2012 – 2013 PROJECT NARRATIVE

INTRODUCTION

Powder-based 3D Printing is a billion dollar market. The Economist considers it to be "The Third Industrial Revolution" and Money Magazine predicts it will be the next trillion dollar industry and a key technology to bring manufacturing back to the U.S. Using previous funding ($36,000 for research and development and $16,000 in startup funds) I have developed a proprietary cement polymer material that can be used to produce large, mass-customized industrial grade 3D printed objects. I would like to create a start-up company that sells this powder to 3D printing companies and users of 3D printers and demonstrate the potential of this technology and material by producing architectural scale building systems and architectural components. The usefulness of architectural components will give potential investors and customs insight to the materials' structural performance and the possibility to produce large objects. Also, unlike current technologies, which are primarily geared at the production of small objects and parts that employ materials such as plastics and nylon-based powders, this patented material process is eco-friendly (producing zero waste), inexpensive and much stronger, making this a very viable material for the construction and manufacturing industries.

Additive manufacturing technology typically employs materials intended for the immediate analysis of form, scale, and tactility. Rarely do the materials used in this process have any long-term value, nor does the process—except in rare cases with expensive metal prototyping—have the ability to create durable and sustainable working products. This project would alter this state of affairs by demonstrating how this patented material can produce long-lasting performance-based components that require no formwork, which are typically up to 60% the cost of construction. Because the process requires no dies or molds, building components can now be mass-customized, employing the flexibility of computer-aided manufacturing systems, rather than mass-produced processes, allowing design parameters to be quickly changed and tested without incurring costs associated with labor and retooling. Thus, the process bypasses several of the steps involved in traditional production methods making it possible to go directly from "file to fabrication", by-passing the need for blueprints or other construction documentation.

This project will demonstrate the commercial potential of this material by producing large-scale 3D printed "smart" building skins/building envelopes and structural architectural components that demonstrate a radical rethinking of the construction and manufacturing industry. The prototypes will be used to demonstrate the material's structural characteristics, accuracy, it's abilities to withstand fire, weathering and demonstrate assembly methods. While this project will focus on the production of architectural elements, it will also demonstrate how a single, or small number of relatively inexpensive machines can produce components that have implications in other areas of manufacturing that are currently looking towards 3D printing, such as the fields of space exploration, the biomedical industry, the Department of Defense and the automotive industry, to name a few.

It would be invaluable for potential investors and customers to see examples of the material put to use in the creation of large-scale objects, because the invention, a structural 3D-printable material, has high strength characteristics—up to 4,537 psi (fig. 1) in compression in the most recent tests. This exceeds typical concrete, which is around 3,000 psi.

