RESPONSE OF ECO-SYNTACTIC FOAM TO LOW VELOCITY IMPACT

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ABSTRACT

Cellular cement is a lightweight material consisting of Portland cement paste or mortar with a homogeneous void or cell structure created by introducing air or gas in the form of small bubbles (usually 0.1 to 1.0 mm in diameter) during the mixing process [1-4]. Their unique set of properties makes them attractive as a foam core material for structural sandwich panels: they have moderate thermal insulation, high heat capacity, high stiffness, excellent fire resistance and low cost compared to polymer foams [5]. For most sandwich structures, however, it is required that the core be able to dissipate a major amount of impact energy without significantly sacrificing strength, for instance as a blast mitigation layer in engineering structures like buildings, bridges, etc. Due to the brittleness of hardened cement paste and the open-cell structure, the currently available cement foam is unable to dissipate a sufficient amount of impact energy and to retain water tightness [6,7], making it impossible for it to be used in high performance sandwich structures or blast mitigation layers.

Polymer and cement based syntactic foams have been toughened by adding rubbers. In order to increase the toughness of epoxy based syntactic foam – hollow glass beads or microballoons dispersed in an epoxy matrix, rubber latex coated microballoons have been used to prepare syntactic foams, which show a considerable enhancement in toughness and the capacity to absorb impact energy [8]. In order to reduce the cost, crumb rubber has been used instead of rubber latex. Again, it shows a significant enhancement in energy absorption with an insignificant reduction in residual strength [9]. A constructive or positive composite action has been proved by an equivalent medium based finite element analysis [9]. In a recent study, a cement based syntactic foam was also modified by crumb rubber particles [10]. The results also show that crumb rubber is effective in enhancing the toughness of cement matrix and may have a potential to be used in engineering structures.

The objective of this study is two-folds: one it to enhance the toughness or impact tolerance of cement based syntactic foam and the other is to further reduce the cost so that an economic syntactic foam can be obtained and it can be used in large engineering structures for impact or blast protection. In order to achieve the objectives, crumb rubber particles used previously by others [9, 10], which are powders of waste tires, will be used in this study. Further, flyash, a by-product and waste material in coal burning, will be used to replace glass microballoons. Flyash is a hollow particle that is similar to microballoon. Therefore, the incorporation of flyash will reduce the weight, just like the microballoon does, and can also enhance the long-term strength due to its cementitious properties. Silica fumes, another by-product and waste material from iron&steel plant, will be used to replace nanoclay particles. It has been found that inclusion of silica fumes in the cement matrix improves the compression strength, bond strength, abrasion resistance and reduces permeability. In addition, milled glass fiber will be used, which will help in arresting the microcracks from propagating into macrocracks. Since the majority of the constituents will be waste materials, flyash, crumb rubber, and silica fume, it is expected that the syntactic foam will be a low-cost material or economic material.

This is an-going study. This abstract presents the preliminary results obtained so far. In-depth and refined study results will be reported in the near future in the form of conference proceedings or journal publication.

Three groups of cement based eco-foam are fabricated with varying volume fractions of flyash and glass beads. The volume fractions of cement and water are maintained at 15% and 33.5% respectively in all the three groups of composites. Also, volume fractions of silica fumes, milled glass fibers, crumb rubber are maintained at 0.75%, 0.75%, and 5% respectively. Hence any significant change in the mechanical properties can be attributed to volume fractions of flyash and glass micro balloons respectively. Therefore,
by varying volume fractions of micro balloons and flyash by keeping the other filler volume fractions constant, a thorough analysis of effect of flyash and microballoons on the mechanical properties of cement based eco-foam can be performed. Group 1 contains 45% of flyash and 0% of microballoon; Group 3 contains 0% of flyash and 45% of microballoon; and Group 2 contains 22.5% flyash and 22.5% of microballoon. Further, sandwich beam structures are fabricated using the core specimens in groups 1, 2 and 3. Plain woven 7715-style glass fabric reinforced polymer is used as facing and backing skins to fabricate these sandwich structures. Vacuum assisted resin infusion molding process (VARIM) is used for fabrication. The VARIM process can be seen from Figure 1. To evaluate the impact energy absorbed, low velocity impact testing will be performed on all the specimens using two different hammer weights at a velocity of 3m/s. Further four-point bending test with a loading rate of 4 mm/min will be performed on pre- and post-impact sandwich structures to evaluate the residual strength.

Figure 1 VARIM process

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