RE-IMAGINING CONCRETE:
A MATERIAL FIRST DESIGN APPROACH

By

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AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

ABSTRACT

This thesis asks the question: "What if we began the creative process of design with material?" In an age where digital images dominate the design process, architecture's main medium of expression remains through matter. In this thesis, I explore the creative process of design through material fabrication.

A material first design process uncovers and draws out the inherent capacity of materials through direct encounters. For eight months, I trained as a craftsman in an Engineered Cementitious Composite (ECC) concrete workshop. This fiber-reinforced concrete has a bending strength many times greater than ordinary Portland cement concrete. It can be cast in thin sections. Yet like ordinary concrete, it transforms from a formless solution to a man-made stone.

Working with my body and the senses I developed an intuitive knowledge of ECC's capacity and the techniques of concrete fabrication. I then applied my design training to find expressions that revealed the nature of ECC. I cast ECC on fabric forms, draped them onto supports in their plastic state, and sculpted the formwork as this fluid material hardened into stone.

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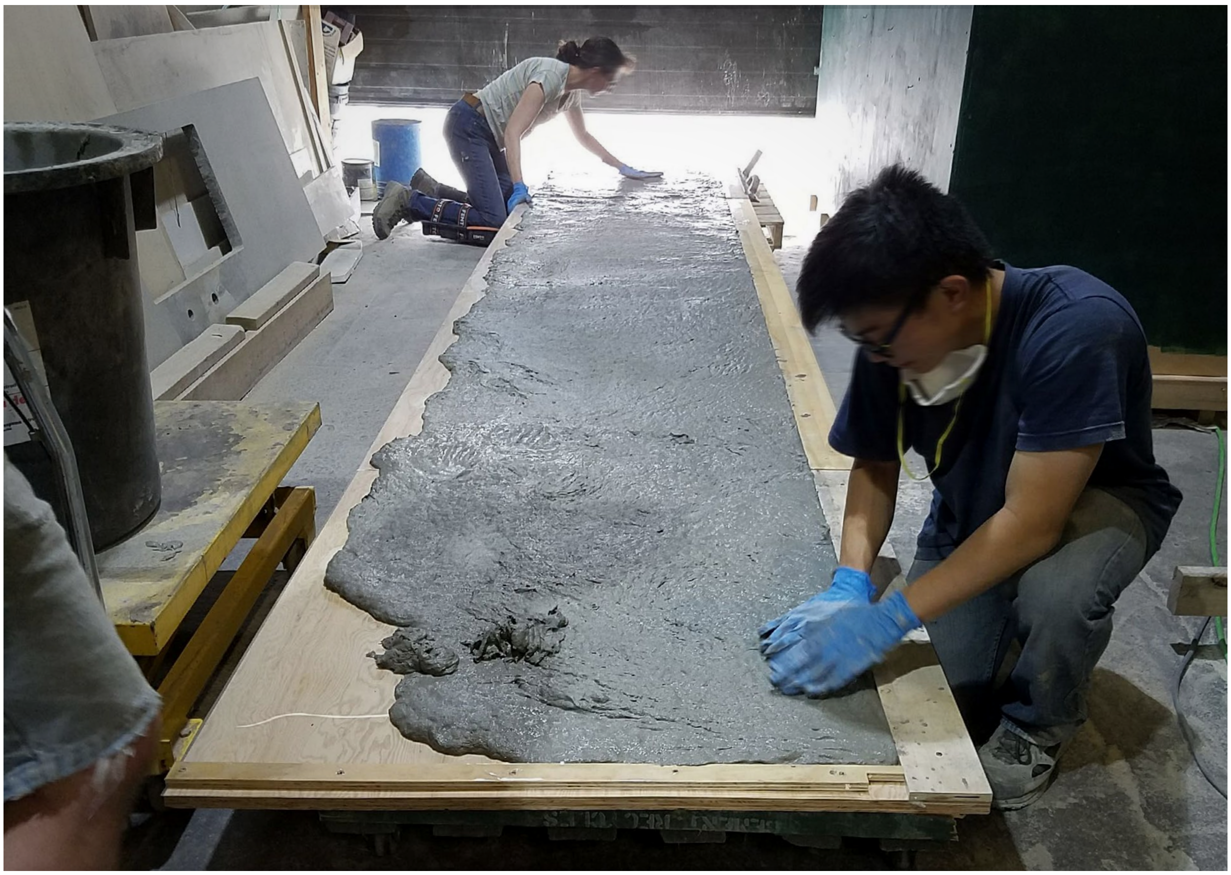

fig. 1 Spreading fresh concrete

COMMON CONCERNS

Throughout my architectural training, my design process usually began from an aesthetic, cultural, programmatic, or conceptual idea. The selection of materials always came at a later stage. Then the material was made to fit into the conceptual idea. This thesis explores the question: "What if the design process started with the material instead?" After all, architecture's main medium of expression remains through matter.

When design begins with the matter, the designer recognizes the power of the physical realm. A physician once told me that most medicine works to nurture and expand upon the powerful systems already present in the body. Vaccines, for instance, prevent disease by stimulating the body's natural production of disease-fighting antibodies. Similarly, materials possess an embedded capacity.[1] For example, corrosion in metal is the result of the refined metal attempting to regain its stable, natural form. This reaction is especially pronounced in steel. The corrosion forms in flakes that easily break off, exposing fresh material for further corrosion. Weathering steel is a steel alloy that cultivates the corrosion into a stable, protective layer, preventing further corrosion.[2] Matter responds to the forces around it. They do not stay in an ideal state. When designers tune in to matter, they can capture matter's innate potential.

Techniques are the methods through which craftsmen bring an idea to fruition. In the three years of working full-time in architectural practice, I find design is usually not limited by the imagination but know-how. For architects, sketches and vignettes express potent ideas, but "figuring out how" to build it is the hard part. This process of "figuring out how" is the architect's most fundamental responsibility. Most of the architect's time and fees are directed to the drawing of construction documents and administering those instructions during construction. In the end, architects are bound by law to deliver a working building to the client. Knowing how things are made gives the architect greater creative agency in the design process.

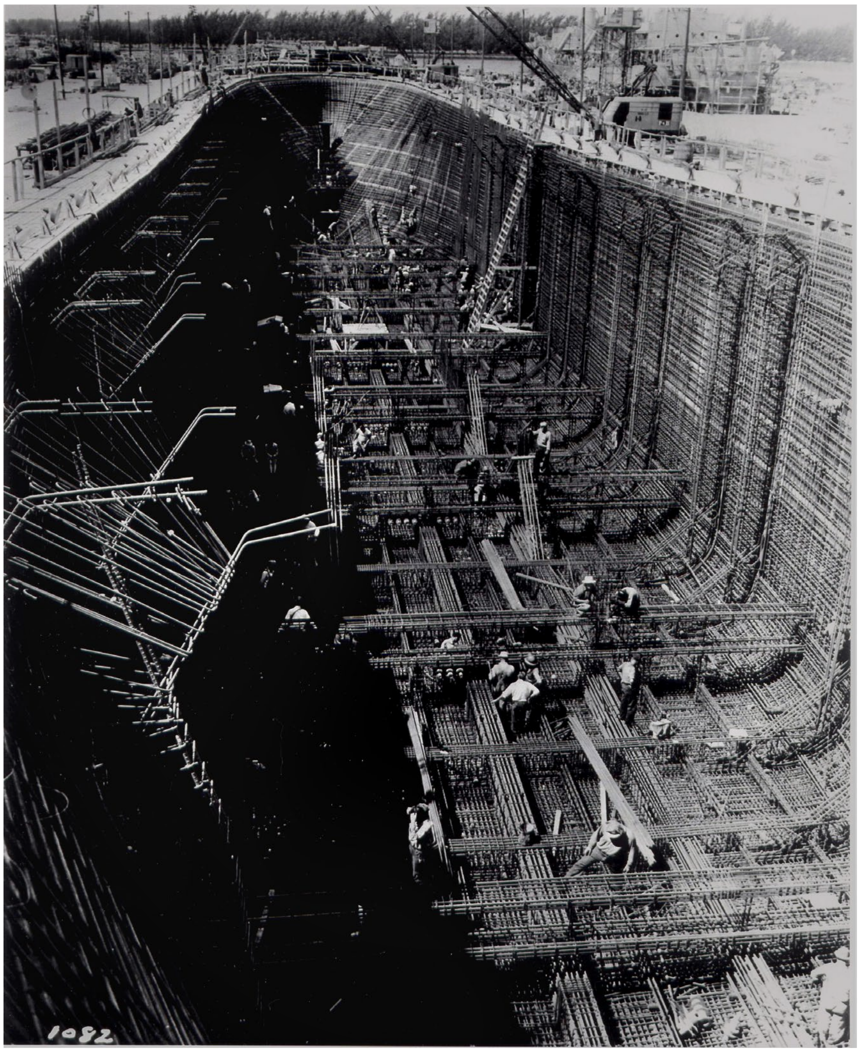

fig. 2 Concrete Ship Construction, Laying Rebar

DRAWING NEAR CONCRETE

My personal encounters with concrete began as a child. I remember playing on the bare concrete floor in my grandmother's apartment in Hebei, China. The choice of this finish was most likely driven by economic factors. However, the rawness of the bare materials in the apartment provided a unique space of exploration for me.

In the summer, I laid on the cool surface and played with my collection of marbles, rolling them effortlessly over the smooth floor. I remember there was a long slender crack in the floor that crossed almost the entire length of the room. I would adjust my aim slightly to compensate for the deflection when it rolled over the crack. Other than this basic knowledge, I lived life largely unaware of concrete's presence, its origin, the way it was made, or the way it responds to its environment. I now know that the thermal mass of concrete allowed it to stay cool when the ambient temperature was high. I also know that concrete cracks over time; it was just a matter of how long it would take the forces to create the crack.

The common presence of concrete caused me to overlook its capacities. What is the true nature of concrete? And what potential does it have in the context of design? When I first began researching concrete in January 2018, I was led to some intriguing insights about its nature. The origin of concrete as a man-made rock was found in natural processes. The earth was the original maker that first began mixing, homogenizing, and differentiating the minerals that were present in the ground into stone. Cementation is a natural process chemically and geologically similar to concrete. This is the process of limestone formation where water filled with cementitious sediments, calcite and silicates, flowed into voids between mineral grains to crystallize into rock.[3]

Concrete has a long history of unique uses. In the first millennium BCE, the Nabataeans in the Middle East made a water-proof cement that allowed them to make cisterns in the desert. While their neighbors avoided the barren land, water-proof cement allowed the Nabataeans to funnel the scarce rainwater into cisterns for storage. This exceptional knowledge of the material allowed the Nabataeans to flourish on the profitable Silk Road between the ancient Far East and Europe.[4]

fig. 3 Throwing a clay bread pot on the wheel

During World War II, McCloskey & Company of Philadelphia built a fleet of twenty-four concrete ships. Steel was a scarce resource during wartime, but concrete was readily available. Pouring the ships took as little as four to six weeks. Some of these durable ships are still floating today as breakwaters.[5]

Like a potter with clay, people who work with concrete are mindful of its properties. As a child, a local professional ceramic artist, Nina Ward, generously allowed me to play with clay in her studio. In between fiddling with my own creations, I curiously watched her work.

Learning to work with clay has deeply influenced the way I work with concrete. Clay is the plastic state of ceramics before firing. In working with clay, the plasticity is key to manipulating its form. Clay is easily shaped by hand; it responds readily to impressions from the maker. At the same time, clay impresses upon the maker its own nature. Through the microscope, clay appears as water suspended in a matrix of silicate particles. Adding or evaporating water changes the plastic nature of the material. If the clay is too saturated, the structure will collapse. If the clay is too dry, the pieces becomes fragile, making it prone to cracking and unworkable. The potter's hands sense the quick changes in the clay's behavior and adjusts the intricate moisture levels while they work. Water is also what changes the clay into ceramics. When fired above 350°C, the chemically bonded water in the clay begins to escape, transforming it irreversibly into durable ceramics.

The potter learns by diving into making. They pay close attention to the characteristics of the clay, then works to imbue matter with purpose and meaning. The piece of pottery created is as much a reflection of the character of the clay as it is of the maker's hands. It is with this approach that I began my work with concrete - by going back to the workshop.

