Architectural Techne’

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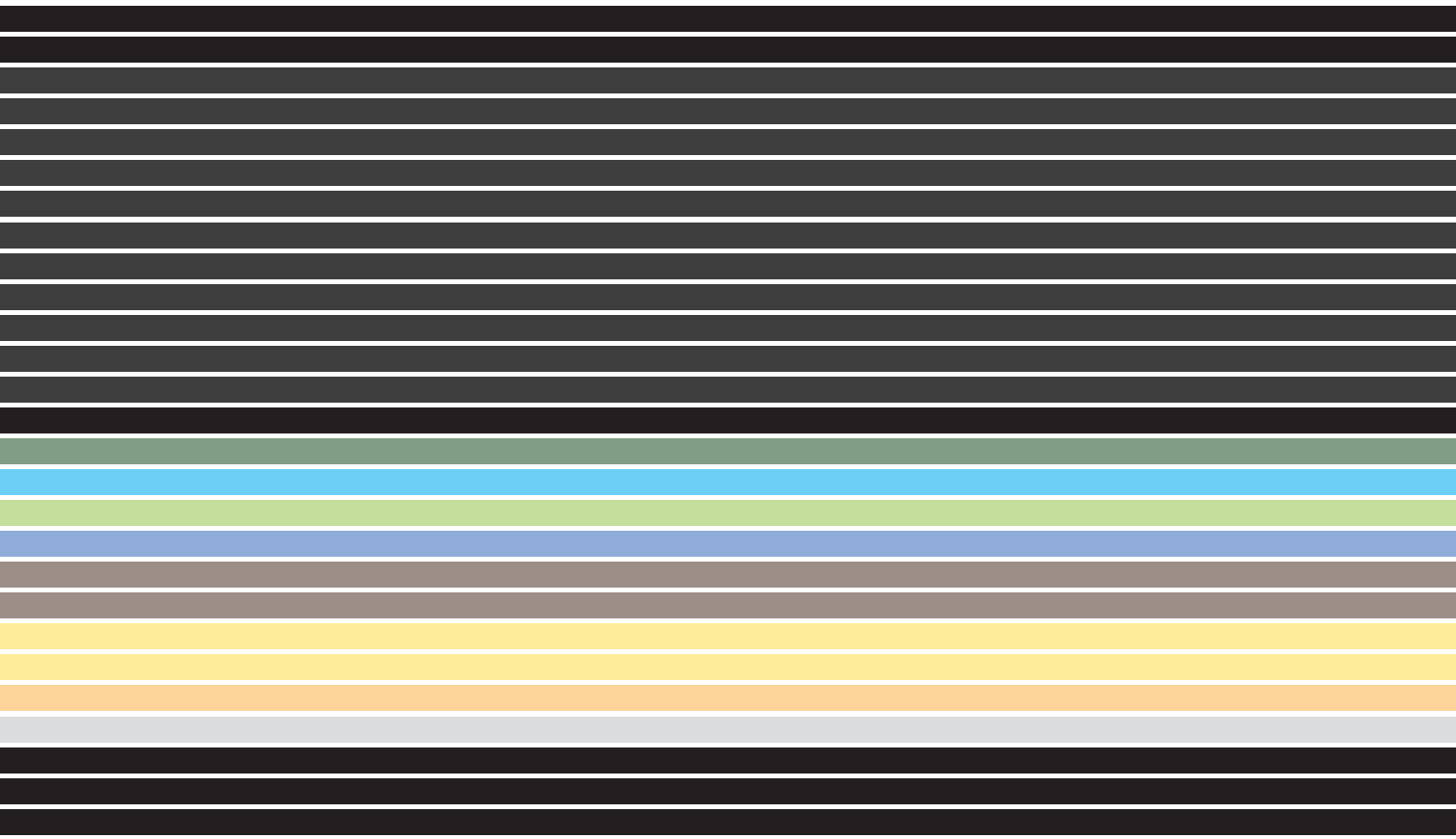
Words of Thanks

For my family and friends who have believed in what I do from a very young age and support me in all of my ventures, for all the prayers and good words of wisdom that I am forever gracious for.

I want to extend my greatest appreciation and gratitude to all that have shown their time and dedication as a mentor, close loved one, or helpful friend during this process. It has been a true and amazing collaboration of architects, engineers, artists, designers and friends that have influenced the way I design, build and interact with the world. The fruitfulness of this exploration is due to the combined efforts of many persons that I am fully indebted for forever.

...dream it, build it, breathe it.



