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Determination Construction Quality Using Non-Destructive Testing Methods

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ABSTRACT

Many destructive earthquakes have occurred in the past because of the geographical location and geological structure of Turkey and these earthquakes will also take place in the future. According to researches and reports, existing buildings have lost their capacities of bearing day by day because of earthquakes. For this reason, concrete quality is the most important parameter for in-situ construction. Furthermore, estimation of conditions of steel bar is important for buildings's earthquake resistance. Concrete quality is mostly determined by core samples and trixial compression test method. Determination of concrete moisture is used for quality of concrete surveys. They only indicate the core samples not all construction. The conventional methods take time to do, waste to money and also damages constructions. Quality of concrete must need essential standards for building's earthquake resistance.

Geophysical methods are increasingly used by civil engineers at non-destructive testing (NDT) explorations. Its aim is to detect to estimation of concrete quality, degree of corrosion, buried dielectric interfaces on site (concrete delamination, steel rebars, tension ducts, etc.) and measuring the depth or thickness of layers of material.

In this study, ultrasonic ground penetrating radar (GPR), and micro-resistivity methods were used to determine the physical characterization of concrete, depths of steel bars and the effect of concrete moisture on concrete laboratory slab. GPR measurements were performed to with 2.7 GHz ground-couple antennas. Intervals of profiles are as 60 and 120 cm for GPR. Data processing is controlled and 2-D and 3-D GPR sections were prepared by RADAN-7 software. Electrical resistivity method utilized resistivity profile using Wenner electrode array configuration on slab. The electrical profiles entatiled 1-D vertical probing of the surface. Pulse velocity measurements (ultrasonic) were done for every each 5 cm on prepared concrete samples. Graphs of electrical resistivity and longitudinal wave velocity are plotted by SURFER 8.0 software for different directions.

Estimation of concrete strength from pulse velocity measurement, degree of corrosion estimated from electrical resistivity measurements, existing and depths of steel rebars from GPR profiles on different samples of construction are discussed in this study.

Keywords: Construction Quality, Ultrasonic, Ground Penetrating Radar, Micro-resistivity, Non-Destructive Testing

1. Introduction

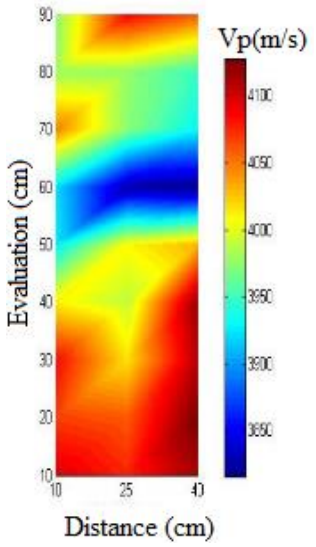
Turkey is located in an active earthquake zone that caused large earthquakes. For this reason, investigation of building characteristics is very important for decreasing the damage of earthquakes. To know the numbers of steel bars, estimation of their diameters and positions, determination of fractures at the structural members and concrete moisture is essential parameters for stability. For this purpose, researchers who has worked about determination of structure quality using geophysical methods are painted a positive picture of big improvements Nowadays ground penetrating radar (GPR), electrical resistivity and ultrasonic method have often been used at structure geophysical research. (Uyanık, 2012; Hannachi and Guetteche, 2012; E. Cheilakou et al., 2013; Lakshmi et al., 2016) .

Aim of study is to investigate effect of geophysical methods which have been used in structure research. Evaluation of taken measurements by high frequency GPR, ultrasonic and resistivity tools on reinforced concrete samples, concrete which was especially prepared. Determination of concrete strength, degree of corrosion, numbers and depths of reinforcement were discussed in this study.

2. Methods

Ground-penetrating radar (GPR) is a geophysical method that uses radar pulses to image the subsurface. A GPR transmitter emits electromagnetic energy into the ground. A receiving antenna can then record the variations in the return signal. The electrical resistivity method involves the measurement of the apparent resistivity of soils and rock as an function of depth or position. During resistivity surveys, current is injected into the earth through a pair of current electrodes and the potential difference is measured between a pair of potential electrodes. Ultrasonic testing (UT) is a family of non-destructive testing techniques based on the propagation of ultrasonic waves in the object or material tested. In most common UT applications, very short ultrasonic pulse-waves with center frequencies ranging from 0.1-15 MHz, and occasionally up to 50 MHz, are transmitted into materials to detect internal flaws or to characterize materials. Vertical and horizontal reinforced concrete samples and cubic concrete samples were designed in this work. GPR, resistivity and ultrasonic measurements were taken on vertical concrete sample. GPR and ultrasonic measurements were taken on horizontal concrete sample. Ultrasonic and compression tests were done on cubic samples. Furthermore, GPR, ultrasonic and resistivity methods were applied on existing concrete column. Data found by GPR method were evaluated by software and steel bars were determined. According to data collected by electirical resistivity method, corrosion degree of structures were identifed.

