Cement based composite loaded with medicinal package waste for Low Profile Electromagnetic Shielding

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***Abstract*—A novel technique to enhance the electromagnetic shielding property of cement mortar is presented. Blister refers to LDPE-Aluminum composite prevalently employed as high grade package material in food and pharmaceutical industry, whose disposal has significant negative environmental impact. Blister pack particles employed as package materials for tablets and capsules in pharmaceutical industry is proposed as the conductive filler. Cement mortar formed with Ordinary Portland Cement (OPC), sand and water forms the base. Blister composition attempted was 6.5% with a particle aspect ratio less than 1mm. Shielding Effectiveness measurements as per ASTM 4935 two antenna standard, in J band is determined. Enhanced shielding effectiveness around 6dB is observed. No degradation in mechanical strength unlike the conventional mortar. The proposed filler provides dual purpose: the aluminum provides the EMI shielding, and the LDPE component provides mechanical strength. Further research on determining composition levels for achieving specified SE level, automating blister machining process and expanding the frequency range of analysis is underway. This paper aims to propose a Cement-Blister composite at a low cost, field deployable EMI mitigation scheme at structural level.**

***keywords*- Microwave absorber, Cement, Medicinal package waste, Shielding Effectiveness, Composites**

I. INTRODUCTION

Electromagnetic wave is the basic entity for wireless communication and the subsequent Information and Communication Technology (ICT) based applications. The rampant uninhibited deployment of these technologies has increased the ambient amplitude of electromagnetic (EM) wave in our environment significantly leading to EM pollution which is on a rise. The major impact of EM pollution is observed in malfunctioning of electrical, electronics and communication equipment, referred as Electromagnetic Interference (EMI). Design and development of EMI mitigation schemes has been high priority for the defense sector, health care and even in civilian applications. A review of structural deployment of EMI schemes is listed in[1]. EMI performance including shielding effectiveness (SE) and reflectivity of brick wall made of horizontally perforated clay is presented in [2]. The analysis is in the frequency range from 1-9 GHz. The SE increases with frequency and a maximum of 30dB is attained at 8GHz,and less than 10dB is observed at GSM and blue tooth frequency bands. Reflectivity levels are appreciable. Low cost cement based EMI mitigation schemes mandate deployment of low profile conductive fillers including fly ash and other carbon based by-product of thermal power industry, which help in programing EM properties. Coke and fly ash employed as partial sand replacement in cement mortar is reported in [3]and [4] respectively in L band. An initial research with various low profile conductive fillers of carbon based products in cement composites are studied in the light of EM waves in [5]but loss of mechanical strength,made it to incorporate polymer fillers along with carbon based fillers [6] and have observed lesser mechanical strength degradation without loss in electromagnetic performance.

The rapid explosion of wireless applications mandate low cost EMI mitigation schemes at lower frequency bands. bamboo-charcoal[7] and graphite[8] where also used as a sand replacement in cement mortar for EM shielding in 100-400MHz range A good shielding was achieved along with a tolerable degradation of strength.

The presented work proposes to employ blister pack particles as conductive fillers in cement mortar. The combined occurrence of EM attenuating metal and strength enhancing polymer in a single material is the primary motivation for the work. The shielding effectiveness of blister loaded cement mortar composites is analyzed in J and X bands. The paper is organized as follows: Section II describes sample preparation and experimental set up, the results are discussed in section III and section IV provides the concluding remarks.

II. EXPERIMENTAL SETUP AND SAMPLE PREPARATION

A. *Experimental Setup*

The analysis frequency ranges along Swith the antennas employed determines the sample size. As per ASTM—D 4935 standards, two antenna set up is employed. Schwarzbeck BBHA 9120E standard gain horn antennas are employed. The horn exhibits directivity around 18dB in the J band, which necessitates a minimum aperture size around $160cm^2$. The samples are required to be larger than the effective aperture offered by the standard horn in the frequency range of interest. Metal mold with dimensions $50cmX50cmX4cm$ are fabricated. The molds are fabricated to cater to a wider frequency range of analysis.