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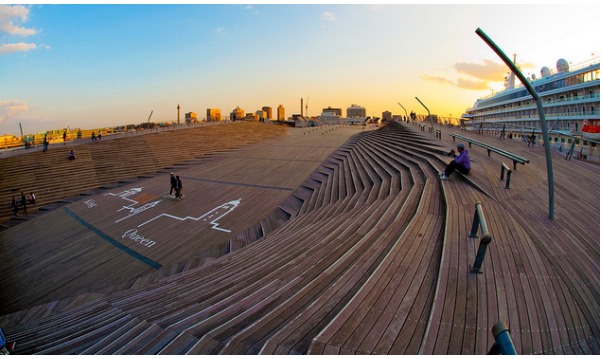
abstract

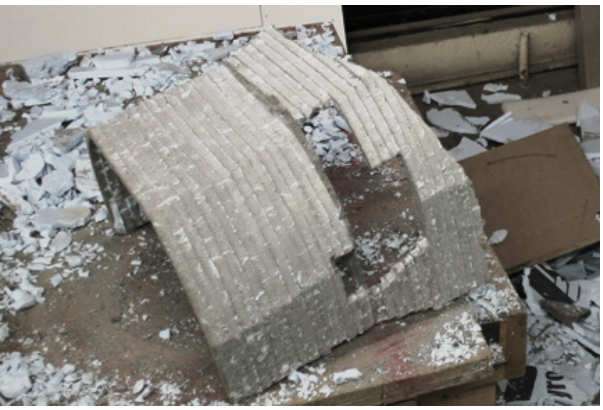
This thesis is about digital crafting in architecture. We have applied digital methods of making from the aerospace industry for over twenty years now. In that time, the architecture industry has attempted to figure out issues of scale and hyper-tolerance that come with this system, but instead these limitations are the rules of the digital realm of making. Not all things are scalable and currently we build at the component level. Digital fabrication, in part, has brought our society to a level of mass-production in most ways except architecture, which bases itself mainly as one-off buildings. No two are alike, in theory of course, and it should continue to be practiced and celebrated in that way. Instead of a mass production of a building, we are provided from a material representative, our materials, which most times include standard construction details from which we use to design and build. So I pose the question, where do architects truly stand as the master builder of their time? Ever since the digital realm has arrived, architects have been more disoriented against materials. Do we fully understand our technology and our role as architects to take on its possible advancements and its ability to also transform the way we practice? Digital fabrication in architecture is still new and we are still in the play stages. The first half of the digital realm of architecture is the math and algorithms that produce a certain design. With that comes the second half of architecture, the single component or material which makes our building stand, the panels that clad our walls down to the furniture in which we work and play. Not only must we explore architecture through digital design, but we must also through digital production. The architectural implications of this thesis are to promote the digital crafting of architectural components by supplementing the materials pallet to allow digital design and fabrication to become a holistic process of building. Through this we have the ability to reinforce the craft and craftsmanship that was lost in architecture with the modernist movement.

This thesis establishes itself by restructuring the normative design process in the exploration and experimentation of material based research through the methods of, or the technology transfer of digital fabrication to influence a new process of architectural making of components and techniques. Layering is seen as one process inherent in the digital design process by which it transfers digital information. The symbiosis between analog and digital will always be required in the process of making. This acknowledgement has the ability to enhance the understanding and advancement of architectural component production, materiality and experiential spatial quality through various scales, of which are seen through industrial, furniture, building and landscape design. Exploiting digital fabrication through these scales further shifts our understanding and allows an opportunity to bridge the systems of hyper control and manual tooling. This thesis seeks to influence the capabilities of material usage and design possibilities through the information transfer of digital and analog methodologies.