Figure 1. Samples of reinforced and unreinforced concrete



Vertical Distance (cm)	Horizontal Distance (cm)		
	10	25	40
10	4096	4076	4115
20	4068	4059	4128
30	4084	4017	4109
40	4012	3989	4120
50	3926	4010	4032
60	3921	3826	3816
70	4048	3973	3931
80	3978	3976	3947
90	3973	4087	4059

Figure 2. Ultrasonic velocity measurements and results on prepared concrete block

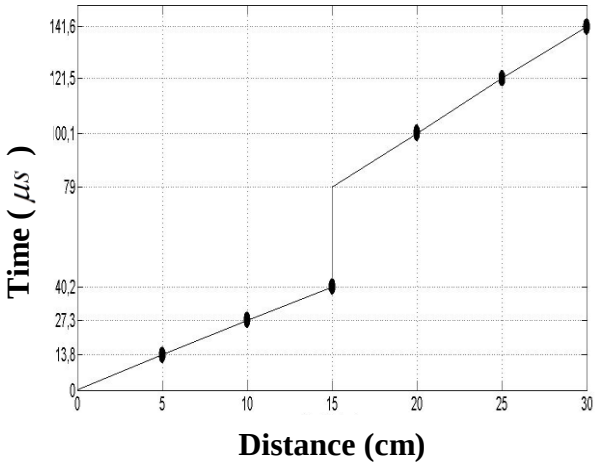
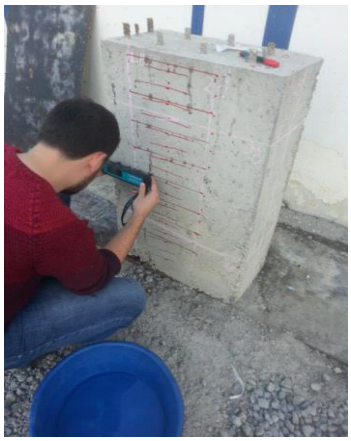


Figure 3. Estimation of crack inside concrete sample and ultrasonic time-distance graph



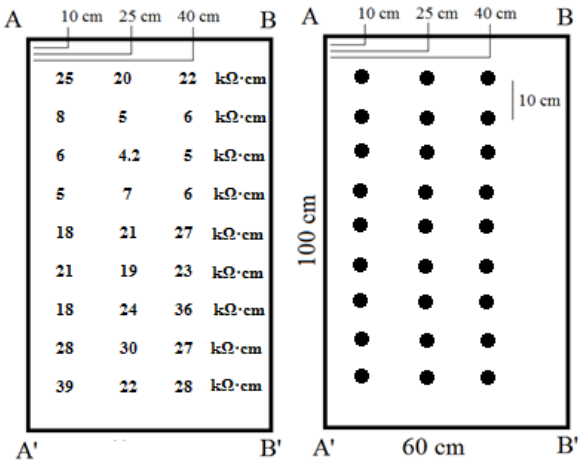


Figure 4. Microresistivity results for vertical concrete sample. First picture is design of measurement. Second picture is microresistivity results as $k\Omega$/cm . Third picture indicates profiles on concrete block.

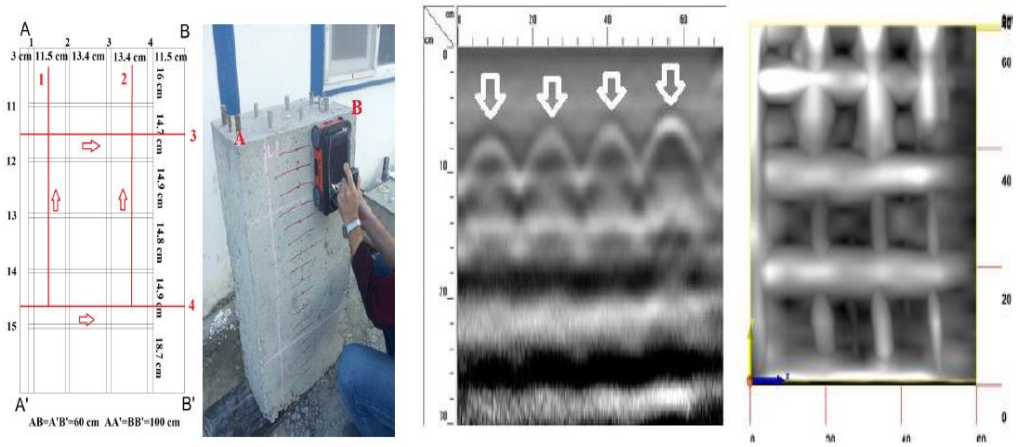


Figure 5. 2D/3D GPR sections for vertical concrete sample. First picture is design of measurement. Second picture is profiles on concrete block. Third picture indicates steel bars positions as 2D. Fourth picture is 3D GPR section for same sample.

4. Conclusions

Results of micro resistivity, GPR and ultrasonic measurements demonstrate that geophysical methods at civil engineering applications are quick and reliable. Concrete quality is researched by ultrasonic method on vertical/horizontal and cubic concrete samples. Depth and width of crack was detected by ultrasonic measurements. According to ultrasonic measurements, degree of concrete quality is determined as good. Micro resistivity measurements were done for estimation of corrosion degree. When percentage of water content is increased, risk of corrosion will be higher. Effects of plaster on survey blocks were searched by micro resistivity method. Due to the resistivity measurements, effects of reinforcements can be seen near 5 cm. Steel bars, ties and plastic pipes were determined by 3D and 2D GPR measurements on samples. 2.7 GHz GPR measurements were done and after basic acquisitions, steel bars can be seen clearly and we determined them as deformed or not.

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