THE FABRICATION CLASSROOM

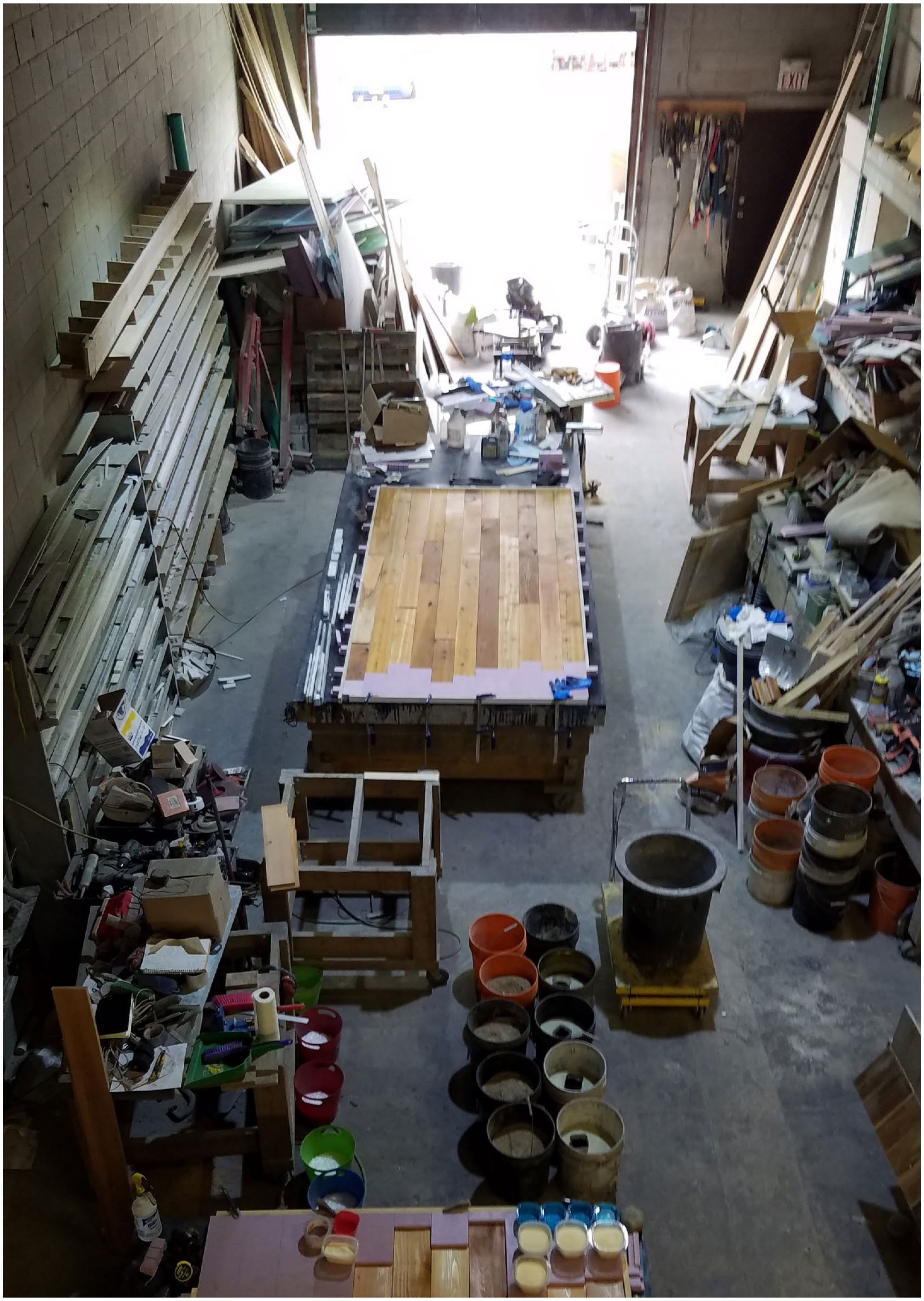

fig. 4 Concrete Elegance workshop

APPRENTICESHIP

In April 2018, after three years of working in an architecture office, I decided to join a concrete workshop to be trained as a craftsman. I searched through several websites and found a studio that worked with a thin, light weight concrete, stronger and more durable than traditional Portland cement concrete. The online biography of one owner said that they were an experienced mechanical engineer who previously inspected industrial accidents and nuclear reactor pressure tubes.[6] Intrigued, I contacted the company, Concrete Elegance. The owner, Alla Linetsky responded quickly and was more than happy to show me her work. When I walked in, I found myself in a workshop showroom filled with concrete wall panels, tables, countertops, cabinet faces, and most intriguingly, a piece of drapery fabricated out of concrete.

When Alla spoke about the material there was an unmistakable enthusiasm in her words. Her passion for concrete matched her vast knowledge about the material. From my first visit onwards, she always began design conversations with the unique character of the material. Alla worked with the attitude that whoever designed with the material should love the material for what it is. It should not be something we acquiesce to because there is no other option. When we settle, we force the material to fit the design rather than work with the inherent capacities of the material, often naively hoping it will rise to our expectations.

Perhaps her love of materials is a result of her previous engineering career. When I mentioned my thesis to a friend, he observed engineers tend to design from the bottom-up, starting with the basics of the materials. While architects tend to work top-down, starting with design ideas and finding materials afterward. At Concrete Elegance, I put away my preconceived notions of design and soaked up this material-first approach.

During my first visit, I asked if I could observe or lend a hand. She needed help for a pour that day and let me join in. She was willing to teach me if I was willing to put in the effort. The first cast was a 48”x48”x20” concrete coffee table. In traditional construction, concrete is cast as a solid mass, perhaps with a few hollow elements to lighten the weight. We cast the concrete table with only three-quarter inch thick walls on its exterior with half-inch ribs supporting the otherwise hollow middle.

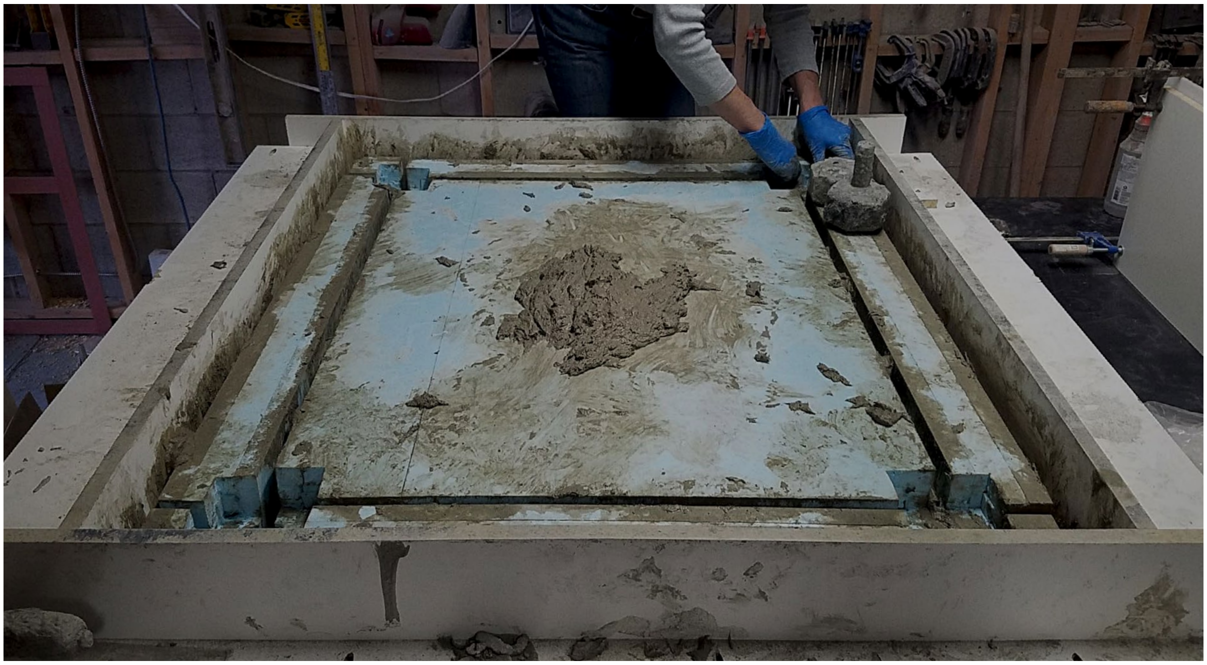

fig. 5 Coffee table cast on melamine and foam form

fig. 6 Coffee table

This is the unique property of the concrete Alla uses. She does not use a traditional Portland cement concrete typically found on construction sites or in backyard builds. Traditional concrete is strong in compression. The mix of cement, sand, and gravel takes a considerable amount of force to crush. However, concrete is weak in tension, cracking and breaking under minimal loading. The resulting designs are thick, bulky and heavy. The pieces do not take on fine details and have sharp corners that break off easily. Though there are many formulations or mixes of traditional Portland cement concrete, they all have this character in common.

fig. 7 Broken ECC with fibers exposed

ECC (ENGINEERED CEMENTITIOUS COMPOSITE)

One day over lunch, I asked Alla how she got started with her material. She told me that when she began in 2004, traditional Portland cement concrete was still the material of choice for the workshop. In the winter of 2009, the project pipeline was in a slow phase when she saw an opportunity to develop a new concrete mix. With two co-op students, she engaged in a month and a half of testing three hundred batches of concrete to find one that was easy to work with and cured with exceptional strength. The result was a type of high performing concrete call ECC (Engineered Cementitious Composite). The first ECC mix was developed at the University of Michigan in 1993.[7] Since then, ECC has evolved into a family of concrete mixes. ECC has exceptional strength in tension. It is even ductile. ECC will bend without cracking while traditional Portland cement concrete will break under similar loads. Even after cracks develop, ECC retains tensile strength to keep its structural integrity.

Randomly dispersed fiber reinforcing and the high cementitious binder ratio makes ECC stronger than traditional Portland cement concrete. During the mixing process, bundles of half-inch long polyvinyl alcohol and acrylic fibers are blended into the mix. The fibers bond to the concrete in a structural web. The effect is a concrete that is exceptionally thin. The material captures a high level of refinement in detail because of its greater tensile strength. This high-performing composite combines concrete, which is strong in compression, and fibers, which are strong in tension. It allowed the coffee table to be light enough to be moved into place by only a two or three people, but strong enough to endure the beating of daily use.

As we talked, Alla walked me over to an enormous plywood bin filled with grains of multi-colored translucent aggregate. It was recycled glass washed and ground into fine granules like a soft beach sand. In high quality concrete, the consistency of ingredients in quality and quantity gives the concrete exceptional strength and durability. The glass possesses better contaminate control than sand, because of industry processes and material properties. Washing conventional construction sand leaches out a muddy concoction of an unknown chemistry, while the recycled glass is rigorously washed and cleaned of residue.

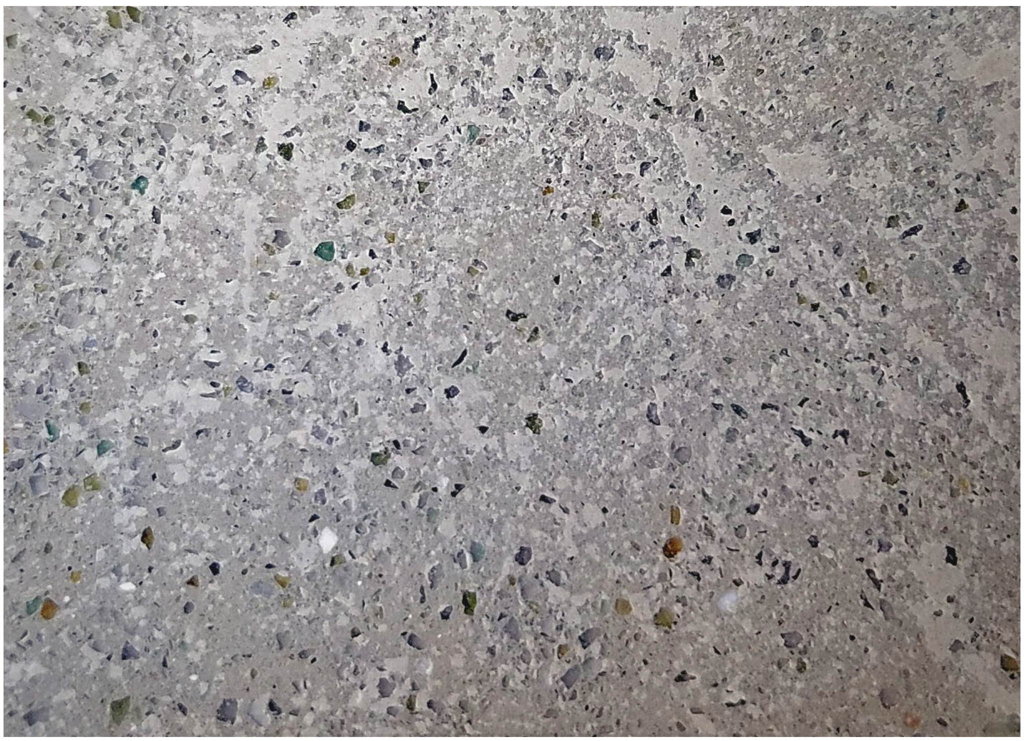

fig. 8 Exposed glass aggregate

Sand has the capacity to retain water between its grains. The various sized particles of sand pack closely together resulting in a large surface for water to be drawn into by capillary action. This is most evident when digging a hole at the beach. Layers of sand in the hole will feel progressively moist to the touch the water pools at the bottom. When more water is present than what the sand is able to retain, the excess water stays pooled around the sand. Construction sand can hold up to 10% of its mass in water. This excess water weakens the concrete when curing. Compared to sand, recycled glass is more consistent in particle size and will not retain water.

ECC also contains five or more times cementitious binder than ordinary Portland cement concrete. The cementitious binder is the glue of the concrete. It contributes to much of the concrete's strength and durability. In ECC, the cementitious binder consists of equal parts white Portland cement and either fly ash or slag. White Portland cement is manufactured with stricter standards to achieve its white color as opposed to the gray ordinary Portland. This results in greater precision from batch to batch.

Fly ash is a waste product of coal combustion furnaces, and slag is a waste product of metal smelting. Both materials are excellent partners to the Portland cement. On its own, Portland cement reacts with water to produce weak crystals of calcium hydroxide (CH). These formations do not contribute to concrete strength. Their presence leaves concrete vulnerable to chemical and physical attack. Fly ash or slag in the binder reacts with the excess CH to form strong crystals.[8] For ECC, potassium silicate is added as a catalyst for the slow reacting fly ash and slag. The cementitious binder to aggregate ratio is also five or more times greater in ECC than ordinary Portland cement concrete. This greater ratio and the use of fly ash or slag produces outstanding strength, non-permeability, and durability in ECC.