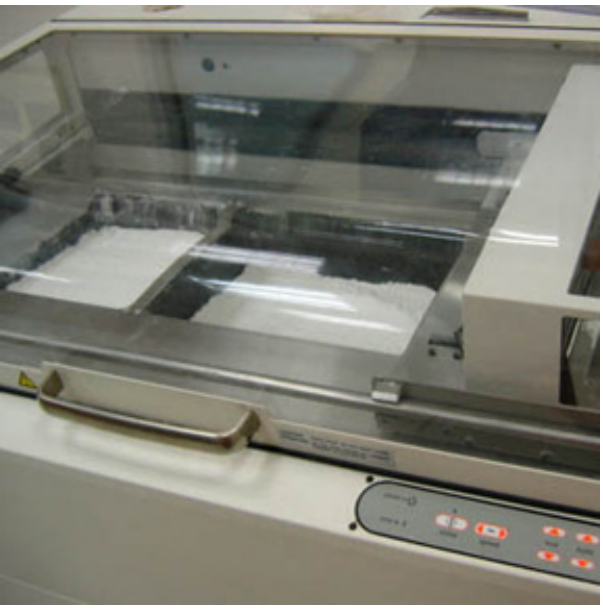


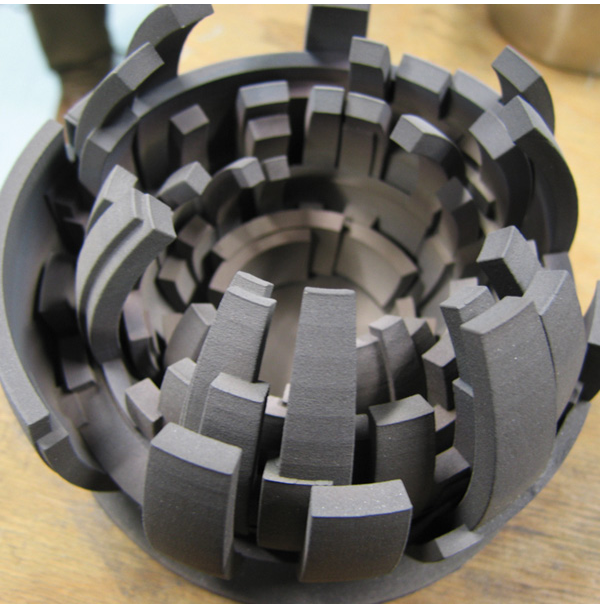
Architecture continues to be influenced by the digital design process and it's realized capabilities through a digital fabrication process. The shift towards digital design and digital fabrication began around the 1990s when the computational design process first started to be accessible to architects. The progression of time has only increased knowledge and capabilities of both the design and fabrication systems, including the hyper control of precision and tolerance in a built component. Digital fabrication is based on processes of two-dimensional cutting, subtractive cutting or milling, additive material or formative material and combinations of these. Each process has opportunity and limitation to not only to be a decorative or formal effect but also the structural architectural form. The technology transfer between analog and digital process will allow for a reassertion of craftsmanship that was lost in the modernist movement.

During the late 1980's, Nicolet Chartrand Knoll Ltd (design engineer) & Rice Francis Ritchie (construction phase) were one of the first companies to implement a digitally created component for use in an architectural application. Their component was used as the structural part of I.M. Pei's Louvre, which was completed in 1989. While the surface was very much so an analog process and clad with glass, the engineered design components that were digitally fabricated, allowed this design to come to fruition. The digital components that were manufactured were the cast 'spider' in which the larger tube structure connected into. This was the basis for the structural component of the glass pyramid. The glass is a standard plane and mullion detail overlaid on the structural tube



system below. The 540 foot stair case is also claimed to be "unequalled in the world to this time" based on current use of digital technologies. (NCKltdwebsite) The blend of engineering tools into architecture was at first unheard of until this point. As the aerospace and automotive technology is tested through architectural implications, it begins to grow a larger understanding how it can be truly adapted to the building scale. We must remind ourselves that digital technology is not fully scalable. Cars and air planes are both built in components so this is also the scale at which architecture begins to experiment.



