recording the reflected and absorbed electromagnetic radiation of the samples were interpreted based on the theory of vibrational and electronic spectroscopy. The objective of this work is to show a novel technique for assisting in the analysis of solid samples using visible and near infrared spectroscopy. Through this study, a spectral contrast between different samples of the paste and mortar was found. The author says that besides, it was possible to detect the presence and the corresponding proportion of water in the samples. Wavelet analysis is used to records of statistical evidence of spectral contrast, and showed that the depth of water absorption features is inversely proportional to compressive strength in the cement materials under this study. This work is innovative, because there are no studies in the literature on the application of this technique as an aid tool for differentiating compressive strengths of Portland-cement-based materials.

**Maruthi Sridhar., et al (2007)[3]:** This study was to investigate the effects of different construction practices on the spectral characteristics of the concrete. Concrete blocks of identical shape and size (20 × 20 × 6 cm<sup>3</sup>) were prepared using different treatment processes to establish eight different concrete characteristics. The different concrete treatments were: TC (control), TNC (no cure), TCL (cool cure), TH (heat cure), THW (high water content), THC (half cement), TG (gravel), and TL (limestone). Spectral reflectance of all the concrete blocks was obtained in the laboratory



from 350–2500 nm spectral range using a portable, hand-held spectroradiometer. The spectral reflectance of the different concrete treatments varied systematically with changes in the concrete characteristics that resulted from different construction practices. Detailed spectral analysis shows that the spectral absorption features around 450, 1380 and 1850 nm are highly correlated with changes in the characteristics of the concrete. The spectral ratios R600/R450, R1380/R1440, R1850/R1950 and R2150/R880 can clearly differentiate the TNC- and TCL-treated concrete blocks from the other blocks with different concrete treatments. The spectral ratio R600/R450 can differentiate the TC-, TG- and TL-treatments, which were considered to have better concrete quality from the rest of the concrete treatments. The spectral results clearly indicate the potential application of spectral reflectance in assessing concrete characteristics after the concrete has hardened.

**Abdul Wahab et.al(2019) [4]:** Various conventional and NDT tests of concrete are reviewed. The MNDT techniques used in concrete applications are summarized. MNDT techniques minimize processing time and preserve of energy. The electromagnetic properties of concrete were emphasized and explained both microscopically and macroscopically via techniques such as magnetic conductivity, relative permittivity, electrical conductivity, and complex relative permeability. The raw electromagnetic properties of material composites with various-sized reinforcement grids of concrete, brick, wood, and glass have been presented.

**Tzuyang Yu, A.M.ASCE et.al (2017) [5]** This paper reports the performance of a 10.5 GHz portable imaging radar system for the quantitative, surface, and subsurface sensing of concrete structures in field configuration. This paper presents a SAR imaging work on real concrete structures (a composite wall, a retaining wall, and a bridge abutment) with quantitative remote-sensing criteria. This paper also reports field applications of a portable imaging radar system for the surface and subsurface remote sensing of concrete structures. This paper first details the imaging principle of SAR, followed by the hardware description of a portable imaging radar system. Selected example structures also are described. Imaging results are provided and discussed. Finally, research findings are summarized.

**CzesławSuchocki and Jacek Katzer (2016)[6]**

The main objective of the research programme was to prove that it is possible to use commercially available geodetic Terrestrial Laser Scanners (TLS) for quick and remote saturation assessment of building materials. During the research programme an impulse TLS scanner VZ-400 produced by Riegl was utilized (see Fig. 3). This scanner uses a narrow infrared laser beam and a fast scanning mechanism. High-accuracy laser ranging is guaranteed by good echo digitization and online waveform processing.

This image represents used TLS apparatus and setup of conducted tests

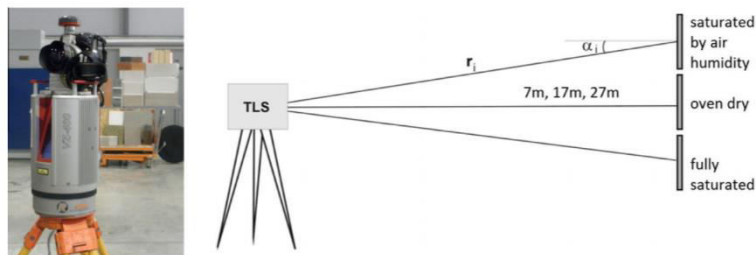


Fig 3 used TLS apparatus and setup of conducted tests.

**AlaaShaban, et al (2016) [7]:** The strength and durability of concrete are the most essential parameters for determining structural performance of any concrete structure. In this test method, the reflectance radiations across the visible near-infrared and shortwave-infrared (VI-NIR & SWIR) in the region between (350 - 2500) nm were utilized as an approach to predict unknown concrete properties. This paper presents the fundamental elements of hyperspectral technology and discusses the possibility of utilizing hyperspectral imaging sensors for detecting characteristics of concrete structures in-situ.

**Rochelle Schneider dos Santos et.AI[8] (2015):** Radiance measurements of cement materials were made using a FieldSpecprospectro-radiometer, manufactured by Analytical Spectral Devices (ASD, Inc., Boulder, CO, USA), which contains three non-photographic sensors that detect the electromagnetic radiation reflected from targets in the portion between 0.35 and 2.50 μm (ASD Analytical Spectral Devices Incorporated 1999). Two features are in the near infrared portion (1.40 and 1.90 μm) and their depth decreases as the mechanical strength increases between the curves.

### 1.Importance of the proposed research work

Non-destructive remote sensing method for testing the concrete cubes for analyzing the material composition by using Spectroradiometer.

### IV. SUMMARY OF REVIEW

- [1]. To cast the concrete cubes in the laboratory (as shown in the fig 4)
- [2]. To determine the properties of concrete cubes using Destructive methods.
- [3]. To determine the properties of concrete cubes using on destructive methods.
- [4]. To analyze the material composition in concrete cubes using non-destructive remote sensing techniques using spectroradiometer.
- [5]. Compare results obtained from destructive and non-destructive methods.



Fig 4. Casting Concrete cubes



Fig .5.Curing of Concrete Cubes

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