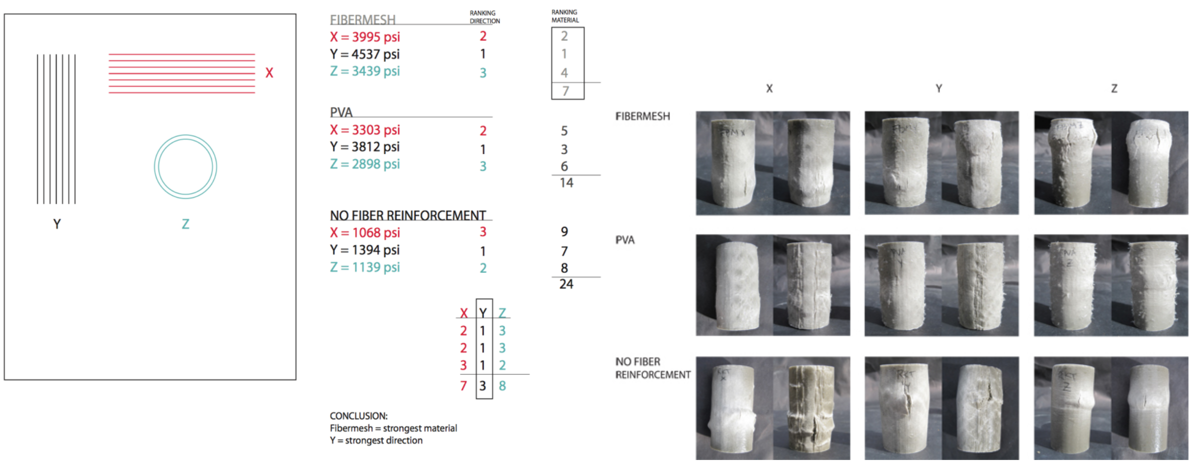

fig. 1: Structural test conducted at the University of California of fiber reinforced 3D printed objects

Furthermore, the material can be sold at a lower cost than currently available powder-based materials (which have no structural capacity), and substantially less (over 200% less) than currently available 3D printable structural materials. Thus, what once seemed financially unrealistic, is now a reality and large-scale objects can be produced with commercially available 3D printers. Therefore, the primary activity that would take place if awarded, would be the creation of architectural components demonstrating the potential of the patented invention to be used in the construction industry. This is critical as California's construction industry has shed nearly 100,000 jobs, according to the Wall Street Journal, who cite this loss in jobs as an important barometer of the state's economy. Innovation that is both cutting edge and ecological would be positive contributions to an industry that is critical to the State's economy and moreover, to an industry is seen as deeply responsible for producing waste in landfills and for producing CO2 emissions.

The small objects that we have produced thus far with the material, which include assemblies of various sizes (fig. 2 and at http://www.emergingobjects.com) and a bench (fig. 3), which represents one of the largest-to-date pieces of furniture ever produced with a commercial powder printer, have brought much attention to the work in the form of outside interests, exhibitions and publications and potential customers. However, these objects do not realize the full potential of the research, which is to suggest that the material could be used to produce large objects, such as a house, for example.

PROPOSED ACTIVITIES

The first step towards demonstrating the full potential of the material would require the design of the architectural components using 3D design software. The Principal Investigator, along with a consultant and Graduate Research Assistants would accomplish the design of the components as well as the design of the component assemblies. 3D analysis software would also be utilized for structural analysis of the assembly system. The next step, and the largest part of the effort, will be the fabrication and assembly of the structures. This involves the making of the powder, binder and the fabrication of each part for assembly.