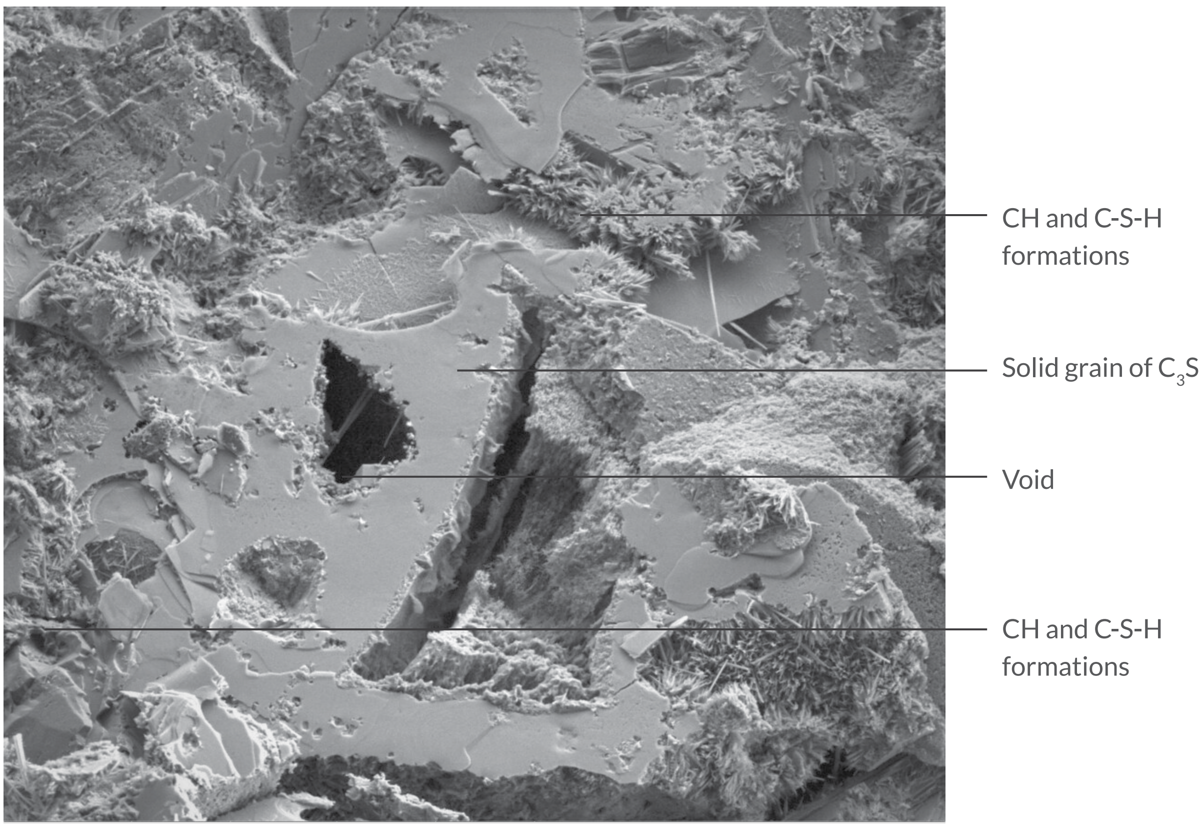

fig. 9 Structure of cement paste under scanning electron microscope

The crucial cement-water reaction transforms the ordinary ingredients of concrete into stone. When cement contacts water, it undergoes a hydration reaction as concrete becomes hardened or cured. The concrete appears to dry out to the naked eye, but no water evaporates. Instead, the concrete undergoes a chemical reaction that consumes the water. The chemistry is complex, but a simplified equation is thus:

Tricalcium silicate		Water		Calcium silicate hydrate		Calcium hydroxide
(C_3S)	+	(H_2O)	→	(C-S-H)	+	(CH) *
$2\ Ca_3SiO_5$		$7\ H_2O$		$3\ CaO\text{-}2SiO_2\text{-}4H_2O$		$3\ Ca(OH)_2$

*cement chemistry shorthand

The main compound in cement, tricalcium silicate (C_3S), reacts readily with water. As soon as water is added to C_3S, calcium, silicate, and hydroxide ions, plus large amounts of heat are released. In the beginning, grains of C_3S float freely in a solution of ions and water. Soon the ions begin crystallizing into calcium hydroxide (CH) and calcium silicate hydrate (C-S-H) formations on the free-floating grains. The formations fill the water solution until the water is no longer able to reach the C_3S within the formation. In the later stages of hydration, the remaining C_3S grains are bound together by the C-S-H crystalline matrix giving the cement its structural integrity. The calcium silicate hydrate (C-S-H) formed is the crystalline matrix responsible for most of the strength of cured concrete. C-S-H forms rapidly at the early stages of hydration, but hydration reactions will continue provided there is interstitial water between formations although the rate of strength gain decreases over time.[9]

Both the quality and the quantity of water are vital to high performing concrete as the water and binder reaction is the main strengthening reaction in concrete. The water should be of drinking quality. An excessive amount of minerals in the water reacts with the cementitious binder and has adverse effects. In ECC, the water is 22%, by weight of cementitious binder. At 22%, the concrete mix is not workable, and does not have fluid characteristics. The hard paste is difficult to mix and place into the form. More water should not be added to create a fluid concrete mix.. Excess water will be trapped in the concrete, creating voids when evaporated, resulting in weak, even brittle concrete. Instead, a super plasticizer (high-range water reducer) is added. Super plasticizers break the polar bonds

fig. 10 Plastic phase of ECC

between water molecules, found in the surface tension of water. When the water molecules float around more loosely in a relaxed state, the mix immediately becomes more fluid.

The extraordinary character of ECC is its capacity to be a stone that is both thin and elastic. A piece can be as thin as card stock and long pieces can flex like a diving board. Once mixed, the ingredients transform from a shapeless fluid, to a clay-like plastic phase, and finally into solid stone. The plastic state of ECC is important to the creative potential of the material. The capacity to be shaped and retain its form produces an easy to sculpt material. This interstitial phase transformed my thinking.

fig. 11 Casting

TECHNIQUE

> *Today I had some soreness in my shoulder from pressing and pulling motions. I need to think about how I can work in harmony with the concrete to not wear down my body trying to fight the material.*
>
> *- Journal entry from September 12th*

In my apprenticeship, I was striving for a mastery of technique, one which embodies a deep understanding of material.[10] Skilled craftsmen feel the material they work with deeply. Every push and pull of the tool engages an intuitive understanding of the material. This embodiment is built over thousands of repetitions.

I learned to play the viola from a young age. Every practice session began with the basics - scales. My fingers ran up and down the fingerboard, familiarizing myself to the series of tones that accompanied the movements. My other hand drew the horsehair bow over the strings, the friction vibrating the strings into notes. I felt each subtle change in angle, direction, and velocity in the bow ringing through the hollow wood body of the instrument. After countless practices, I no longer thought about where to place my fingers or how to draw the bow. My mind and body simply felt the music flow from the instrument.[11] This is the process of mastering technique.

The craftsman thinks through the body and its senses. The body identifies information and processes responses to the physical world. Embodied thinking is not a logical or conceptual understanding but lived experience. [12] Playing the viola, I thought through my hands and ears. They worked to imagine and create music through touch and hearing.

In my apprenticeship, seeing, touching, and hearing were the most instrumental in the development of my material understanding. This embodied knowledge was particularly helpful in the timing of the curing process, which is challenging to predict with a timer. The most reliable way to gauge ECC's curing status was to touch the material with the hand. The

Fabrication Interdependencies

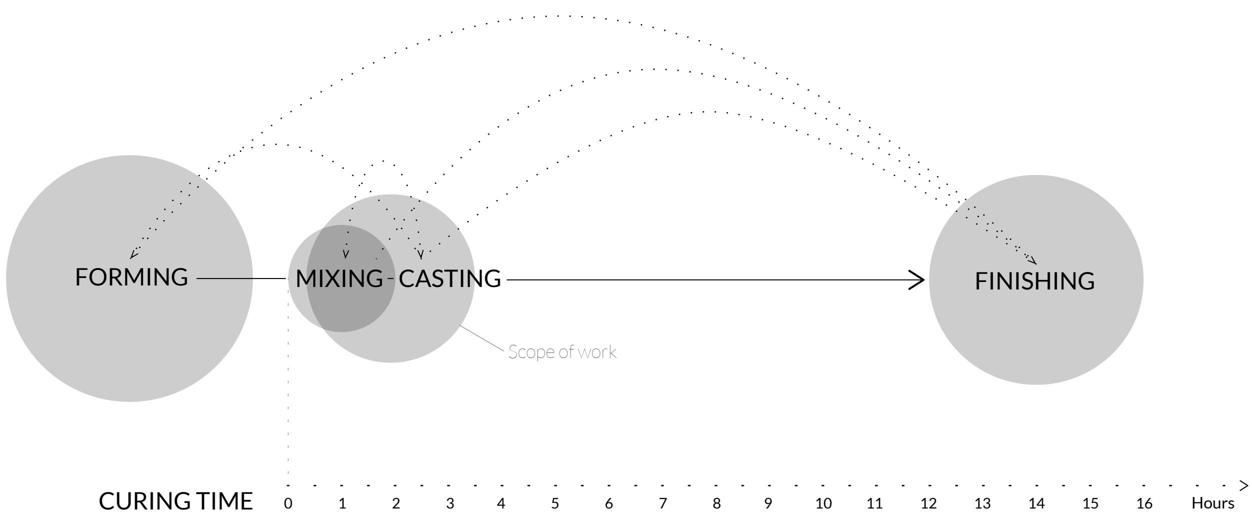

fig. 12 ECC fabrication diagram for typical cast

curing time of ECC is relatively short, so the pieces are processed quickly. In the same sitting, I witnessed the entire hardening process from when it was first poured to when it was no longer workable. Throughout the stages of mixing, grabbing the flowing mix, and troweling the surface, I was in constant contact with the material.

In my personal work, I permanently deformed the ECC in its plastic phase. In the later stages of hardening, I hear the faint tearing and cracking of the ECC fibers as I sculpt the form. However, the ECC does not experience sudden failure like brittle cement. The micro-cracking behavior of ECC means multiple small cracks form instead of singular long cracks, like in traditional Portland cement concrete.[13] Along with the exceptional flexural strength of ECC, the piece holds its shape. Tearing then becomes a celebrated part of the making process.

Our ability to tune in to our senses contributes to how well we think with our bodies. As we are more aware of our bodies, we hone our ability to create with our hands. Our intuition directs us before we rationalize them into thoughts.[14] When I trowel, I don't consider every movement before I make them. Rather, I move with the experience of a craftsman having troweled the surface hundreds of times before. My intuition, honed through my senses, directs me to create.

In the design of buildings, we often select materials based on tradition or aesthetics. Architects typically select materials based on limited considerations in the form of two-inch square samples and images of already built structures. Designers involved in fabrication gain more holistic understandings of the character and potential of materials, which in turn provokes innovation. It creates a framework in which design happens, through understanding what the material can do and how it is made. Once this framework is established, new possibilities play on what is known and already done. This is how creativity emerges from making.

The following sections describe the techniques of making ECC. Through my work, I began to think of the ECC fabrication process as the five stages of forming, mixing, casting, finishing, with curing occurring during the latter three. However, these stages are interdependent. Not only does each step directly affect the next during fabrication, the steps inform each other during fabrication preparation. While the techniques are common to all concrete, they are described in specific application to ECC.

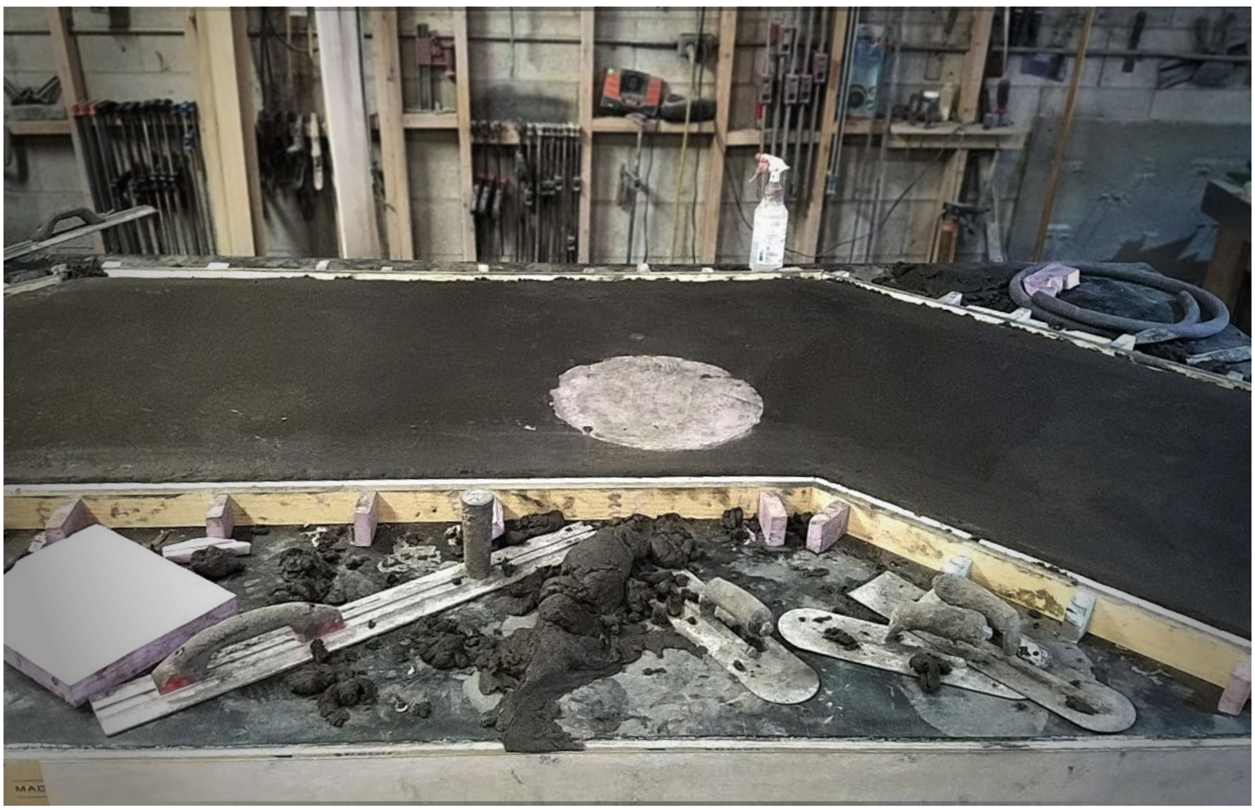

fig. 13 Chaotic aftermath of a struggle with the timing of a countertop cast

CONCRETE'S CLOCK

The timing of concrete's setting is one of the most critical factors in working with ECC. Setting or curing is concrete's transformation from a fluid to stone. For concrete, the transformation begins the moment the water contacts the cement. One pour of an enormous island countertop required five, fifty kilogram, batches of ECC. We cast this piece with the top surface of the countertop facing up and exposed. Formwork for the edges of the countertop were fixed to a casting table. And rigid foam boards filled the inside to reduce weight. We started the cast with one batch which filled halfway up the sides. Another batch fully filled the sides. Then we started on the top surface. The third batch started to fill the top surface of the countertop. Everything had gone well.

