[0015] Alternatively, a compressible (or deformable) vehicle arresting system may be placed on or in a roadway or pedestrian walkway (or elsewhere), for example, for purposes of decelerating vehicles or objects other than aircraft. They may be used to safely stop cars, trains, trucks, motorcycles, tractors, mopeds, bicycles, boats, or any other vehicles that may gain speed and careen out of control, and thus need to be safely stopped.

[0016] Embodiments described herein thus provide phosphate ceramic materials that are manufactured using novel methods and that result in specific compressive strength ranges. The materials may be used in a number of applications, but they are particularly suited for use as non-lethal vehicle arresting systems or blast attenuation composite materials.

BRIEF SUMMARY

[0017] Embodiments of the present disclosure~~invention~~ provide cellular phosphate bodies formed using specialized steps to ensure a specific strength range, and specifically, a compressive strength less than 100 pounds per square inch. They further relate to methods of manufacturing such materials using prepared foams. Further embodiments relate to uses for various phosphate ceramics as vehicle arresting systems and other crushable or deformable materials.

[0017a] In a first aspect, there is provided a cellular phosphate ceramic material, comprising: a binder comprised of a phosphate compound and a metal oxide, wherein the binder is mixed with water to form a slurry; and a foam; wherein the foam is combined with the slurry to form a cellular phosphate ceramic material having a 28-day compressive strength of less than 100 pounds per square inch (psi).

[0017b] In a second aspect, there is provided a method of manufacturing the cellular phosphate ceramic material as defined above, comprising: a) obtaining or making a foam; b) mixing a phosphate compound and a metal oxide powder for a first mix time effective to form a powder blend; c) mixing the powder blend with water for a second mix time effective to form a slurry; d) mixing the slurry and the foam together for a blend time effective to form a cellular phosphate ceramic material; e) curing to form a ceramic material having a 28 day compressive strength of less than 100 psi.

[0017c] In a third aspect, there is provided a cellular phosphate ceramic material made by: (a) mixing potassium phosphate and magnesium oxide to form a binder; (b) adding one or more fillers; (c) mixing the binder and filler(s) with water to form a slurry; (d) obtaining or making a foam; (e) blending sufficient foam and binder, wherein the foam structure is preserved; and (f) curing the ceramic material to form a cellular phosphate material having a 28-day compressive strength of less than 100 psi.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] FIG. 1 shows a perspective view of an open cell phosphate ceramic structure made according to various embodiments described herein.

[0019] FIG. 2 shows a perspective view of a closed cell phosphate ceramic structure made according to various embodiments described herein.

[0020] FIG. 3 shows a perspective view of a cellular phosphate ceramic structure after compression testing.

[0021] FIG. 4 shows samples de-molded at one day.

17. The method of claim 11, wherein the phosphate compound is potassium phosphate.

18. The method of claim 11, wherein the metal oxide powder is magnesium oxide.

19. The method of claim 11, wherein the foam comprises a cationic, an anionic, a non-ionic surfactant, air, water, or any combination thereof.

20. The method of claim 11, wherein the foam comprises an anionic surfactant blend with foaming action and high expansion rate, water and air foamed by foam generating equipment, or any combination thereof.

21. The method of claim 1, further comprising one or more fillers comprising fly ash C, fly ash F, slag, foundry ashes, red mud, expanded polystyrene, organic aggregates, wood pulp, recycled plastics, air, silica ashes, grinded glass, cenospheres, wollastonite, gypsum, sand, calcium-alumina-silicate powder, hydraulic cement or cementitious mixes, but not Portland cement, or any combination thereof.

22. A cellular phosphate ceramic material made by:

(a) Mixing potassium phosphate and magnesium oxide to form a binder;
(b) adding one or more fillers;
(c) mixing the binder and filler(s) with water to form a slurry;
(d) obtaining or making a foam;
(e) blending sufficient foam and binder, wherein the foam structure is preserved; and
(f) curing the ceramic material to form a cellular phosphate material having a 28-day compressive strength of less than 100 psi.