White Paper: Techniques for using Conductive Concrete for Electro-magnetic Shielding
Application Notes: Conductive, EM Shielding Concrete

Techniques for Using Conductive Concrete for Electromagnetic Shielding

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Abstract

Motivation: The use of traditional electromagnetic shielding methods are well-documented and understood. The use of newly-developed innovations in the application of conductive concrete for electromagnetic shielding is discussed in this paper. This paper is intended to communicate the basic applications of this new formulation of conductive concrete to achieve electromagnetically shielded environments to Engineers, Architects, and General Contractors so that they can consider it as an option for new facilities.

Results: Conductive Concrete provides an “All Hazards” barrier that effectively encompasses resilience to Electromagnetic Fields, Blast Effects, and Ballistic projectiles in a single structure. It also is as effective a barrier against the effects of natural disasters such as hurricanes, tornadoes, and earthquakes as conventional concrete.

Availability: The proprietary conductive concrete, referenced in this document as EMB3 (Electromagnetic, Blast, and Ballistic Barrier Concrete) is available today in commercial quantities.

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Supplementary information: Supplementary data are available at http://www.americanbcg.com/

1 Introduction

A new durable option has been developed that can be used to construct electromagnetically shielded facilities. Electromagnetic, Blast, and Ballistic Barrier Concrete (EMB3) is now commercially available to construct any facility that has electromagnetic shielding requirements.

There are many ways to accomplish an electromagnetic shielding objective. Traditional methods may use fully-welded steel, mechanically fastened steel panels, welded aluminum, brazed copper, or even mesh – depending on the target electromagnetic shielding attenuation and the expected source/threat field strength. High-Altitude Electromagnetic Pulse (HEMP) unclassified waveforms have frequency content from 10 kHz to 1 GHz and require both magnetic and electric shielding performance. Intentional Electromagnetic Interference (IEMI) shielding performance must reach from around 100 MHz to 10 GHz or even higher, with attenuation levels that may approach 100dB in some cases. With every type of shielding there are distinct performance elements – 1. The Shielding envelope, 2. The Access Penetrations (Doors, hatches) and 3. Other Points of Entry that include power, communications, plumbing, HVAC, and other penetrations to support the functional requirements of a specific shielded environment or facility.

Figure 1: Overall Shielding Performance Factors

No matter what approach is chosen the Operations and Maintenance of the shield over time is one of the largest cost items of any electromagnetically protected environment. Traditional envelope shielding measures risk degradation and failure over time, and must be periodically tested to ensure performance. Military Standards dictate monthly, quarterly, and annual inspection regimes by specialized personnel for DOD facilities.
Sometimes, due to operational or design requirements of a facility, it can be difficult to detect, isolate and repair the source of a failure of electromagnetic shielding integrity. Operational experience and testing indicates that Conductive Concrete provides a durable, repairable, and forgiving option for electromagnetic shielding that will require less maintenance and be less prone to damage, yielding a more favorable O&M lifecycle cost profile.

EMB3 is the only Conductive Concrete available that is effective and commercially practical for electromagnetic shielding applications. Researchers at the University of Nebraska built on their pioneering developments of conductive concrete for heating to facilitate removal of ice and snow in transportation applications in the early 2000’s. This practical civil engineering experience was complemented by electronics engineering department research to successfully develop a conductive concrete that is compliant with both the commercial requirements of the American Concrete Institute (ACI) structural concrete as well as enabling structures to meet the electromagnetic attenuation specifications of the military HEMP protection standard, MIL-STD 188-125. This R&D was undertaken with grant support by the Defense Threat Reduction Agency (DTRA). For the past 3 years, the American Business Continuity Group invested in an ongoing joint Sponsored Research Agreement with the University of Nebraska to refine the EMB3 formulay and develop practical application techniques that have evolved into proprietary, patent protected/patent pending, construction methods used to create EMB3 shielded facilities today. The current status is the successful construction of an International Building Code (IBC) compliant building with electromagnetic shielding exceeding MIL STD 188-125 HEMP requirements at the American Business Continuity Group disaster recovery complex in Lakeland, Florida.

2 Methods

Electromagnetic/Blast/Ballistic Barrier (EMB3) Concrete is unique in composition but can be applied using largely conventional concrete techniques, including cast-in-place, pre-cast, and shotcrete-derived structures.

