Chapter 6: Sand

Sand

Natural sands are eroded or weathered particles of rocks. Sand is made by simply grinding up rocks into increasingly smaller pieces and glaciers do it best. Sand can also be made biologically, from shells and other organisms of the living world and many beaches are comprised of pulverized animal shells. Sand grains can originate from catastrophic geological phenomena as when molten lava erupts from volcanoes and shatters in the air, scattering particles across the oceans and land as tiny grains. This black volcanic sand can be found throughout the world, as on the black beaches in Hawaii. But by far, most sand grains are made of quartz, one of the Earth’s most common ingredients, and are formed every single day, on every exposed piece of land, by the process of weathering.[[1]](#footnote-1) [Figure 96]

Sand is found in every country of the world and is used to make the most mundane, and the most technologically advanced, products, from toothpaste to microchips. Sand is also a material in flux, blowing in the wind creating shifting sand dunes, but also as an important global commodity upon which grow our nations build. For example, Singapore is 22 percent larger today than it was in the 1950s, because since that time, billions of tonnes of sand have been added to the existing island. Singapore is also planning to expand its territory by another 15,000 acres over the next 15 years.[[2]](#footnote-2) However, the increase in one nation means the decrease of another. In Indonesia, some two dozen islands have disappeared since 2005 because of sand mining—largely by Singapore[[3]](#footnote-3)

Sand and 3D Printing

The writer Jorge Luis Borges wrote, “Nothing is built on stone; all is built on sand, but we must build as if the sand were stone.”[[4]](#footnote-4) And we do. Sand is one of the most important aggregate materials for the building and construction industry. Wet sand is workable; it can be combined with water, gravel, and Portland cement to be transformed into one of the strongest and most ubiquitous building materials in the world. It doesn’t take long to learn that water mixed with sand changes both completely, the two fluids become a formable solid and very little water, or liquid, is needed to make this happen. That is why 3D printing with sand and other sand sized materials is possible. There is enough surface tension between the liquid and the particle to make them “neighborly” and stick together.

Sand is found in fluvial riverbeds and floodplains, shorelines, deserts, dunes, and also man made sites that include mines and quarries. Sand is everywhere and has the potential to be a valuable local material resource for 3D printing, especially sands that are not currently being used in construction or for reclamation.

In the context of 3D printing, sand is most commonly used in large volume printers that produce sand molds for industrial metal casting. Molten metal is poured into the 3D printed silica sand molds to produce automotive and aerospace components such as engine blocks and airplane propellers. Another example of 3D printing with sand can be found in Markus Kayser’s desert Solar Sinter project.[[5]](#footnote-5) This example is exciting from a technological point of view but also from a material resource perspective because most sand currently being mined for the construction industry does not come from deserts. The shape of desert sand particles are round which means in concrete construction they don’t close pack and are therefore less desirable. In the solar sand project two elements dominate - sun and sand. Sun offers a vast free and powerful energy source of huge potential, the sand is almost unlimited in supply and it is silica in the form of quartz. Silica sand, when heated to melting point and allowed to cool solidifies as glass. The process of converting silica via heat into a solid form is known as sintering and has in recent years become a central process in design prototyping known as SLS (selective laser sintering). SLS printers use laser technology to create very precise 3D objects from a variety of powdered plastics, and metals, and in the case of Kayser, sand. By using the sun’s rays instead of a laser, and sand instead of plastic, Kayser has the basis of an entirely new solar-powered machine and production process for making 3D printed sand objects that tap into the abundant supplies of sun and sand to be found in the deserts of the world. Additionally by using large particles of desert sand the objects that he prints have a gritty, rough texture that connects them to their material source, they aren’t simply white and smooth like most resin SLS prints that seem to have no connection to context, material or culture.

Emerging Objects uses sand 3D printing to imagine the potential of employing Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM) processes in the construction of future architectural landscapes where the building material source and the building itself are seamless. Building with the ground beneath one’s feet is not a new concept. It is possible to find communities all over the world where buildings are constructed, quite literally from the material directly below the building itself. For example, buildings are made of salt in the Salar de Uyuni South American, igloos are made of ice built on the frozen seas and across the arctic tundra, and buildings made of earth exist in arid landscapes in many regions around the world.