Up to this point, things that might have gone wrong are insufficient bracing, the lateral pressures of the mix breaking the form, or the mix flowing under the foam and lifting it up. None of those things had gone wrong, and we felt good about the pour. But perhaps we relaxed too much. As the fourth and fifth batches were poured into the form, we realized that the batch below was piled too high. However, this only led to the realization that too much time had passed between batches and the underlying batches had already set into a stiff semi-solid state. The more we struggled to push the layers around the more we realized that time was only solidifying the ECC. After a brief fight with the it, the ECC triumphed. It would not budge anymore. We had to accept failure and start anew. These setbacks are critical learning experiences for the craftsman. Through sensing with the hands, the craftsman gains an intuitive awareness of the concrete's clock. The hand senses the fluid mix setting into solid stone while working.

The setting time becomes a unique technique for working in ECC. For the coffee table cast, blocks are placed in the ECC for attaching wheels at the base. During the pouring process these blocks are set into a semi-hardened mix that will not shift readily. This construction worked with the ECC's clock as a technique to achieve the design. The mix is designed for a rapid set, in mere minutes, or a slow set over several hours. According to the cement–water equation the reaction produces heat. Overtime, ECC will heat up. It transforms from an icy fluid to thermally radiant stone.

fig. 14 Fluid topping layer is applied over the already set bottom layer

Calcium sulfoaluminate (CSA) is a fast reacting cement. In my tests, CSA set more than ten times faster than Portland cement. For ECC, part of the white Portland cement is substituted with CSA to achieve faster setting and strength development. On a hot day the ambient temperature increases the reaction time in the ECC, sometimes even before placing into the form is complete. Ice is often substituted for part of the water to cool down the mix. But on a winter day, the reactions necessary for concrete to gain strength halt when the temperature falls below five degrees Celsius. When the reactions stop, the concrete risks drying out before full strength is developed. Heating elements or thermal insulation keeps the temperature optimal for curing in the cold. While the techniques work in theory, their application requires mindful practice to allow concrete's clock to become its own creative tool.

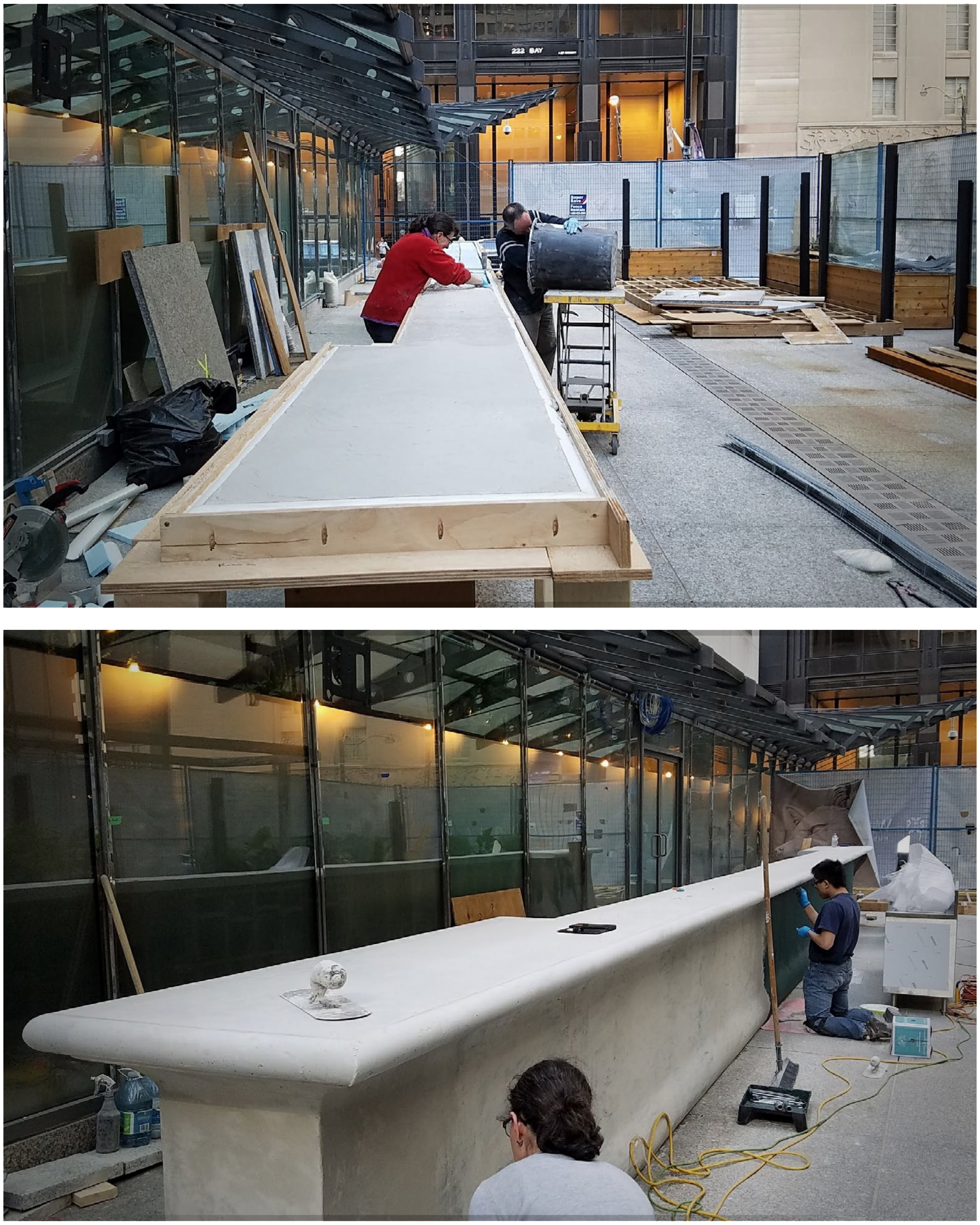

fig. 15 Casting 20-foot bar in sequence

MIXING

Consistent quality and timing are the key requirements for mixing. When done well, mixing goes unnoticed, but inconsistent mixing will ruin a project. In the second project during my apprenticeship, we cast a twenty-foot long bar on a restaurant patio. The cast required three men mixing twelve batches of ECC. The timing required the batches to be mixed one after another. We focused on the progress of the pour as any mistiming meant the ECC sets up too quickly or does not bond to the previous batch. A good mixing process also ensures repeatable finishing. Otherwise, seams appear when one batch does not match the next, resulting in a patchwork of pours. It was both an exhilarating and exhausting experience.

Mixing ECC is quickest with a handheld mixing tool compared to mixing with an automated standing mixer. Mixing well requires a tactile feel of the mix through the tool blade. Clumping occurs often during mixing. The craftsman senses a loss of fluidity as the blade torques hard against unmixed clump. To free the mix, the mixing blade is turned into the clump from the side or brought out of the mix and pushed down on top of the clumping area. Through this tactile feedback, one is able to feel when the mix is fluid and ready for pouring. The automated stand mixer lacks this intuitive feedback and instead powers through the mix, requiring longer cycles to work through the mix. Its advantage is the exponential increase in power, saving the craftsman's strength for the other stages of the cast.

The technique of mixing is best understood through stages. All ingredients are measured before mixing starts. In measuring, precision is more important than accuracy. Even minute differences between batches appears as seams on the surface. Mixing happens between adding ingredients to the mix to ensure proper disbursement. Clumps and unmixed ingredients stuck to the surface of the mixing drum are scraped into the mix to ensure the full incorporation of each ingredient. For consistent mixing, ingredients are added by category. First, the non-reactive ingredients, aggregate and any color pigment are mixed. Aggregate acts as small tumbling mixers to break up material in later phases. Pigment will clump and create color splotches if added after liquids, so these come first. Second, other non-reactive ingredients like admixtures are added to

fig. 16 Mixing ECC

the mix. Third, water is added to create a slurry that receives the cement. Adding water to dry cement results in clumping. Adding everything to the water slurry ensures even dispersion.

Mastering the technique of mix consistency is achieved through mindful repetition. Precision is a sign of technical mastery. The craftsman considers the effect of each movement and refines the technique. The hands feel irregularities in the mixing. In casting the twenty-foot bar, the ingredients for one batch was measured in error. As soon as mixing began, the batch turned stiffer than usual. At the end, the batch was unmixable, having clumped into hard chunks. An experienced craftsman would have felt the odd viscosity of the mix when the errored ingredient was added. Muscle memory is one way embodied knowledge is stored in the body. Just as a baseball player knows the precise weight of their bat from thousands upon thousands of swings. An ounce of variance in the weight would throw off their swing. The muscle memory of a craftsman grows through repeated making. Always learning from the relationship to material is a mindful way to approach making.

fig. 17 Board form concrete mirroring the wood form

FORMWORK

Formwork endows concrete with its identity. The form shapes the void and the concrete fills it. After curing the form is stripped away, reused or forgotten, and the finished piece of concrete is born. Hence, the artisan not only creates concrete, but formwork. They must be well versed in formwork materials. When the formwork is complex, it can be designed and fabricated in close partnership with other artisans. The success of the concrete cast depends on the formwork.

ECC captures every nook and crevasse on its skin. Small scratches, hard and soft particles all show on the unveiled piece, but the responsive nature of the material also makes it attractive to cast. Cast against a plastic sheet, ECC glistens like glossy plastic; against brushed stainless steel, ECC acquires a dull uniform face; and wood boards will cast a surface that captures every variance of the wood's grain pattern. The thin cement skin is a solution of cement in water. Water sticks to the mold, even when upside down, fighting the pull of gravity and clinging to the surface, though voids appear when air is trapped at the surface. The paper thin cement skin is much weaker than the ECC body. Over time, chemicals, water, or wear and tear breaks down the skin. However, this natural process of aging shows the humanness of this stone. The imperfections and changes through time are inherent to natural processes we see. When we pay attention to these things, we have a deeper understanding of the life of materials.

The other half of the form is the bracing. If the form supports the concrete as it hardens, then the bracing is the support for the form. Bracing is needed when the form itself is not enough to support the forces of the concrete. It provides concrete structure before it is cured. Even before complete failure, the form bulges from the forces exerted by the concrete, resulting in the same bulges on the surface of the finished concrete. Lateral forces on vertical formwork surfaces exerted by the internal pressure of the concrete are of great concern. Tall walls are difficult to form, because of the extensive bracing required to resist the forces of large volumes of concrete. Sufficient bracing is fundamental to the cast. Just as a building's structural integrity is the most basic requirement of a good building, bracing is the most fundamental requirement for a good cast. During

fig. 18 Formwork breaks open from lateral pressure of concrete revealing semi-hard mix and foam cavity

casting, movements in the bracing are felt and seen by the maker. Over time, the craftsman acquires an embodied knowledge of bracing, intuitively understanding the bracing requirements.

fig. 19 Initially hands flatten the viscous mix and blend the seams together

CASTING

Casting is the process of marrying the fresh mix and the formwork. The surface of the ECC records the traces of the casting process. The minutiae of each unsuspecting touch are cast into visible marks. Dragging the mix across the form will result in streaks on the surface. Lifting the mix off the surface leaves residue paste stuck to the formwork. If not bonded well to the layers above, the residue paste will become weak and flake off after unmolding. Each unmolding brings to light the ways the ECC surface is etched with a record of the craftsman's motions.

First, fresh mix is placed on the surface by hand and blended into the old. Then a trowel is used to spread ECC and finish the casting. Troweling is the motion of dragging a flat-bladed tool (called the trowel) over exposed mix. A long metal straight edge, called a screed, can also assist in leveling out the surface. The role of the trowel is to spread fresh mix, create a flat surface, and harden the already set ECC surface.

Troweling is used most on projects in which there are exposed surfaces as opposed to surfaces cast against a form. A cube piece might have formwork on five sides with one exposed, typically the top. Most often, horizontal slabs, like exposed concrete floors, will be troweled after casting to create a flat and level surface. If not troweled, the surface will take on an uneven appearance with bumps and depressions, often reflecting how the ECC was placed into the form. Take as an example, a tabletop cast. Typically, the bottom surface and sides might be surrounded by the form, but the top surface is usually exposed. The ECC is filled to the top of the form. To finish, the top surface is leveled off with a long straight edge, then troweled. This last action of troweling creates a flat yet irregular surface far different from the homogenous underside.

Troweling becomes a complex act of thinking through making where the surface becomes a canvas on which the craftsman's tool is drawn. ECC is not a homogenous material. The ECC mix comprises many particles including glass, fly ash, cement, and fibers. All the parts of the mix form patterns that become visible on the surface when troweled. The act of troweling becomes an expressive display of artistry. Every act of pushing, pulling, and turning of the trowel has a simultaneous effect on the parts

fig. 20 Trowelling the mix as thin as possible to reduce weight
on the underside of a coffee table

underneath. In this way, the trowel creates a grain on the ECC surface. The surface fibers in the mix become oriented in the same direction as the motion of the trowel. Areas passing under the trowel are smoothed over and compacted. Not simply aiming to create aesthetic patterns on the surface, the craftsman uses the trowel to form a smooth, well packed, and flat surface. Instead, the working of the surface results in patterns that display the skill of the craftsman. In particular, the irregularity tells the tale of the quality of the surface. The body of the piece is flat, square and close to perfect in form, but the visual markings on the surface are the answer to the question of workmanship. Marking should be random because the motion of troweling should be in irregular patterns to avoid directionality in the surface, which only weakens its durability. A randomly marked surface will resist attacks well in every direction while directional markings will reveal any opposing marks readily.