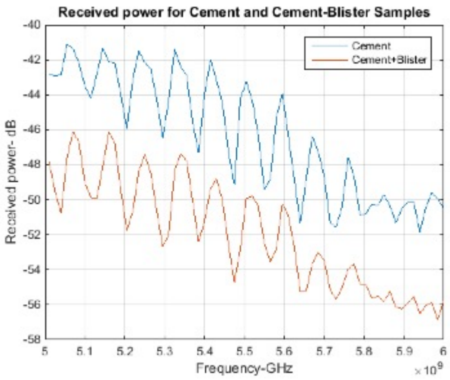

Fig. 1. Received power levels for both samples

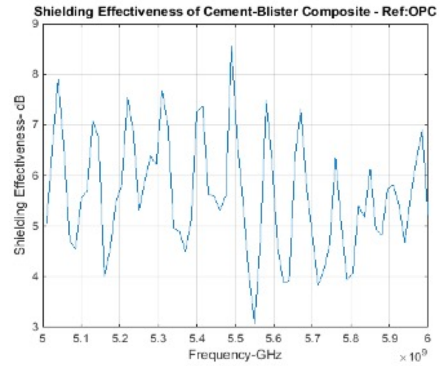

Fig. 2. Shielding Effectiveness of Cement Mortar Loaded with Blister Pack

B. Sample Preparation

Ordinary Portland Cement (OPC), 53 grade, manufactured in India was utilized. River sand is employed as fine aggregate. No coarse aggregate was employed, as to provide EM shielding through cement mortar employed for plastering purpose. Used medical capsule/tablet package material is employed as filler, with a size less than 0.5cm. Conventional UJZ mortar mixer is employed for mixing and transferring the mix to oiled metal molds. The filler concentration employed was around 7%, and was employed as sand replacement. The samples were subjected to ten days curing in water, followed by three days normal curing in atmospheric conditions. Sample of blister loaded cement mortar with dimensions $50cmX50cmX4cm$ were subjected to shielding effectiveness measurement.

III. RESULTS

Ordinary cement mortar incorporating sand and water prevalently employed for plastering applications and cement mortar loaded with blister pack particles are subjected to plane wave shielding effectiveness experiment.The received EM power level and shielding effectiveness of both pure cement mortar and mortar loaded with blister pack are presented. The J band of frequencies allotted for WLAN, WAN, and upcoming applications in intelligent transport systems is the analysis frequency range. The received power levels for both the samples are presented in figure 1.

Cement is inherently conducting. Addition of blister pack, a combination of Aluminum and LDPE provides additional shielding around 6dB. The shielding effectiveness is determined as follows: SE = Received Power of OPC - Received Power of $Cement + Blister$ composite. The SE of blister loaded cement mortar is presented in figure 2. The variational behavior observed is similar to the one reported in [7]. The samples were subjected to Universal Testing Machine and no appreciable degradation of compressive strength is observed. The improvement in shielding effectiveness of cement by 6dB with the incorporation of blister particle provides prospective concept for employing the blister loaded mortar for plastering applications in situations necessitating EMI shielding at structural level.

IV. CONCLUSIONS

The metal part of the blister provides the required electromagnetic shielding character and LDPE prevents degradation of mechanical strength, which makes the blister an attractive option for easy deployment of a shield at structural level. A good improvement around 6dB is observed additional to the natural shielding provided by normal cement mortar.

The authors emphasize on proposing a solution for blister disposal which is an important aspect of this research. Blister utilization for applications including EMI shielding provides low cost, field deployable EM shields at structural level, and concurrently reduces the negative environmental impact due to rampant, uninhibited disposal of blister pack.

REFERENCES

[1] S.Naveenaa, Sruthi S and Sabarish Narayanan B,“Microwave Characterization of Ecosand for EMI Shielded Constructions”, Applied Mechanics and Materials, vols: 813-814, pp: 263-266, 2015.

[2] Marek Pavlik, Iraida Kolcunova and Lukas Lison,“Measuring the Shielding Effectiveness and Reflection of Electromagnetic Field of Building Material”, Proceedings of the 16th International Conference on Electric Power Engineering, pp. 56 59, 2015.

[3] Jingyao Cao, D.D.L.Chung,“Coke powder as an Admixture in cement for Electromagnetic Interference Shielding”, Carbon,vol: 41, pp: 2433-2436, 2003.

[4] Jingyao Cao, D.D.L.Chung, “Use of Fly ash as an Admixture for Electromagnetic Interference Shielding”, Journal of Cement and Concrete Research, vol: 34, pp: 1889-1892, 2004.

[5] Hongtao Guan, Shunhua Liu, Yuping Duan and Ji Cheng,“Cement Based Electromagnetic Shielding and Absorbing Building Materials”, Cement and Concrete Composites, vol.28, pp. 468-474, 2006.

[6] Li Baoyi, Duan Yuping, Liu Shunhua,“The Electromagnetic Characteristics of Fly Ash and Absorbing Properties of Cement based Composites using Fly Ash as Cement Replacement”, Construction and Building materials, vol:27, pp:184-188, 2012.

[7] Hsien Hua Lee and Tz-Huang Yen, “Upgrading Cement Mortar Properties of Electromagnetic Wave Shielding in Buildings”, Proceedings of Second International Conference on Mechanical and Electronics Engineering (ICMEE 2010), pp. 437-441, 2010

[8] See Khee Yee and Mohd Zarar Mohd Jenu, “Shielding Effectiveness of Concrete with Graphite Fine Powder in Between 50MHz to 400MHz”, Proceedings of Asia - Pacific Symposium on Electromagnetic Compatibility, pp. 1-4, 2013