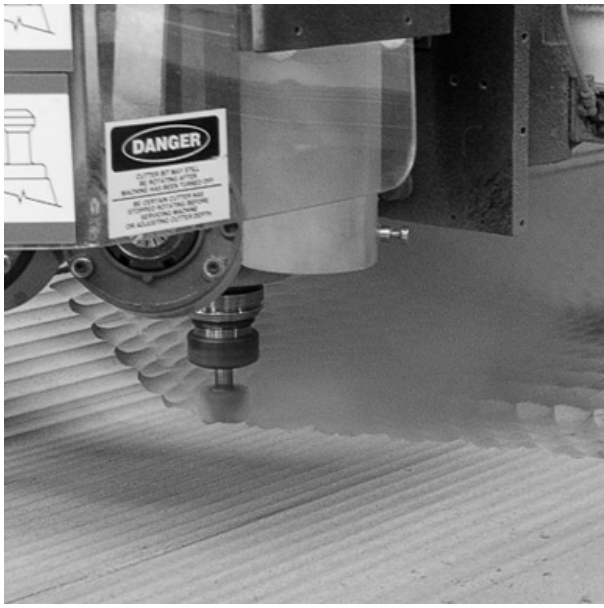


Digital Fabrication Typologies

There are four different digital fabrication typologies in which today's various digi-fab machines fit into. They are, additive, subtractive, two-dimensional and formative. There are many machines that fit into each category and very often, more than one method can be used to accomplish a certain result and finish. An additive digital fabrication machine is typically a printing device of some sort. Most readily available are starch and laser printers which is the appropriate use for prototype pieces. The data is inserted into the computer and it will lay down a bonding agent to bond each layer that is then spread across the bed on top. A laser printer will instead, shoot a laser into a resin, and where it places the beam, the resin will form into a plastic. The result for either process is a component piece or scale model. A standard inherent texture is a slight layering in which one can see where each thin layer was put down upon the next.

The additive process is currently being challenged on a larger scale. Two companies have scaled up machines as to allow a larger component size to be realized. One company named D-Shape, started by Enrico Dini, is working with his sandstone type printing. Similar to the starch printing, the machine lays down a bonding agent and then lays sand. The machine lays down precisely and accurately in the locations on the plotter bed, based on the design, one layer on top of the next. Thus far, Dini has been capable of printing a small ¼ scale pavilion. Dini was inspired by Gaudi's Sagrada Familia in Barcelona and now is capable of producing some parts for this project himself.

There are hopes that these scaled printing machines will be able to print the buildings and structures we live in, on site. The largest issue with scaled up equipment is that they would be extremely difficult to move and then reassemble on every site. Other considerations would be variance in typography and weather conditions for on-site printing.



The subtractive typology consists of removing material from a surface, usually done by a computer numerical controlled machine, or CNC. These machines are capable of various axis of use, starting at a two-axis in the X and Y, up to capabilities of a robot arm in which seven axis is possible. A CNC can mill or cut components themselves into a finished piece or machine a void or cavity into a material to create a formwork. This is good for forming anything from a plastic, glass or even concrete.

Two-dimensional process can be seen as exactly how it sounds, machine process based on a two-dimensional axis only. These two-axis cut components do not have to stay two dimensional, but when combined but have opportunity to establish three dimensional spaces. Water jet and laser cutting machines are the two that are mostly used. The water jet uses high pressure water with an abrasive material such as sand to cut materials such as metal. Laser cutters are capable of cutting plastics, wood and also metals.

Formative machines are typically CNC bending machines such as a metal tube bender or a calendaring machine. They are also presses and brakes, just about any machine that is able to form a material such as metal through a computer controlled process. Another material to consider would be wood in this situation.

The major use of all of these digital fabrication machines is to create components to combine together and make larger components. These can then be applied in a building system or to make the formwork that will be used to make the component or building itself. Using these machines in certain applications and situations can override the initial cost for a digitally fabricated product. A digital fabrication process can produce parts or components of parts faster than if done manually by a laborer. Even though the cost up front is greater for this process, the assembly time for the components is often times easier, having a higher accuracy and a faster overall building process. This is the point where this type of process earns its value in time and is possible to be most affordable in terms of the full project process.