The bare hand running over the surface should sense but the smooth surface with the most subtle irregularities. These subtle irregularities point to the work of masterful troweling. A surface can be machined to perfect uniformity, but this surface loses the natural quality of stone captured from the forces of the earth. Thus, troweling is a way of seeking the beauty of natural things in something made with the aid of machines. These irregularities reveal the quality of a surface that has been worked with skill and thought.[15]

From afar the surface may seem flat, but in fact it is full of irregularities. To the seasoned craftsman, the flexible steel blade reveals bumps and depressions on the surface through the hand, a task that is difficult to sense through the eyes alone. Listening to the chattering sounds of the blade against the ECC, the artisan senses the variations on the surface. The artisan not only listens but thinks through his hands to sense how to treat each unique piece. Bumps and valleys are worked over with the steel trowel with progressive force and speed to create the finished smooth surface. Other areas are treated only minimally, left alone so as to not over-burnish, leaving dark patches and lifting up the glass aggregate. All this thinking is happening at rapid speed as the ECC is turning to rock. The optimal period for troweling is limited. The craftsman hones the technique through sensing the surface quality through the tool. In this way, it is possible to create beautiful surfaces with irregularities which show the art of the thinking hand.

fig. 21 Irregular patterns from trowelling

fig. 22 Irregular patterns filled with new ECC during finishing

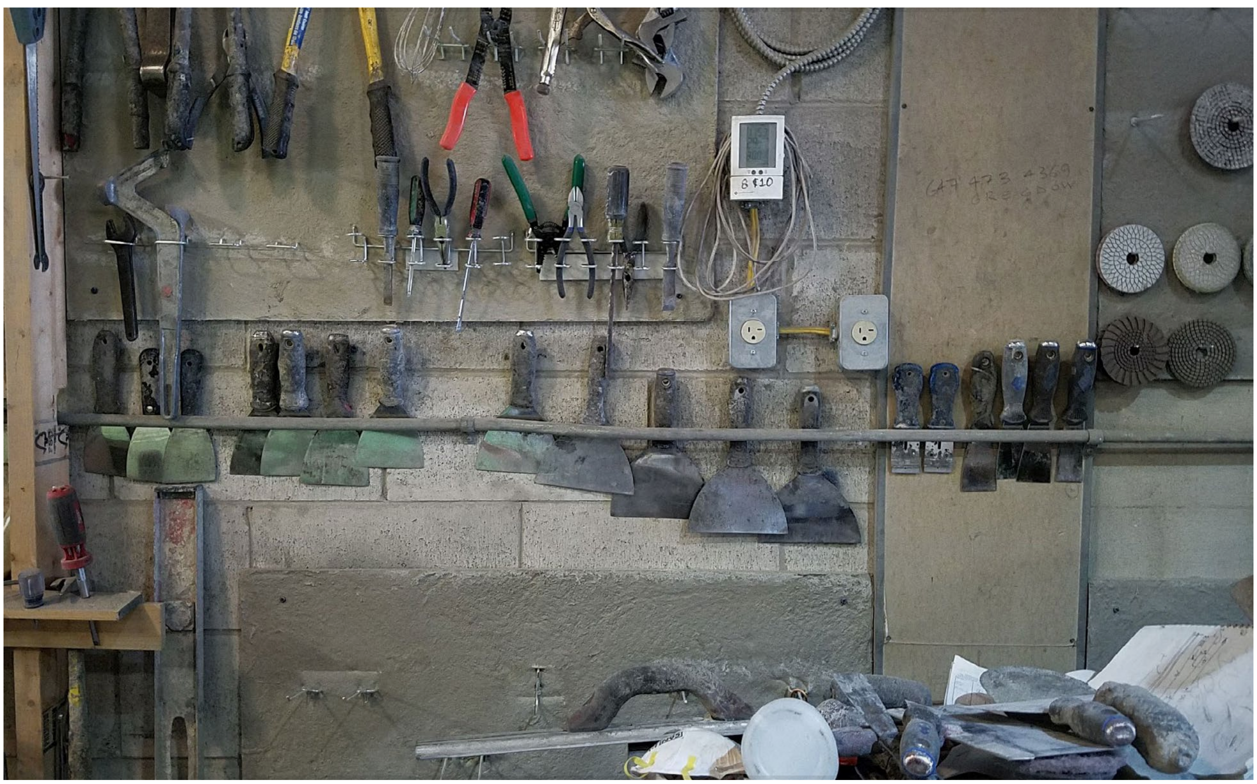

fig. 23 Array of putty knives and tools

FINISHING

The skin of the ECC is remade through finishing. It is difficult for the skin of the ECC to be in a desirable state right out of the mold. For a desirable skin, the mold needs to be meticulously made, because the skin of the ECC will take on every scratch on the mold. The cast will never result in a perfect surface. Pin sized air bubbles will be trapped on or just below the surface. Mixing inherently stirs air bubbles into the aggregate. Even after vibrating a fluid mix bubbles will remain. Finishing remakes the skin after unmolding.

There are a myriad of ways to finish concrete that each has developed into a specialty in and of itself. Tools and chemicals for finishing are in constant development. Three major ways I have learned to finish ECC are with chemistry, by bonding new mix to the surface, or with tooling. Since concrete is highly alkaline, acids react readily with concrete. Applying acids to the surface will etch away the top layer and leave a rough surface. Fresh layers of concrete are applied with a putty knife to fill any voids and smooth over the etched surface. The fresh layer should be mixed with bonding agents to prevent separation from the hardened concrete.

Tooling is the most intuitive method of working on the concrete skin. A variety of tools are used to take away material from the surface. For ECC, the most common way to produce a smooth and durable skin is using a grinder. The grinder is a handheld tool to which a single or multiple disc head is attached. These discs spin at high speed, often over 3000 revolutions per minute. Sanding disks, brushes, and sponges are attached to the disc head to wear away the surface. The first sanding is the roughest. Its purpose is to quickly flatten surface irregularities. Subsequent passes use finer and finer grit pads. The goal is to take away the scratches from the previous passes. The progressive passes leave a smooth, even surface.

fig. 24 The roughly cast surface and the same surface after grinding

I found grinding ECC very challenging. The skill requires a firm, yet sensitive hand to feel the texture of the surface through the vibrating machine. Areas with a more irregular surface may need more passes. The hands sense how much grinding each area needs. Each piece also responds differently to grinding. Variables like stage of hardening, surface glossiness, and moisture all affect the surface property. Grinding also requires an experienced eye to recognize the patterning left by grinding. Half-moon arcs signify a tilted disc head. Fuller arcs result from shifting the tool too quickly. The surface transforms visibly as the sanding pad passes. First, the formwork's texture is removed. Then, surface tones shift from light to dark or dark to light. Last, embedded aggregates are revealed. Grinding is akin to painting. The tool is easy to learn, but the skill is difficult to master. Through experience, the craftsman learns to select the best pad, the amount of pressure to apply, and when to stop. Grinding reveals the beauty of the inner material.

fig. 25 Single-head grinder

fig. 26 Grinding a large countertop cast

THE SELF, DESIGN, AND MAKING

fig. 27 The finished countertop is ready for transport and installation

BEGINNING MY OWN WORK

After eight months, I found myself bored of producing pieces based on designs that overlooked ECC's character and the value of the craftsman's knowledge. The designs commissioned to us did not draw upon the capacity of ECC and revealed little understanding of the techniques. They referenced traditional ideas for poured concrete as monolithic blocks, and some designers expected the fabrication process to present an undifferentiated surface.

Designers did not even seek to understand ECC until the design was finalized. Throughout the design process, Alla was consulted minimally. Designers simply sent us final designs and expected the shop to figure out how to make them. The relationship between designer and maker lacked genuine dialogue. For the Greeks, dialogue meant the free-flowing exchange of meaning.[16] Genuine dialogue happens when we open ourselves to new understandings. These exchanges take us towards new directions we did not plan beforehand or would not have arrived at on our own.

While I was still a student in ECC, my training and the encounters there propelled me to start my own explorations. The apprenticeship had given me agency to apply my own design training to making. Through learning ECC's creative potential and fabrication methods, I could depart from traditional ways of casting flat surfaces in rigid forms. In my training, one unique method of fabrication I learned was ECC's capacity to be poured on fabric and draped like cloth. This novel method of casting became central to my own design explorations.

fig. 28 Trowelling ECC onto fabric to be draped

INSPIRATION

Choosing how to begin and what to do is a daunting task. I tend to over-study and over-think things, which prevents me from starting. I often ask, what should I make, why should I make it, who is it for, how useful will it be, and even, do I want to make it? This kind of intellectualizing gets in the way of making and kills the creative spirit. Wanting to establish clarity on an issue is a good thing but becomes problematic when it becomes inordinately consuming, because the creative process of experimentation and development never takes hold. The best advice is to simply begin on something. The project will unfold in the creative process. The creative process will take you through many phases of testing, success, failure, near-disasters, and finally the finished piece. The numerous details and decisions of the project produce its effectiveness. The metaphysical foundation reveals itself through personal encounters with the details of the project. The process will not guide me to the finished piece if I never begin engaging with the specifics of the project.

When I begin the creative process, I allow an inspiration to call me and I immediately start making. My own work with ECC was inspired through a dialogue with a friend. He was interested in my apprenticeship in ECC. We began discussing how the unique properties of ECC allow it to be shaped in a way resembling clay. ECC does not exist only as a liquid mix and solid stone but for a short period in an in-between state. The in-between state is where the potentially new way of working with ECC exists. Under the microscope, the cement-water reaction slowly builds up particles of solid cement, crystallizing the fluid mix in stone. Drawing on the ideas of the cement-water reaction, I drape ECC on a fabric form. The conversation got me excited about the possibilities for design. We sketched through flowing dialogue back and forth. Each sketch built upon the previous one. Increasingly, this ambition challenged me until I did not know how the design could be fabricated. In the end, the only sure way to know if something will work is by doing it. The love of material and its capacity is what drives my passion to this day. I have a friend to thank for this new way of creating.

fig. 29 The first cast

FIRST CAST

The first piece I cast on my own was on fabric. I used vinyl tablecloth fabric and cut them up into squares to pour the ECC on. To contain the still fluid ECC in the form, I set four, half inch-high acrylic bars in a pinwheel arrangement around the fabric. The first cast was a half-inch thick, later casts became half that thickness. I measured and mixed the ingredients. Then I poured the fresh mix onto the fabric to spread with my gloved hands. The mix was fluid and easy to work with. I let the mix sit on the fabric for about half an hour, testing the hardness of the ECC by touch. The mix was already setting, so I then tried to drape the hardening ECC over the cylindrical bracing. The mix turned out to be far too fluid. As soon as I took my hands off the fabric, I looked at the edge of the fabric and saw bits of ECC mix pulling away from the rest and falling from the fabric. I could not leave the cast to fall apart. I removed the mix and fabric from the bracing. Placing the fabric on a flat surface, I re-consolidated the broken up ECC mix. Spreading it onto the fabric again, I waited approximately thirty more minutes. The ECC seemed more set, and I attempted the drape again. This time the ECC draped into shape under its own weight and held together.

Each cast becomes a teacher that reveals more of the design path. Upon reflecting on the experience, I realized that I had troweled on the ECC too thick. The weight caused the mix to pull itself apart. The next step was to try thinner casts. I needed to test other fabrics as well. Though vinyl tablecloth was waterproof and easily shaped, it imprinted a crisscross pattern on the surface. The setting time was also difficult to sense. I would pour an extra test piece alongside the next pour to better gauge the timing. While the cast did not turn out as expected, the process became a valuable learning experience from which I could draw upon often.

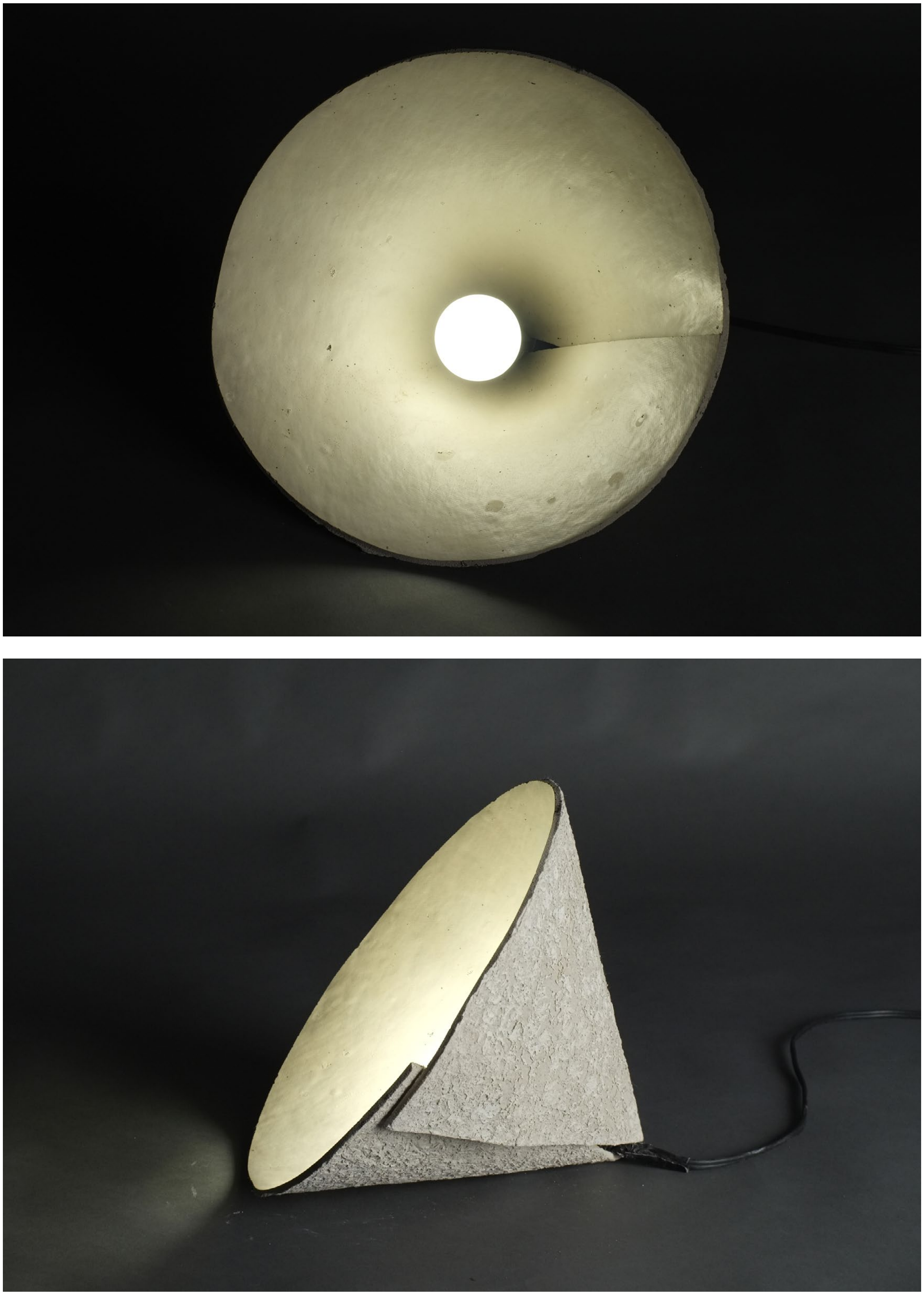

fig. 30 Cone Light

DISCOVERING THE PROMPT

> *I sense Light as the giver of all presences, and material as spent Light. What is made by Light casts a shadow, and the shadow belongs to Light. -Louis Kahn*[17]

I became interested in lights through a series of encounters at galleries and stores in New York City. The light brought the material to life. During my apprenticeship, the light in the workshop encountered concrete in similarly special moments. The setting sun streamed through the tiny rectangular window on the garage door and cast a glowing light that rippled on the uneven surface of the newly unmolded concrete.