Architects, Engineers and facility designers can plan on utilizing typical concrete design methods with some minor modifications for rebar and penetration embedding. Pre-stressed/post-tensioned methods may also be employed with EMB3 Concrete. Commercial off-the-shelf Points-of-Entry (POEs) are commercially available from several suppliers that are also appropriate for conductive concrete designs. Commercially available filters, doors, waveguides-below-cutoff (WBC) may also be employed with conductive concrete facility envelopes. The design of specific EMB3 wall/floor/ceiling sections are straightforward depend on the specific performance requirements of the structure, room, or facility, as shielding performance is primarily dependent upon the thickness of the EMB3 wall. Testing has validated that electromagnetic field attenuation levels on the order of 10dB/inch of wall thickness is a typical broad-spectrum attenuation level for EMB3 concrete construction. Otherwise, EMB3 concrete performs similarly to conventional concrete in terms of curing time and cured strength. If blast-resistant applications are desired, additional reinforcement that may be typically required can be incorporated as necessary to meet specific blast pressure scenarios for a conductive concrete facility, just as it would in a conventional concrete facility. In general the EMB3 concrete is well-behaved and structurally similar to conventional concrete.

Construction using pre-fabricated/pre-cast elements is also possible and has been demonstrated. A contiguous electromagnetic shielding barrier is achieved by using EMB3 concrete in precast panels and connecting panels using a patented EMB3 Shotcrete formulation to seamlessly combine (with no cold joints) precast panel seams of walls, floor slab, and ceiling building elements.

Hybrid EMB3/Steel construction is also feasible through techniques to embed steel components in the EMB3 concrete.

2.1 Shielding Envelope

The Conductive Concrete Shielding Envelope is comprised of the conductive concrete mix, rebar, and other components. The concrete mix itself is comprised of standard concrete supplemented with various materials to support its shielding properties. The additional materials do not compromise the final strength of the concrete, but various proprietary means and methods are used to achieve the shielding attenuation in building designs. The electromagnetic attenuation performance of the shield envelope is proportional to the thickness of the shielding envelope.

2.2 Access Penetrations

The addition of required access penetrations is achieved through the integration of standard facility doors/hatches from existing shielding suppliers with the EMB3 shielding envelope.

2.3 Other Points-Of-Entry (POE)

Other POE’s are added to the shielding envelope through a variety of methods, including the addition of an imbedded steel (or other appropriate metal) penetration plates. POE’s are affixed to the penetration plate just as they would be installed in a “traditional” metal shielding installation, this includes filters for power/communications, Waveguide Below-Cutoff (WBC) arrays for plumbing, HVAC, and other penetrations as necessary to meet the facilities performance requirements.

Figure 2: Construction of EMB3 Shielding Envelope
2.4 Ballistic Protection

Due to the properties of the concrete, ballistic protection of structures made from EMB3 concrete will be similar to any other concrete structure.

2.5 Blast Protection

Due to the integration of steel fibers into the EMB3 concrete mix and some of the rebar configurations utilized, calculations indicate that EMB3 concrete performs better than conventional concrete. The addition of extra rebar to increase blast performance of the EMB3 concrete is possible in the same manner as it is applied to conventional concrete.

3 Results

The American Business Continuity Group built a full-scale test facility at their disaster recovery facility in Lakeland, FL utilizing EMB3 shielded concrete. This facility was independently tested. The test facility includes a full-sized conference room with power, communications, HVAC and represents a typical EM shielded environment.

4 Conclusion

It has been demonstrated that EMB3 concrete is an effective electromagnetic barrier and is now a viable option for the construction of electromagnetically shielded facilities. For facilities that must also integrate ballistic and blast resilience properties into their structure, EMB3 concrete is an ideal solution because the ballistic/blast properties are integrated into the shielding structure. EMB3 can support the integration of “traditional” shielding elements and can support complex cast-in-place shapes that may be difficult to shield with conventional methods. EMB3 concrete has been demonstrated to be effective over extended periods of time in corrosive environments (e.g. high salt, or industrial) environments that would quickly compromise standard shielding approaches.

The ABC Group EMB3 concrete has been tested, prototype facilities have been built and is ready for application in standard shielded facilities, as well as in industrial, utility, data center, backup-power, substation, power generation, communication, and any other civil, military, industrial environment.

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