DYNAMIC CERAMIC

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“Even A Brick Wants To Be Something”

-Louis Khan
PREFACE

I believe that architects need to combine the new technology of 3d printing with traditional hand crafting to create architectural ceramics that respond to their structural and environmental characteristics.

Ceramic is one of the earliest known material that were used in construction. It has been used in architecture for approximate 7,000 years with the invention of the fired brick. The use of hands played an important role in the making. Traditional Spanish roof tiles were made by slumping clay slabs on the maker’s thigh. However, the role of the hand in crafting the material has been increasingly displaced by machines. Ceramics, during the industrial revolution, became mass-produced employing machines that mix, mold, glaze and fire the clay.

The development of ceramic 3D printing, a technology that has only recently to be available to designers, holds promise to create ceramic architectural components that are both mass customized and the possibility for mass complexity through a series of inventive fabrication practices. My thesis took advantage of ceramic 3D printer to create series of cladding systems that could be mass produced and customized. However, there are limitation with these 3D printers and along with the nature of the material one can’t print a more complex form without it failing or collapsing on itself.

By bringing the handcraft back into the process I was able to shape the clay before it is harden into a more customized finishes. These process were made by taking 3D printed forms and manually manipulate them by hand into a mold which in itself could be customized to create variation between each panel. They are then load and fired with glaze applied. Each panel are then cast or mortar onto each other to create cladding or screen for the façade. The drawing itself were created by hand printing method onto ceramic tiles. These process allowed for opportunity to create wall systems that are unique and respond to different needs and functions of the building. It is also allowed for a flexible system that could be applied to different construction methods from typical wood construction, concrete and steel frame structure.

The use of ceramic 3D printing could enable a greater environmental, labor and cost efficiencies in the industry. With that said I want to continue this exploration in my future practice--connecting my passion for ceramic and architecture, while using the new digital tools that can expand both practices.
“Designers are losing the understanding of the nature and potential of materials gained from creating things by hand. With a father who is a fabulous craftsman, I was raised with the fundamental belief that it is only when you personally work with a material with your hands, that you come to understand its true nature, its characteristics, its attributes, and I think – very importantly – its potential.”

-Jonathan Ive
(chief design officer at Apple)
“3D Printing a technology that has “the potential to revolutionize the way we make almost everything”.

-Barrack Obama
(President of the United States of America)
The New CLAY Technologies

The emerging trend in architecture field today had the desire for complexity, both functional and geometry intersects the demand with individualized customization. In part a shifting in the industrial manufacturing overall cost reduction, and in parallel to emerging computational tools and automated machine programming workflows, industrial robots have been rapidly adopted in the production of art, architecture, and design.¹

3D printing gained popularities recently as a new exciting field in technology development for architectural applications. Material research, design computation and digital fabrication methods, triggered the innovations in new ceramic technology which enabling expanded applications for ceramics as a multifunctional, performative material system. The emergence of clay 3D printer along with highly controlled clay mixed and computer controlled kilns, can be customized to design specific material behaviors.

The rediscovery of architectural ceramic marked an exciting milestone of ancient building material that has been merely served as a practical surface treatment for buildings. The history of architecture is inherently linked to the ceramic sector. The soft and hardened nature of the material have attractive qualities, both technical and formal feature of clay can be manipulated making it an ideal material for new innovative and customization demand in architecture and design.

CLAY

Clay has been use as a building material both fired and sunbaked. Modern clay architecture uses clay bricks, tiles and other clay products such as rammed earth, mud brick, compressed earth, cob, to add to its variety and finess. The benefit for reconsidering clay in a modern era due to the fact that it is an eco-friendly building material that can be manipulate by hands or large scale industrial machines. Looking back into history clay has proven for it versatility, endurante and sustainable.

¹ M. Bechthold, A. Kane and N. King. Ceramic Material Systems, (Birkhauser Verlag GMbH 2015) Pg. 204
Fired clay has a porous structure which are filled with air when dry thus providing insulation properties used to regulate temperature by keeping the enclosure cool in summers and warm in winters.

Advancements in clay 3D printing technology are helping researchers, manufactures reform clay into one of the finest forms to suit contemporary architecture thinking adding aesthetics and functionality.

**CLAY 3D PRINTER**

3D printing is quickly emerging as an exciting field in technology development for architectural applications. This process of additive manufacturing technologies (AMT) have been explored in the context of clay-based ceramics.

The two most recognizable methods of making 3D clay objects are by using a liquid binder solution or clay powder that is supplied at a controlled thickness to build objects layer by layer to form rigid parts. Additional AMTs, has been explored through automated materials extrusion. By using clay slips and slurries, layer by layer, to realize printed ceramics elements.

**OBJECTIVE**

Design visualization software has increasingly embedded in many professions and getting easier to use. The invention of 3D printing allowed us to explore material like clay in a more precise and creative way that can help enhances architectural production. Architecture sensibility is inherently embedded with the use of clay. It is a primitive material that can be adopted in multiple hybrid system by taking advantage of the contemporary digital fabrication and traditional craft.

Architects must push beyond the current relationship between the traditional material ideas and mass production of ceramic by making use of the digital technology to create new topology to design and build.