After the first cast, I was eager to jump into more. I learned the technique in the first cast, but it lacked design ambition. The experience led me to look for a prompt. I looked at some precedents for ceramic and glass lights. In the end, I sketched two forms. For one, I carved a dome out of a block of foam to drape the fabric on. The other was a simple cone on which I wrapped thin sheets of flexible acrylic. I secured the border of the fabric with insulation foam tape, a technique learned in my apprenticeship. I easily predicted the process through which to make them, and the process went as expected. I unmolded two pieces of ECC lights that were exactly as I had sketched. I thought I arrived at the answer without much challenge.

When I look back on these first objects, I realized they resulted from my training as a craftsman. I relied on my intellect and know how. It took me down the most stable and certain path producing predictive results. Life often draws us down this path. In architectural practice, designers and the trades feel squeezed by outside pressures like time and money. The safe way is doing what has been done before, that which has even been good in the past. The work incrementally improves upon already popular designs. However, these paths do not lead to new things, ambitious things, which have character.

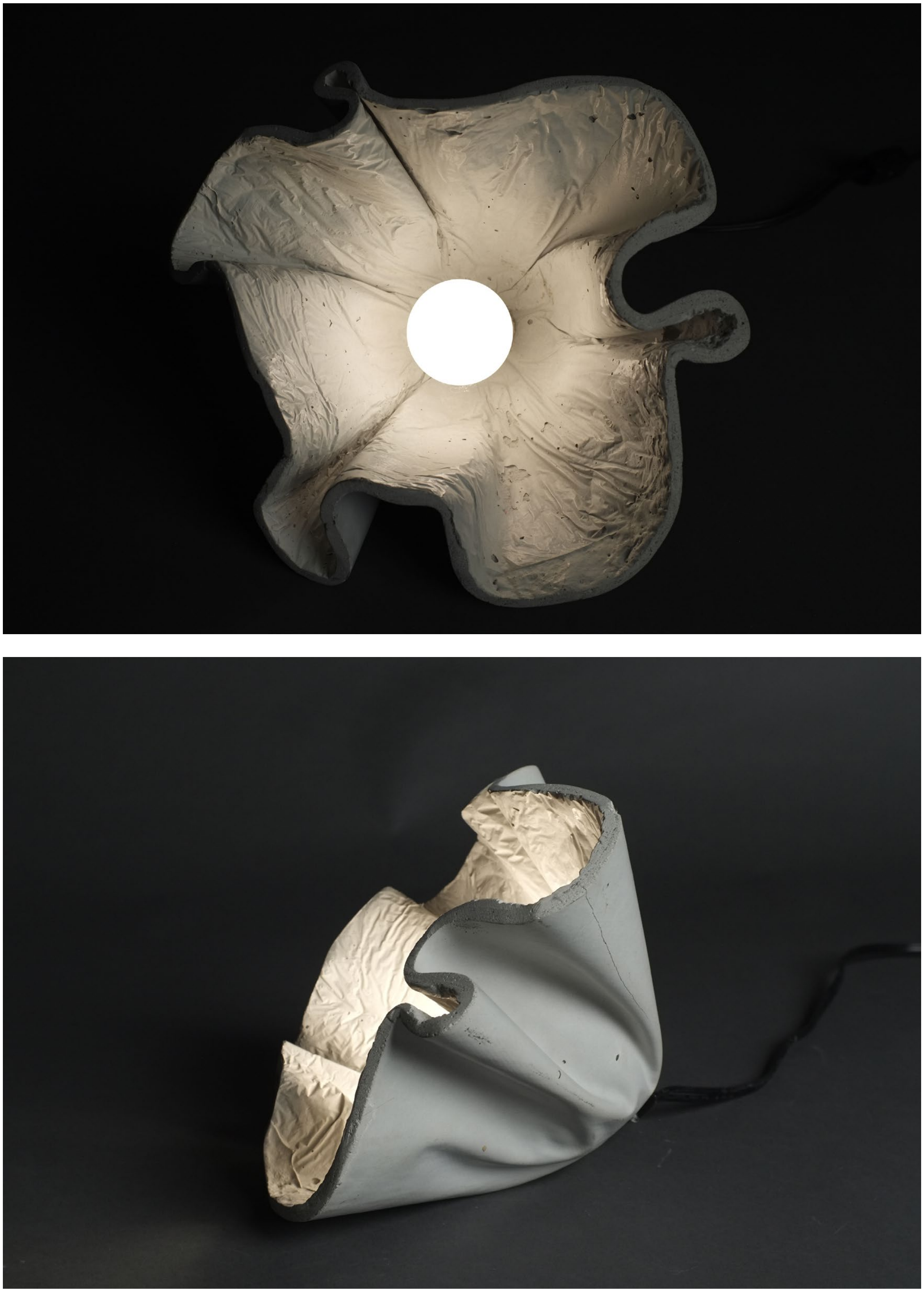

fig. 31 Draped Light

An artist craftsman combines the role of artist, designer, and craftsman.[18] The artist craftsman has the freedom to create out of their own volition. So, while they possess the know-how and technique of the those who make, they work through the instinctual process of the artist. The instinct does not rationalize or fully explain what to make. Rather artist craftsmen simply begin making out of a deep inner prompt or urge to create.

The instinct guides them through the creative process. In the inner prompt, they find the seed of an idea without certainty of how it will end. The maker simply begins. The uncertain creative process is difficult, full of risks, and failures. The artist craftsman learns that failures often lead to new discoveries. Through experimentation and reflective thinking the finished work emerges. The genuine experience of the artist craftsman is manifests in the finished piece. It is a deep expression of the self.

Whether fragrant flower, hardy wheat, or wild bramble, the once unknown seed is manifest in a piece that provokes the view. The word provoke comes from the Latin “provocare” or “challenge.” Vocare-meaning “to call” and pro-“forth.”[19] The work of the artist craftsman provokes the imagination, senses, and the mind of whoever approaches to encounter. They present us with what we are not accustomed to in order to lead us to question our assumptions about the world. Through a long and hard look, they help us see more than we immediately grasp and awaken us to new insights.

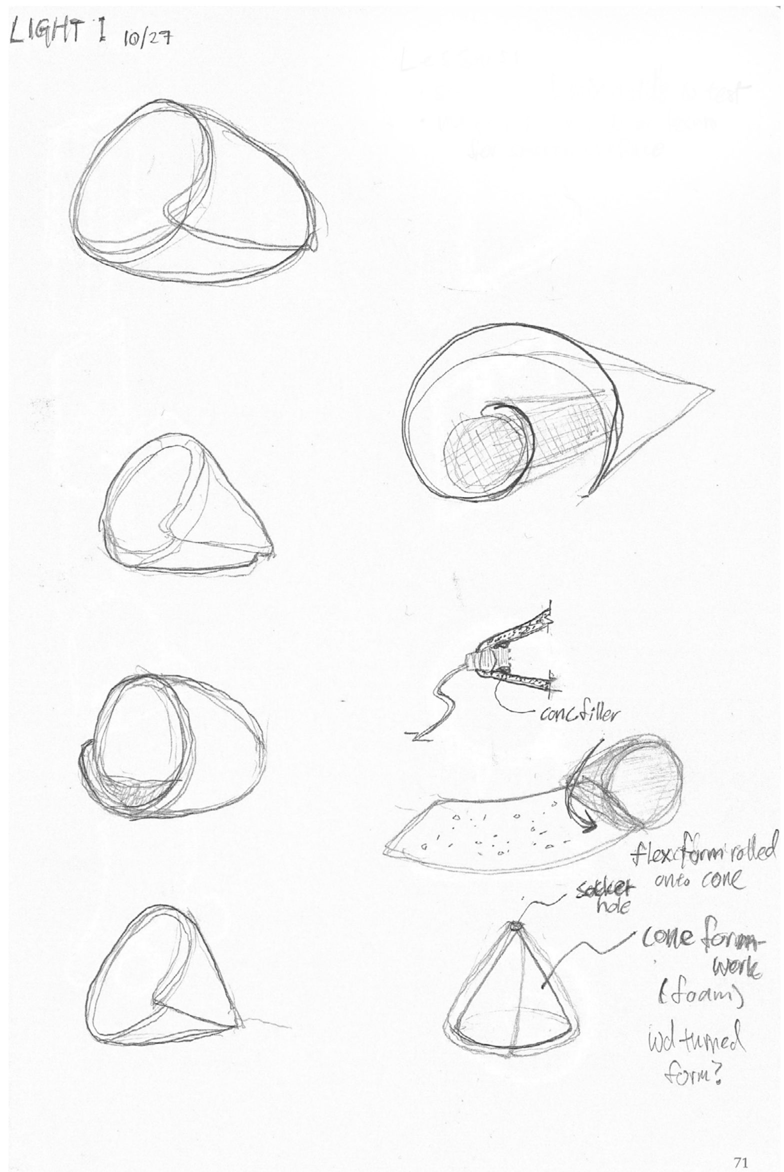

fig. 32 Light design sketches

EXPERIMENTATION

I spent more time looking at images and sketching designs than in making. Working through images and drawings was the way I was trained to design. However, the method led me down a path antithetical to the ECC's nature. I focused on the concept of a lighting element rather than concrete's encounter with light. I needed to see past the concept into the real encounter with ECC.

fig. 33 Lighting test

fig. 34 Thin Cast Light

I furiously engaged in making and testing. At the end of a long day of the apprenticeship, I would sometimes cast up to eight pieces, staying late into the night until I ran out of workspace to put my pieces. One of the first pieces was an attempt at casting paper thin concrete that allows light to pass through. I added more super plasticizer and spread the mix as thinly as I could in the middle of the fabric. I left the edges thicker for structural integrity. When I unmolded the thin concrete, it began to flake apart as I removed the fabric. Light broke through the places where the thin concrete flaked away.

fig. 35 Thin Cast Light

fig. 36 Hydrogel Light

The next cast explored the use of hydrogels: soft gel beads about the size of small marbles saturated with water. Because the hydrogels were full of water, I knew it would be difficult to control the water content, which is vital in high-performance concrete. However, I wondered how the concrete immediately adjacent to the hydrogel might react. The only certain way to know was to test it through making. I laid down the beads on top of a piece of clear vinyl fabric. Then flattened the ECC into pancake-shapes and laid it on top of the beads. The water from the beads liquefied the concrete and the beads broke through the mix. The mix became fluid and difficult to shape because of the added water content. The beads also created holes in the concrete. After curing, these beads dried out and fell away to reveal spherical voids. The voids were crumbly due to the high-water content. I placed a bulb inside the cast and the light filtered through the crumbling holes like sunlight through a leafy tree.

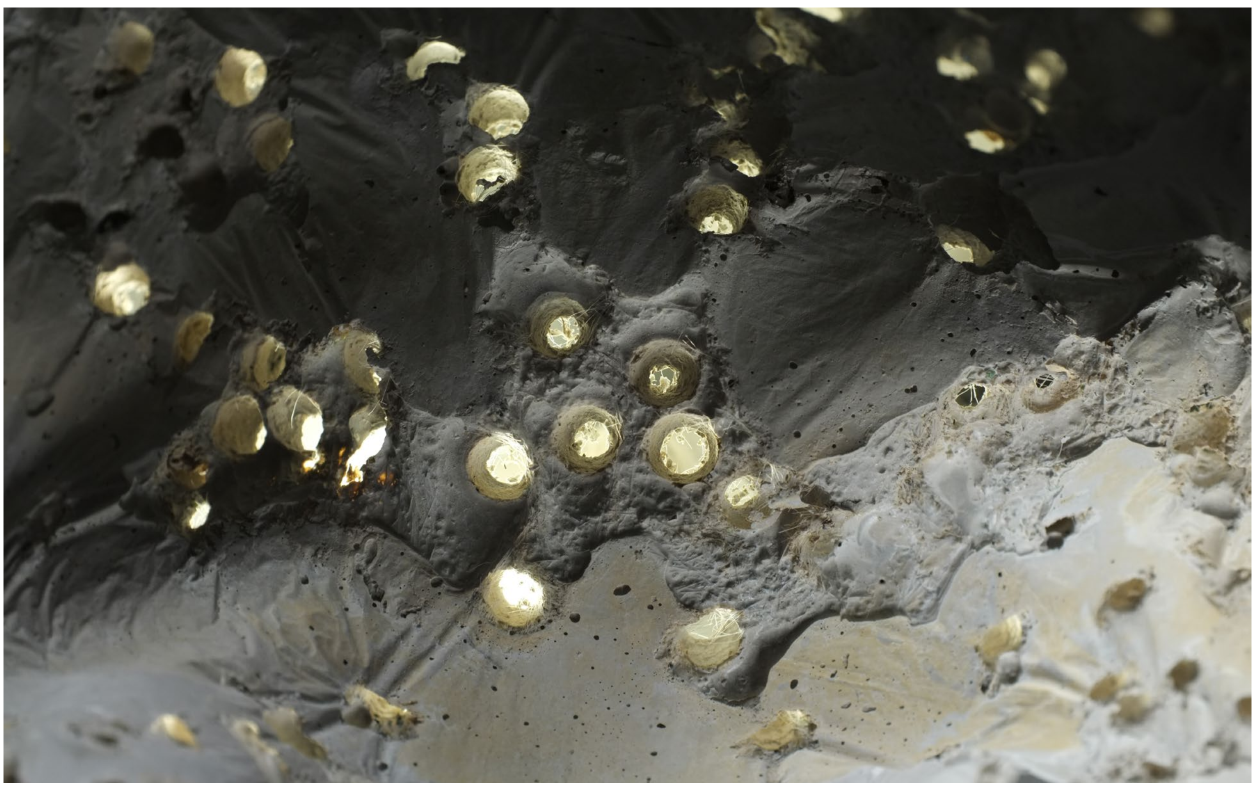

fig. 37 Hydrogel Light Detail

I wanted to find more ways of creating openings that followed the movement of casting process. I adhered foam and glue onto the fabric. After casting, the foam and glue were removed, and cuts were revealed. However, the cuts did not relate to the character of the concrete. They read as alien in their origin.