The automation of building with the ground beneath one’s feet is imminent, and we imagine a scenario where a mobile 3D printer roves across the landscape, scooping up local sand, pumping it through a nozzle, and organizing it into contours and forms that become the building blocks and walls for a new paradigm of architecture made of sand. The sand is mixed with an organic liquid binder causing the particles of sand to stick together to form a new kind of sandstone, a strong and local building material that doesn’t require intense energy usage or the transportation of industrial materials around the world.

*Earthscrapers* imagines a world where 3D printed sand is a scalable technology—one that dissolves the siloed professions of designer and builder. [Figure 97] In *Earthscrapers,* which we exhibited at the 2010 Biennial of the Americas, we conceptualized how sites of mining, desertification, dredging and erosion are a few of the many examples of natural and anthropogenic locations where shaping the landscape have become the theoretical material sources, sites, and contexts for the forms and spaces created. [Figure 98] A roving 3D printer can be controlled by the designer in situ or remotely. Acquiring information directly from the CAD file, the designer can make changes to the 3D printed sand as it is being deposited. 3D printing with sand, the material beneath our feet, proposes a future where designer, builder and geomorphologist merge—a landscape where the earth is architecture and the architecture is earth. [Figure 99] [Figure 100] [Figure 101][Figure 102]

Objects:

*Quake Column*

3D printing building components has the potential to create seismically resistant structures by using masonry principles that diffuse the force of an earthquake through the interlocking components of a wall or column. The *Quake Column* draws from traditional Incan ashlar masonry techniques to explore this possibility. Peru is a highly seismic land and for centuries the mortar-free construction proved to be apparently more earthquake-resistant than using mortar. The interlocking stone of Incan structures creates an absence of resonant frequencies and stress concentration points. The dry-stone walls built by the Incas could move slightly during and earthquake and resettle without the walls collapsing, a passive structural control technique employing both the principle of energy dissipation and that of suppressing resonant amplifications. Inca walls also tend to incline inwards by 3° to 5° and the corners were rounded, which contributes to their stability. Each “stone” that comprises the *Quake Column* interlocks perfectly with neighboring blocks. Whereas the cyclopean blocks of Inca construction are massive and weigh several tons, the 3D printed blocks are comparatively lightweight and hollow. Each block is numbered to designate its place in the construction sequence. Additionally, each block has a built in handle for easy lifting, control and placement of the massive 3D printed “stones”. [Figure 103] [Figure 104] [Figure 105]

*Involute Wal*l

The *Involute Wall* is a prototype for the study of thermal mass and acoustic dampening in a massive 3D printed sand structure. The involuted surfaces reduce resonance in the room, by absorption and redirection of sound waves. The massive 600lb 3D sand print presents the opportunity for surfaces to serve as thermal mass while keeping much of the wall in shade—ideal for hot climates with extreme temperature shifts. [Figure 106] [Figure 107]

*Picoroco Block*

The *Picoroco Block* is a modular 3D printed building block for wall fabrication printed in sand. Each block is 12″X12″X12″ and dimensional variability is possible using the 3D printing process. The design of the block is such that the joints in between the blocks become invisible because of the porous pattern that rotates along the surface. This allows for a seemingly continuous surface even though the wall is modular. The back of the wall clearly expresses the joints in between the blocks and the underlying geometry of the design. [Figure 108] [Figure 109] [Figure 110]

1. Micheal Welland, *Sand: The Never-Ending Story* (Berkeley: University of California Press, 2009), Kindle Edition [↑](#footnote-ref-1)
2. “Sand, Rarer Than One Thinks”, last modified March 2015, https://na.unep.net/geas/getUNEPPageWithArticleIDScript.php?article\_id=110 [↑](#footnote-ref-2)
3. “Illegal Sand Mining”, last modified March 26, 2015, https://www.wired.com/2015/03/illegal-sand-mining/ [↑](#footnote-ref-3)
4. Micheal Welland, *Sand: The Never-Ending Story* (Berkeley: University of California Press, 2009) 234. [↑](#footnote-ref-4)
5. “Solar Sinter”, last modified 2011, <http://www.markuskayser.com/work/solarsinter/> [↑](#footnote-ref-5)