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Delta Bot Clay Printer
History

Clay, a seemingly infertile blend of minerals consist of mostly fine-grained natural rock or soil material that combines one or more clay minerals with traces of metal oxides and organic matter. Human has long recognized the plasticity and harden qualities of the material. One of the earliest used of ceramic was small figurines and fragments recovered from Dolni Vestonic. History of clay tied closely with architecture.

Ziggurats of Mesopotamia is one of the most recognizable and well preserved architecture that was made out of clay. Built in 2,100 BCE. the first stage of the ziggurat construction was built using seven million mudbricks and 720,000 fired bricks. These mudbricks were created from clay and reeds. The would have been pressed into rectangular molds and left to dry in the sun, or they could have been fired to ensure the brick would better withstand moisture and wind.

The Ziggurat of Ur. Original structure built c. 2100BCE.
Production of bricks increased massively with the onset of the industrial revolution and the rise in factory building in England. The well known highrise brick construction that still standing today is the Monadnock building, Chicago (1891) was design with a 6ft thick base to support the weight of the bricks above. However, the demand of high office building construction at the turn of the 20th century, let to a much greater use of cast and wrought iron and later steel and concrete.

However, with the increase in today new technology clay as a material has been revived. One of the best example of this is the Liling World Ceramic Art City completed in 2015 ia an homage to Liling porcelain. It’s sprawls across nearly a quarter of a million square meters and includes a hotel and an industrial area for ceramics processing. The buildings take the form of vases placed in a circular plan coated with clay tiles with various glazes.
Selfhook Facade Claddings
3D printed ceramic cladding

Metal bracket

Structural beam

Aluminum frame

Composite cable

Double pane windshield

Floor finished

Metal decking

Concrete slab

Structural beam

Plenum heating
Dynamic Cones Screen Cladding
Metal standing seam roof
Vapor barrier
1/2" rigid insulation
Exterior Sheathing
Bat insulation
2x6 decking
6"x36" glulam

1/4" double pane window
Aluminum casting
3D printed ceramic cladding
Metal bracket
Structural column
Gypsum sheathing

Radiant Flooring
Rigid Insulation
Slab on grade
Failed Print Facade
CMU 3D Printed Facade
3D Screen Print Facade
Production PROCESSES

Ceramic production is a complex process of sequence that could take place both in craft or industrial base setting. Clay has a unique characteristic unlike most construction material, it can be formed in a wide range of states. From dry clay to wet slip, clay created a versatile result whether it is sun baked or fired in a kiln.

Clay is an abundant natural occurring materials with a unique properties that’s harden when fired and become ceramic. The production of making ceramic products in the architectural realm can be achieved through both traditonal and contemporary methods to produce different characteristics of the end product to a high degree. The four methods chose to explore here are handbuilding, extruding, slip casting and 3D printing.

While these processes take on challenges on their own the emphasis of the proposal is to investigate how the emergence of additive manufacturing technologies help today architectural applicatons.
Hand Built
Historically clay as a building material started out with a simple method of handbuilding. This process is embraced and practiced in many cultures today.

The process is more organic and are often left to dry out in the sun. Most recognizable method of making architecture with clay hand built process is adobe bricks. It's usually made by hand small enough that it could be air dry and avoid cracking. Another application of adobe mud applied over the bricks to bond the individual bricks into a structure.
Hand Build Process
Hand Build 1

Hand Build 2

Hand Build 3

Hand Build 4
Extrusion
Extrusion

Extrusion is a wet process that exit both in craft and industrial base. Extrusion a primary shaping process where the partl leaves the die in a final cross-sectional shape.

For smaller production research purpose the extrusion method is a manual process using a vertical extruder with lower pressure compare to an industrial extruder. Custom extrusion die is produced with very low tooling costs using laser cut laminated plywood.

Clay Extruded Installation

Clay Extruded Installation at the Archie Bray of the Ceramics Foundation
Clay Extrude into Shape
Slip Casting
Slip casting is a casting process that makes use of plaster mold and a near liquid clay slip (Casting slip). The process required making plaster cast mold and clay slip being poured or injected into a mold and allowed to dry through as a solid part or consolidate only on the adjacent to the interior mold surface creating a hollow form.

This process allowed for a complex geometries through multiple part molds and parts can be joint together to create a larger complex pieces.
Slip Casting into the mold
3D Clay Printing
3D Clay Printing

The new emerging trend of 3D printing allowing possibilities of printing with clay like never seen before. From small scale to 3D printing a whole house the possibilities of using clay 3D printer is a method of future construction.

This process allowed for a more customizable, precise, as well as, cutting labor cost in the construction industry.

The ram extrusion method is common in the process by layering strand of clay one over another to create a more solid light weight structure.

A 3D-printed house in China. 10 of these houses have been built within 24 hours (WinSun Decoration Design Engineering Co.)

Extrusion layers with embedded structure within to give support.
Clay an ancient building material, it is one of the material that has made a come back with the help of new technology. Clay 3D printing bringing new exciting ways for architectural products. This proposal will be an investigation of material with the use of clay 3D printer (Delta Bot).

Through the process of hand building, extruding, CNC mold casting and 3D printing there are different ways to aggregate and layers clay to create solid wall systems. With this finding the hope for the upcoming semester will be narrowing down to one construction method of 3D printing and explore the possibilities of making architectural products that could perform a more specific, precise and cost effective with the aid from compiture software.
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