Searching for more materials to cast voids, I zigzagged down the aisles of the craft store. I landed on a bottle of clear, acrylic semi-spherical beads and a box of wooden beads. Unlike the hydrogels, the acrylic beads did not affect the concrete mix, so they were more precise for casting.

The wooden beads spawned from observing ceramic making methods where organic materials were mixed into the clay and burned out during the firing process, leaving voids in the pieces. In the end, the torching did not end in desirable results. The heat expanded the aggregate, spalling away pieces of the concrete.

fig. 38 Paper mixed into concrete then burned

fig. 39 Burned surface of Wood Bead Light

However, I saw potential in the acrylic beads. Some beads allowed light to pass through, while other light washed the surface of the concrete. The light washing the surface was a soft counter to the spots that shone through the beads. I decided to cast another similar piece with more surfaces for the light to play on. I was quite pleased with this piece.

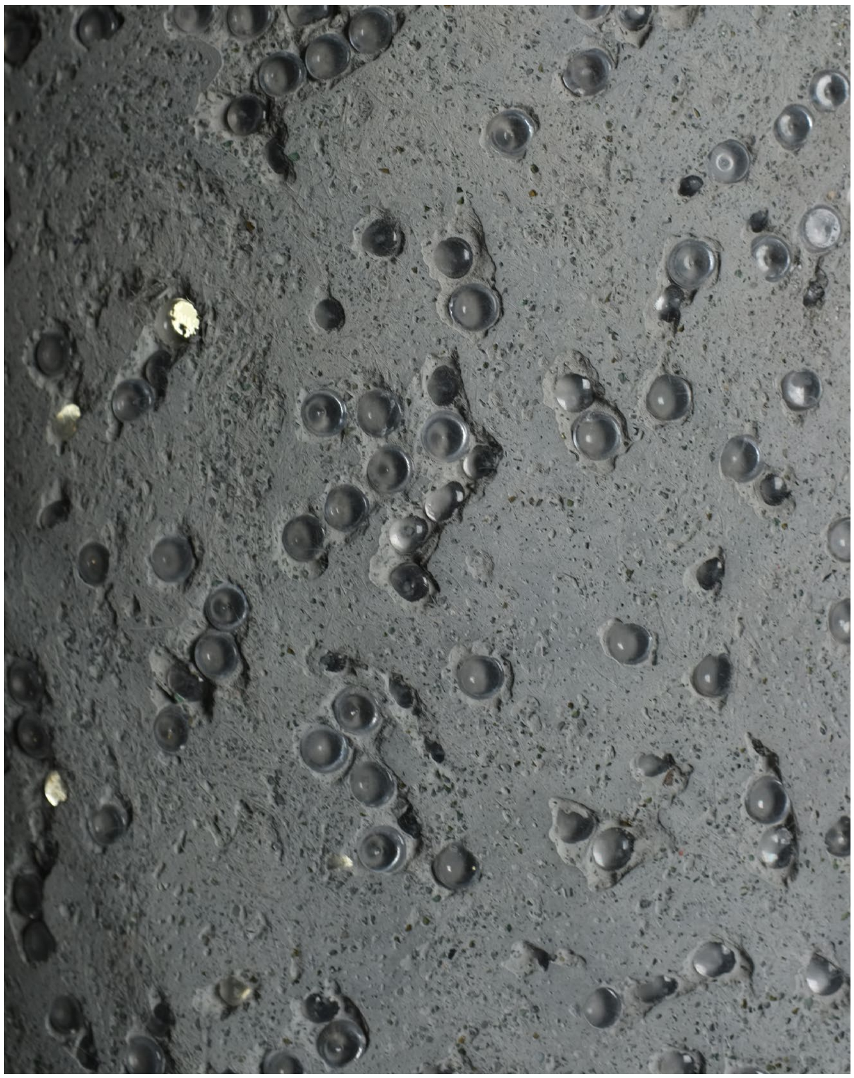

fig. 40 Acrylic Bead Light I - Acid etched surface

fig. 41 Acrylic Bead Light I

fig. 42 Acrylic Bead Light II - Acid etched surface

fig. 43 Acrylic Bead Light II

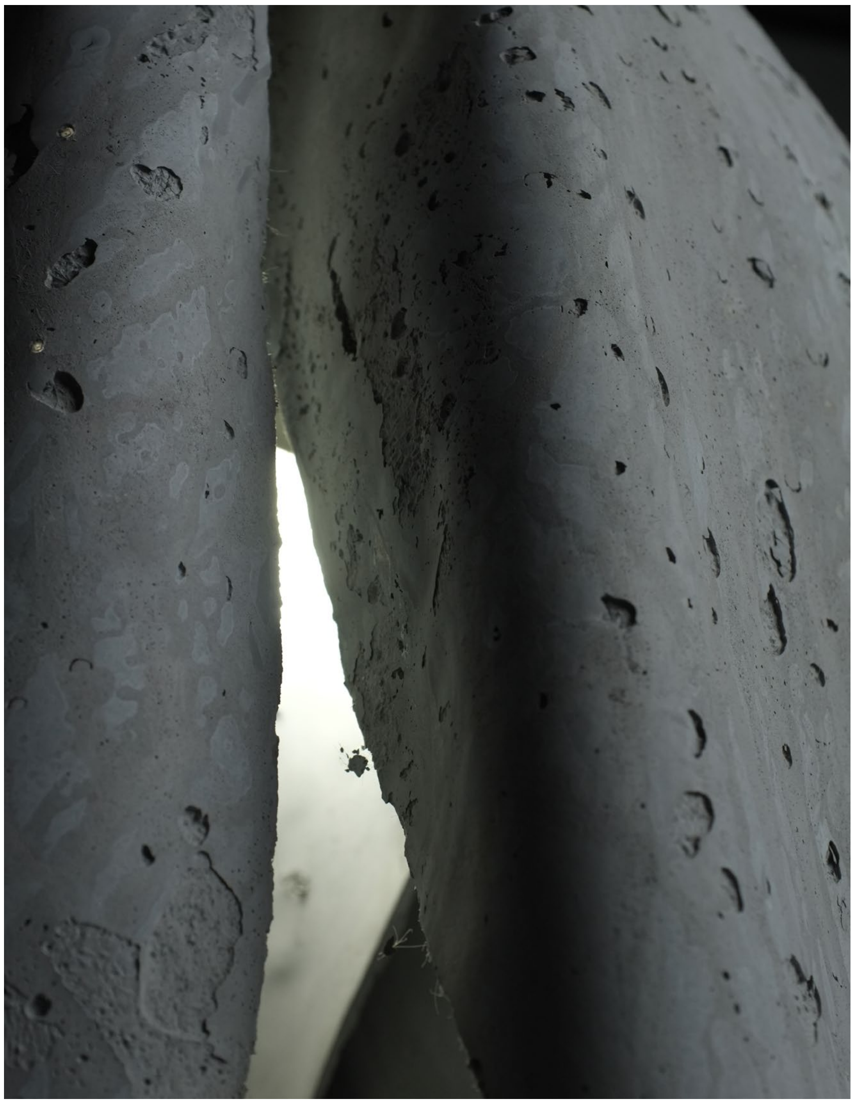

fig. 44 Acrylic Bead Light II Detail

fig. 45 Acrylic Bead Light II

fig. 46 Wood Slice Cast

Finally, I sliced up wood dowels into round medallions and glued them to the fabric. During the cast, I hung the fabric formwork from a wooden frame with lengths of strong utility tape. This allowed me to stretch and pull the hanging piece. I sculpted the form while the concrete cured. The process of sculpting allowed my inner instincts to create. The short curing time of the ECC meant there was around forty minutes to shape the material while it was still plastic. The short malleable phase meant my mind was preoccupied with generating form and critical reflection had to wait. Unexpected movement during sculpting brought about unique forms. When I pulled the form with a new length of tape, the entire fabric would react and stretch. After unmolding, I was captivated by the shape. It resembled a piece of fabric caught in the wind more than the solid, heavy concrete I was used to.

After the pieces cured, I inverted the hanging pieces. The pull of gravity created a sensation of rising. This method of working with ECC brought about forms I never imagined or conceived on paper. About half of the pieces broke when I stretched them too far or sculpted them too deep into curing. Yet, through this process of experimentation I found the limit of ECC, the edge between what is surprisingly possible and failure.

fig. 47 Wood Slice Cast Detail

fig. 48 Wood Slice Cast

fig. 49 The pieces

THE CREATIVE MINDSET

The journey of making was perhaps the toughest and most tiring one, but also the most fun. The tension between working hard and having fun is where the creative mindset thrives. One time, at the end of the day, I could no longer walk properly. I limped home on a strained hamstring, a sore back, and calves that twitched with every stride. When I finally laid down, I could not sleep even though I was dead tired. I just felt adrenaline restlessly flowing through my body. I was happy with what I made and eager to start on more.

I have found that a large part of finding a creative mindset is also to have fun. When the inner self is having fun and the pressure is off, the mind explores without consequence. I once asked a retired farmer why he still enjoyed farming. He told me the difference between work and play is that in play the pressures are off, it is just about having fun. In my experience, this is key to a genuine creative life. Another way to understand it is to enjoy something purely for itself without regard to its value or utility. It means being able to suspend judgment of what others will think, forget about the difficulty of the task, and do not overthink the problem.

A practice I have found useful is to break down the design process into a generative phase and a critical phase. The generative phase of creative work is where I let go and just have fun. The critical phase is where I reason and make decisions on the best choices.[20] While there is a suitable time to engage in the critical analysis of whether something is good, creativity is fostered by separating the generative and critical phases of thinking.

Studies have shown that people are not good at multi-tasking.[21] Instead, we do something more like multi-switching. Our brains switch quickly from one task to another. When I pick up the phone while walking, I have noticed my walking speed often slows. If it is difficult to be walking and talking, how should I think to generate ideas and decide on the best ones at the same time?

fig. 50 Play

When I generate, I open myself to all ideas and go for quantity. When I think critically, I narrow down the choices in the search for quality. I separate the generative and the critical parts of creativity, because I simply cannot do both well at the same time.

The crazy ideas that walk the fine line between safe and insane are the ones that bring about innovation. When I push something to the breaking point, I discover the real limits. Prior to the breaking point, ideas only stay in a safe, conventional space. Sometimes, the ideas I laugh at are actually the most creative ones, because they are something unexpected. I have learned to follow those crazy and ambitious leads. It might not be the finished piece, but there is probably a spark of an idea waiting to be fanned into a flame.

fig. 51 Broken pieces of first large cast

CRITICAL REFLECTION

After a period of generative making, I often paused and critically reflected on what I made. Surveying the casts, I could not stop looking at the way the light glanced off the folds of the concrete. My instincts were drawn to the concrete's play with light. Through dialogue with a colleague on the pieces, I understood the affective quality of the pieces. I decided to pursue this effect of draped casting. To push the design, I would try larger casts to see how they shift in scale in relationship to the human body.

The first large cast was triple the surface area of the previous casts. Everything had to happen a lot faster because there was three times more material to work with the curing time was the same. This change helped the process become more intuitive. Instead of using the previous method of hanging from lengths of utility tape, I began warping the concrete around different pliable objects. The tape could not hold the heavier weight, and the larger size would be clumsy to work with.

When I unfolded it, the first large cast fractured into a multitude of smaller pieces. The concrete was either poorly mixed or the shape was too demanding for the thickness of the cast. Instead of worrying about the failure, I saw the potential in the broken pieces where the folds revealed intricate details at that larger size. I wanted to see more of the folds in a complete piece.

The second piece I cast was half the size of the first one that broke. I hoped the smaller size would ensure that the structural integrity of the piece would stay intact. It also allowed me to learn more by slowing the process. During the casting, I had a hunch that waiting a few minutes longer to fold the form might create some variation in the surface as the concrete would undergo more hardening. The unmolding revealed a cracking and peeling texture, like that found on the skin of an aged elephant.

