Conductive Concrete for Electromagnetic Shielding Applications

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Introduction: Radio communications and electronic devices are experiencing a rapid exponential growth. Consequently, electromagnetic interference (EMI) is becoming a serious concern in which invasive radio waves could disturb or jam sensitive systems or cause a leakage of private signals. Therefore, the need for radio frequency shielding is becoming a must for military, medical, industrial organizations and many more. Conventional concrete is a dielectric whose properties change based on the constituents of the mixture. The ratios of water, cement, sand and aggregates and their properties are the most influential parameters. As a dielectric, RF waves can propagate through conventional concrete with relatively low attenuation. Researchers investigating the EMI shielding considered different techniques involving a variety of materials. For example, aluminum or copper foils were installed on walls using contact adhesive. Foil covered walls proved to be successful in shielding high frequency signals but failed at low frequencies. Other EMI shielding techniques involved welded steel facilities, galvanized sheet metals attached to plywood walls, copper screening mounted on wooden studs, or a combination of the two. New construction techniques utilized shielding materials like modular and welded shielded enclosures to provide alternative shielding techniques. Other shielded structures range from prefabricated enclosures to complete buildings that control the emissions of certain equipment that process sensitive information were also introduced.
In this work, we investigate the EMI shielding effectiveness of a newly proposed enhanced conducive concrete mixture. This mixture was developed for deicing applications [1,2]; however, the mix was enhanced to enable other applications such as cathodic protection [3], EMI and anti-static flooring.

Conductive concrete is a relatively new material technology developed to achieve high electrical conductivity and high mechanical strength. Due to its electrical resistance and impedance, the material could be used in many infrastructure applications. The first generation conductive concrete mixture was developed utilizing steel shavings and steel fibers proposed for deicing

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application[1,4]. However, this mixture was enhanced to meet requirements of the construction industry by using carbon products and steel fibers [2]. The conductive concrete proved effective as bridge deicer [5]. In 2008, Yehia and Host evaluated the conductive concrete material for Cathodic Protection application [3]. This showed the potential of using the conductive concrete mixtures in other applications such as Electromagnetic Shielding (EMS) and Anti-static flooring systems.

Results: Two conductive concrete mixtures were proposed including different additives (carbon and steel fibers). Specimens of conventional concrete and the two conductive mixtures were prepared to evaluate the mechanical and electrical properties of all mixes. The three mixes were evaluated at DC to investigate the resistivity. The investigation was conducted over a long period of time during curing and a long time after curing. Table 1 summarizes the measured resistivity for the three mixes. The results indicate that the resistivity of the proposed conductive concrete mixes is much lower than that of the conventional mix. This means that both mixes will be more effective in shielding at higher frequencies because of the higher conductivity.

Table 1. Measured resistivity (Ωm) over two months and after two years:

	Day 5	Day 10	Day 20	2 Months	Two years
Conventional mix	38	53	88	265	720
Conductive mix 1	2.3	2.0	2.5	6.0	95
Conductive mix 2	2.0	2.5	3.8	5.2	38

Samples of the three mixes were also prepared to investigate the shielding effectiveness at frequencies between 1 GHz to 11 GHz. The free space measurement method was used to measure the electromagnetic shielding effectiveness. Figure 1 shows the attenuation (dB) as a function of frequency for a one inch thick slab. The attenuation has drastically increased in the proposed two concrete mixes.

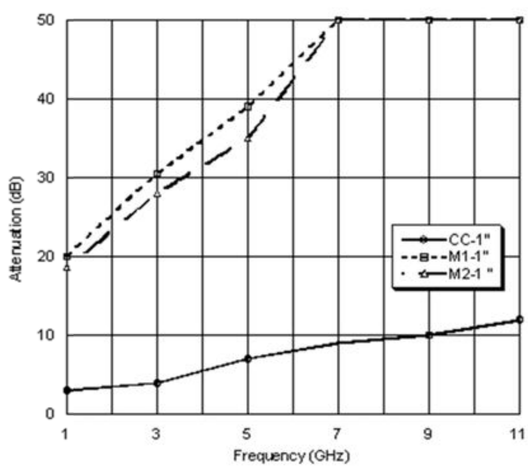

Figure 1. Measured attenuation (dB) as a function of frequency for samples with the same thickness from the three mixes.

Conclusion: The obtained results showed that conductive concrete has improved mechanical and electrical properties over that of conventional concrete. The improved mechanical and electrical properties of the mix showed the potential of the conductive concrete to be efficient and cost effect solution to the EMI shielding problem. In addition to the electric conductivity of the mix, the EMI shielding effectiveness is influenced by the concrete thickness.

References:

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