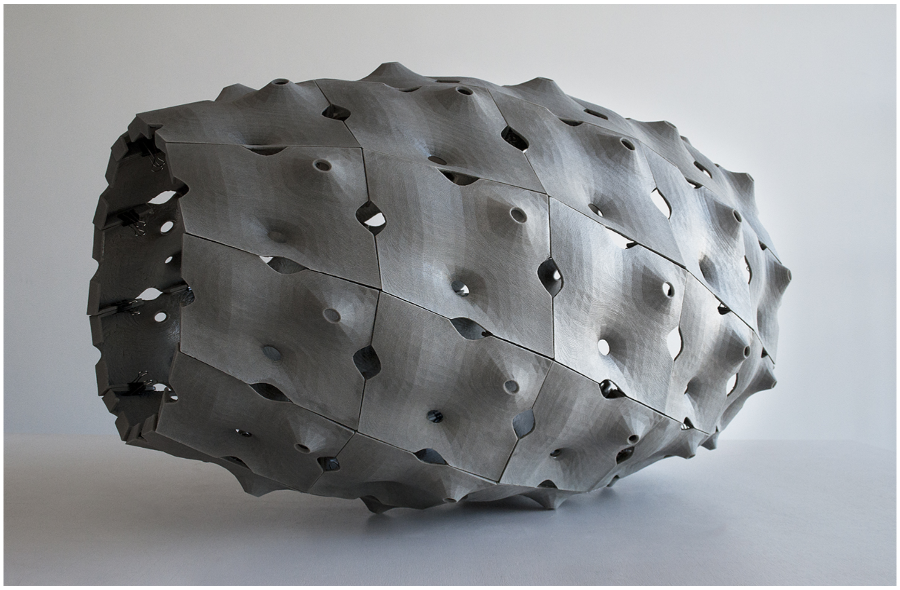

fig. 2: Two-foot-long cantilevered and sand-blasted cylindrical beam

The fabrication of the parts employs 3D printers currently available in the College of Environmental Design's Computer Aided Design and Manufacturing Laboratory, where we currently have 4 small format powder 3D printers and de-powdering stations. The inclusion of a large-format 3D powder printer will allow us to produce larger and/or more parts much more rapidly and allows for us to explore the concept of a 3D Printer Farm, where multiple machines are producing the parts to ensure continuous output of many small parts. Acquiring a large format 3D printer is key to this project as the production of larger scale parts will demonstrate the capabilities of the material on machines that are much larger, but are currently unobtainable as they cost nearly $1million.

Each finished part requires the post-processing of the fabricated elements, also covered by the patent, to give them structural characteristics. The assembly of the finished parts, through various methods (hardware, structural adhesives, interlocking joinery, to name a few) is the final step in this process.

We would use the prototypes to market the powder material for sale and for services for rapid manufacturing. Images of the prototypes or the actual prototypes themselves would be taken to trade shows to promote the materials and the services available by the start-up company.

ANTICIPATED CONTRIBUTIONS

Other researchers in this field include Dr. Behrokh Khoshnevis at the University of Southern California, Dr. Enrico Dini of D-Shape (London) and Dr. Richard Hague of the Additive Manufacturing Research Group at Loughborough University, in the UK. In each case, their research represents a centralized focus on specialized hardware development to use standardized materials. In contrast, the contributions of this project relate to advancing additive manufacturing at large scale through material development, material processes and the use of distributed manufacturing methods tied to parallel computing using commercially available equipment. Whereas Khoshnevis, Dini and Hague's methods are highly specialized, inaccessible, and present technologies not available to the general public, this project would demonstrate methods that are inexpensive, highly accessible and ready to be commercialized.

fig. 3: 11' long bench designed to support the weight of several individuals.

Recently, the United Kingdom named 3D printing a national technology priority and recognizes the way that 3D printing will impact the UK economy. California is the epicenter of digital technology and maker culture on the planet. The innovation of a start-up company that responds to the emergent potential of additive manufacturing in the State of California through the licensing of powder formulas for 3D printing and the fabrication of large-scale structural 3D printed objects, which would in turn, drive more sales to 3D printed powders, is the economic aim of this project. This would also have the potential to transform the building and manufacturing industry in California by putting forward the first large-scale building materials to be mass customized anywhere. The sale of the powder technology could spurn others to start companies in other manufacturing fields as well, from restoration, transportation, construction, or any entity wishing to employ additive manufacturing into their existing workflow in a way that allows for making parts bigger, faster and less expensive than previous methods of 3D printing allowed.

SUMMARY

In summary, successful completion of this project will demonstrate without a doubt the viability for the technology to produce large rapid manufactured building components and assemblies that are cost effective. This will be enormously attractive to potential customers wishing to purchase the powder or customers interesting in producing large-scale rapid manufactured objects or parts. Because the material has been developed and tested, I am no longer able to obtain funding towards its development and the next step is to begin a startup business. Demonstrating the potential of the material would go a long ways towards this goal. Our projected time to commercialization is within 1 year, if not sooner.

Our market assessment has demonstrated that there is a substantial need to scale up current 3D printing technologies, however, current technologies do not make this economically viable. This project will demonstrate that there exists a technology to meet the current billion-dollar market that is almost entirely devoid of large-scale 3D printing. Finally, employing this technology in the State of California could potentially situate the state as a leader in additive manufacturing technologies, and center emergent manufacturing processes here, rather than overseas.