When the maker pushes the limits of the material, failure will inevitably occur. Yet failure is also how new things are discovered. The material will react in new and surprising ways. These are the moments that bring about new knowledge.

fig. 52 Elephant Skin Cast

fig. 53 Elephant Skin Cast

fig. 54 Hanging Drapery Cast

fig. 55 Hanging Drapery Cast

fig. 56 Hanging Drapery Cast

fig. 57 Hanging Drapery Cast

fig. 58 Draping Cast

fig. 59 Draping Cast

fig. 60 Mannequin Form

BREAKING THROUGH

The heavy casts directed me to rethink methods of bracing them. Prior to that, I was typically casting directly on the floor. I started by laying the fabric flat then troweling the mix onto it. Next, I sculpted the forms by wrapping the fabric around a plethora of pliable materials. I casted against bags stuffed with newspaper, but they did not support the weight. I tested half-inflated balloons and then tested bags of foam beads after watching someone lay on a bean bag. I even considered sculpting something out of clay or carving a mold out of wood. In all these tests, the issue was that one side always flattened as the form sagged onto the floor. The challenge of bracing the casts became a bottleneck in the design process. I felt stuck.

A breakthrough often spawns when the designer is stuck and challenged. I needed to step back from the tests that were not working and search myself for what I really wanted in the work. I let my instincts developed through years of design work and making—guide me. I searched for materials that were easy to shape yet supported the weight of the concrete. I looked to techniques and inspiration from other fields. Some friends who looked at the pieces jokingly wondered if I could ever make concrete dresses.

Even though the idea was a bit farfetched, it lingered in my mind. What if I treated the bracing like a fashion designer working on a dress form mannequin? It would be a structure which presented a framework but allowed the fabric to flow freely. The idea quickly led me to brainstorm ways to test the new technique.

One material we often worked with during my apprenticeship was rigid foam. The foam is light since it was mostly filled with air. It withstood significant weight and was easy to carve. It is a big commitment to build something human sized, but I felt I needed to test it. I quickly drew up a sketch to determine how many pieces of foam was required to build the mannequin. It took three trips to carry all the foam board I needed back to my workshop.

Next, I marked out circles on the foam board. On YouTube, I saw a craftsman create a large adjustable compass from a nail and a pencil clipped onto a ruler. Once I marked the series of circles, I began the task of cutting them out on the hot wire cutter. The circles where slid on a square 2x2 construction stud to prevent them from spinning freely and the mannequin was finished.

Casting on the mannequin was an exciting discovery after being stuck on the bracing. It did as much to propel the design forward as it did to champion a new urge in me to create. I began to let the process guide me. I cut out a section of fabric without much reasoning over the shape. Then, I proceeded to mix and pour the concrete on the formwork. The utility tape worked well to hang the fabric on the foam. It was strong, yet flexible, easy to cut into varied lengths. I cast one after another, each building upon the one before. I played with the details of the pieces, lengthening one edge in one spot and trying for more folds in another. Before I knew it, the form emerged.

fig. 61 Sculpture: Breaching


fig. 62 Sculpture: Breaching


fig. 63 Sculpture: Breaching

fig. 64 Sculpture: Breaching | Detail

fig. 65 Sculpture: Breaching | Detail

fig. 66 Sculpture: Awakening

fig. 67 Sculpture: Awakening

fig. 68 Sculpture: Awakening

fig. 69 Sculpture: Awakening

fig. 70 Sculpture: Regeneration

fig. 71 Sculpture: Regeneration

fig. 72 Sculpture: Regeneration

fig. 73 Sculpture: Regeneration

fig. 74 Sculpture: Regeneration

fig. 75 Sculpture: Regeneration

fig. 76 Sculpture: Regeneration | Exterior

fig. 77 Sculpture: Regeneration | Interior

fig. 78 Sculpture: Regeneration | Exterior

fig. 79 Sculpture: Regeneration | Interior

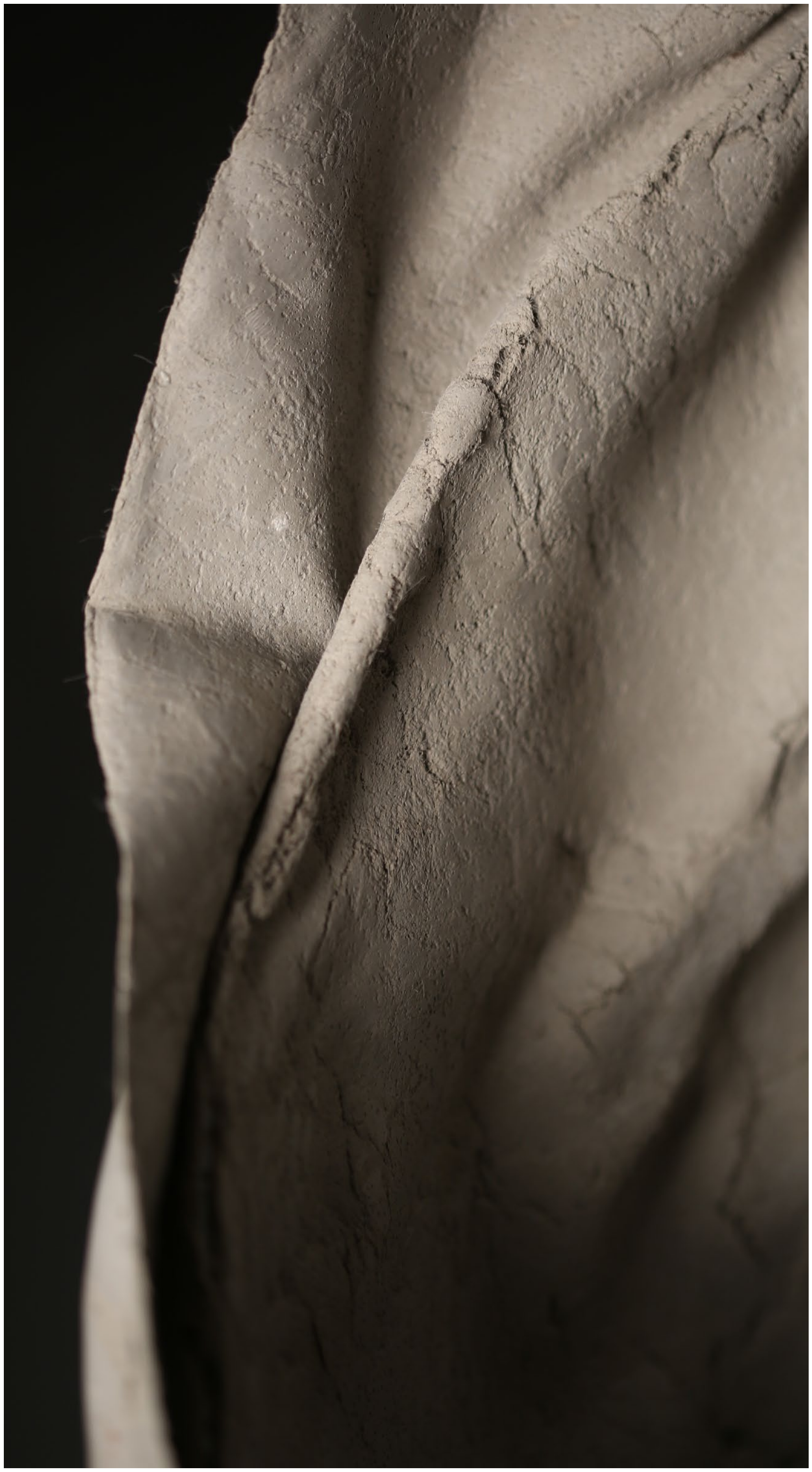

fig. 80 Sculpture: Regeneration | Interior

fig. 81 Sculpture: Regeneration | Exterior

fig. 82 Sculpture: Regeneration | Exterior

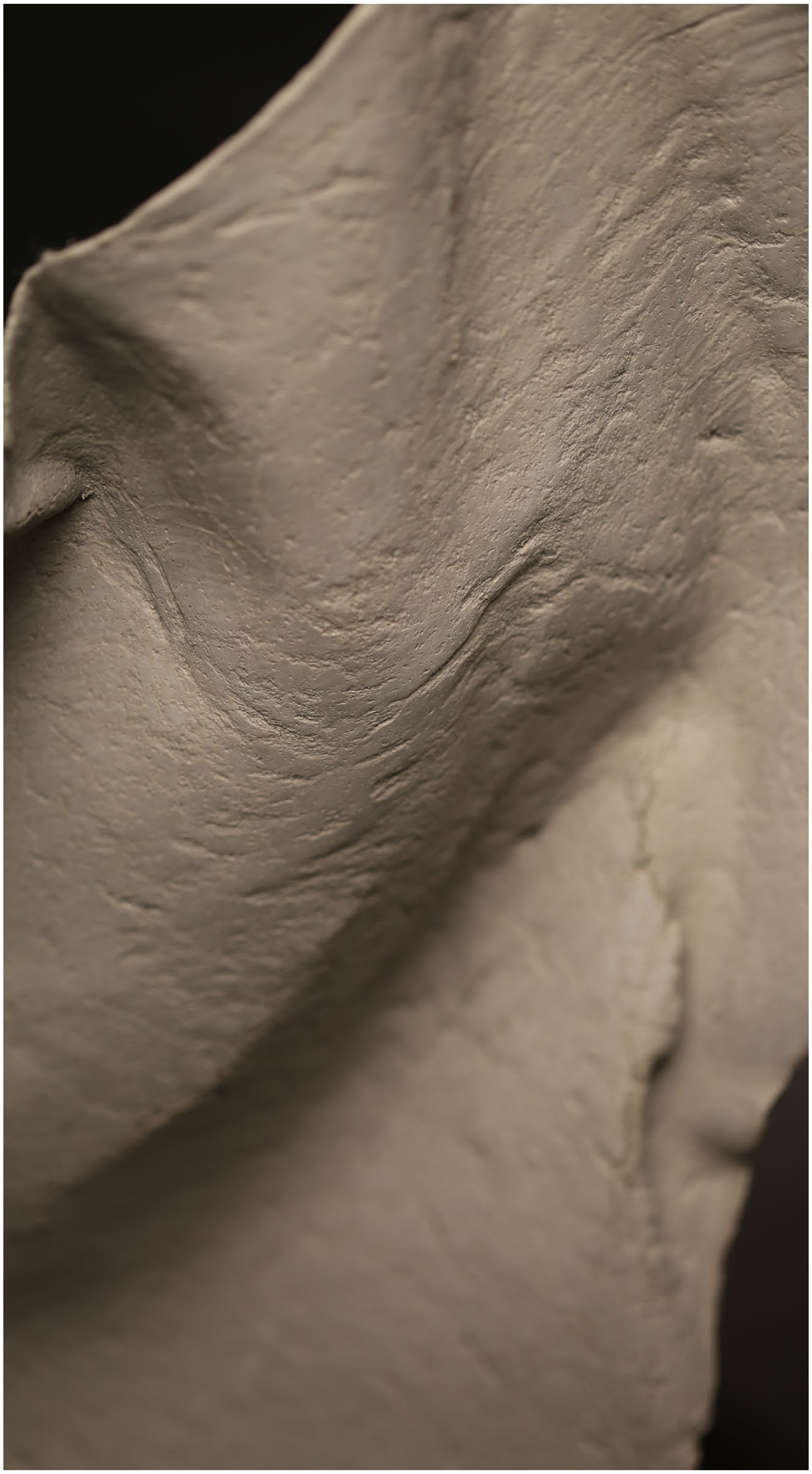

fig. 83 Sculpture: Regeneration| Interior

fig. 84 Sculpture: Regeneration | Interior

THE FEEDBACK CYCLE

The journey of fabrication and design taught me about my biases as a designer and as a craftsman. My first bias, in design education, taught me to always begin with an idea, rather than materials. The projects in my undergraduate studies and internships revolved around a big idea. The material considerations came last. To correct this bias, I pursued an apprenticeship as a craftsman, where I learned to work with concrete with a high degree of skill. However, the reverse bias took root, when I began honing my technique into a predictable process of making, with the same outcomes each time. In both experiences, I lacked a holistic approach to the design process. I now see that in order to make original and ambitious work, I needed to work with creative instinct and technique in a feedback cycle. Each step is treated with equal importance. One builds and improves upon the other.

In the feedback cycle, technique and instinct are fundamentally interdependent. For craftsmen, the mastery of their skills is a way to understand the nature of the material. However, understanding alone lacks ambition. Pure technique breeds a culture of fabricating the same perfectly executed things over and over. Nothing new is created. For the designer, ambition emerges from instinct. The instinct guides the designer to create works that are uniquely beautiful, insightful, and provocative. However, without technique the instinct creates a groundless manifestation of the idea. Technique, then, is what brings the instinctual idea into fruition. They work together to foster a holistic design approach.

Western society has developed a similar bias. It has divided the mind and the body into separate modes of being.[22] This dichotomy has revealed itself in the building profession. Before the modern era, a master builder who was trained in craft and versed in design, oversaw the creation of buildings from beginning to end. In the modern age, design and fabrication has developed into distinct practices for the architect and the artisan. The "intellectual" activities of the architect have not only been separated from, but also privileged over the "physical" activities of the artisan. Over time, the gap widened, and the hierarchy became more pronounced. Through

fig. 85 Sculpture: Regeneration | Exterior

working as a craftsman and a designer, I have realized the immense value of the integration of body and mind. They do not exist as isolated entities but are dynamically and infinitely joined. However, the artist cannot always be the craftsman.

In modern architectural practice, projects are simply too complex and the many individual fields too difficult to master. I believe that it is through genuine dialogue between the trades and architects, the holistic process can be revived. Dialogue is not merely a means to impress one's desires upon another. Dialogue is the free-flowing exchange of meaning. Dialogue works through the feedback cycle of learning, building on, and improving one another. To accomplish that, we need to approach each other as equal and complementary partners. Each should seek to bring the best out of the other. Architects should challenge the craftsman's thinking and the craftsman in turn should push the architect's know-how.

Designing through dialogue produces novel designs and new ways of building. Alvar Aalto, Louis Kahn, and Peter Zumthor are a few of the architects, whose practice exemplifies this approach. Their work provokes us to think about the human existence in a material world. For the craftsman, my apprenticeship with Alla has proved that collaborative partnerships are possible. But we must ask with an openness to understanding. We must take on an attitude of always learning. We must push each other to do better. In architecture, the fate of the designer and the craftsman are inseparably bound.

ENDNOTES

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