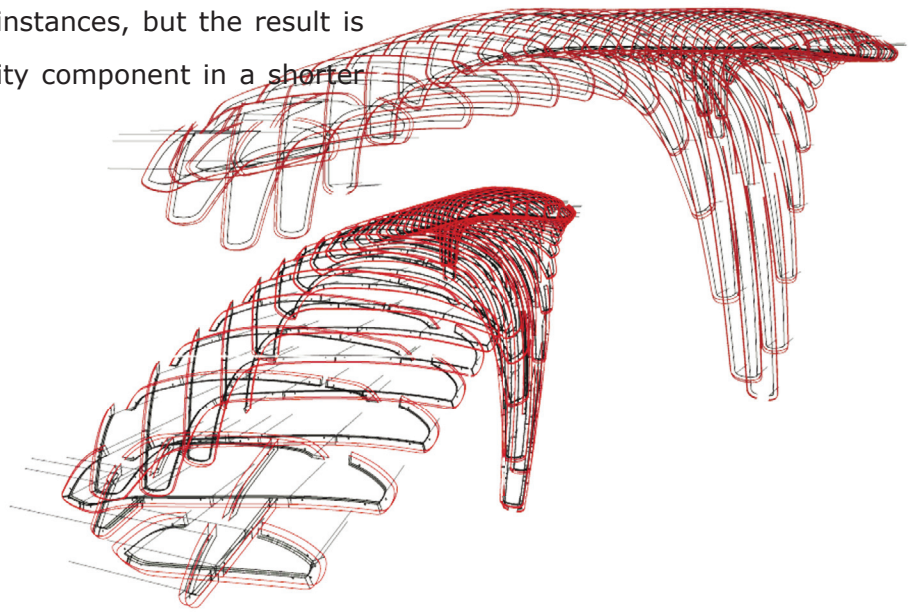
Case Studies

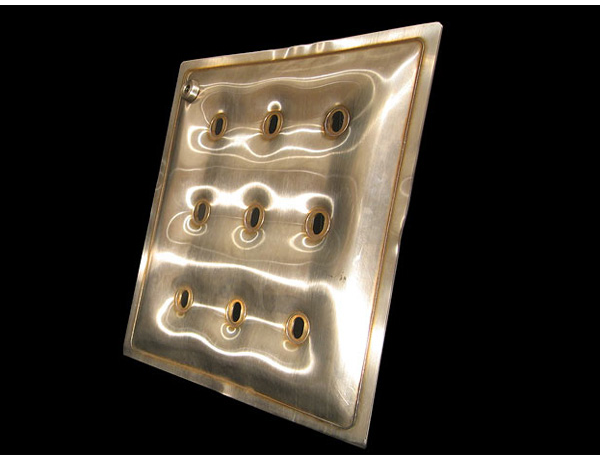
The Stata Center was completed in 2004 and designed by architect Frank O Ghery. Ghery's design process consists of starting with an analog sketch and then moved into sketch models. These sketch models are then transposed into the computer as forms where space is then pushed, pulled and formed into shapes to create the façade and environment the designer wishes to create. These files will be used to derive the information necessary to digitally fabricate the exterior skin. Ghery often uses digital fabrication in his process to assist in reducing costs and increasing accuracy. The largest downfall in this is the lack or over precision of the digital components in relation to the manually fabricated pieces to which they attach to. In the situation of the Stata Center, the manually placed steel frames were made on site with less accuracy or tolerance and the digitally fabricated panels would not fit as planned in some situations, creating gaps. The one aspect lost in the digital process is the human hand and its ability to have high or low tolerance depending on the need of the built piece. This example shows how the relationship between the digital and analog process should be bound closer together and restructured in a way through the digital process in order to increase an accuracy of the built components. Once certain aspects of digital fabrication are implemented in the built process, the accuracy to which a structure is not only built but also designed, changes drastically. There is a standard building and construction tolerance for the standard hand built industry. When large or multiple components of digital fabrication are implemented, if

not properly considered, the results can be a misfit of components and pieces into the larger structure. The accuracy and increased tolerance to which we can digitally fabricate these components is so great that often times it creates these situations. Unless one is well practiced and understands how components are formed and will fit directly from this digital production into an analog form, it must be considered that the methods can be processed in a different way to obtain a better fitting result. In the next case study, it will be explored how using a full digital process can have very desirable end results. As seen here, mixing analog with digital, unless thought through and done properly, will end up with components not having a proper fitment.

The 2006 Hungerburg Funicular, Innsbruck, Austria was designed by Zaha Hadid. In this case study, it was proven to be feasibly possible to use fully or predominately digitally fabricated components in a built structure. The project consisted of four rail stations and a steel cabled suspension bridge. Each of the stations had their own design but the steel structure and glass skin used the same language. "Once a manufacturing method had been established for the glass panels, each uniquely shaped, and an appropriate construction method developed for the load-bearing steel structure, the way in which they were to be joined was considered. The usual method would be to design and make metal adjustable joints, an expensive process that also requires every single joint to be adjusted before the panels are mounted, resulting in extensive measuring and fine tuning during the assembly process," designtoproduction/Fabian

Scheuren assisted in the computation for the profiles and Bollinger & Grohmann, the builder on the project. At this point is where digital fabrication was implemented once again to establish a profile, extracted from each individual steel structural element, to wrap each piece and act as the mounting for the glass panels. "The solution used an inexpensive material which was simple to manufacture, and required no on-site adjustment. Individual profiles, each cut from polyethylene boards to its own specific angle, sit on the steel support ribs, and metal strips are glued to the glass panels and fixed to the profiles with simple screws." Each polyethylene profile was individually marked as they were processed and they were able to have a relatively inexpensive process done in a short amount of time. This relationship between digital design and knowledge of materials and construction details, with the combination of digital fabrication shows a proper use of the collaboration between systems. The work effort is always the same for one project. How it is designed and then by whom it is fabricated makes up the time. The cost may be higher in some instances, but the result is ending up with a higher quality component in a shorter amount of time.

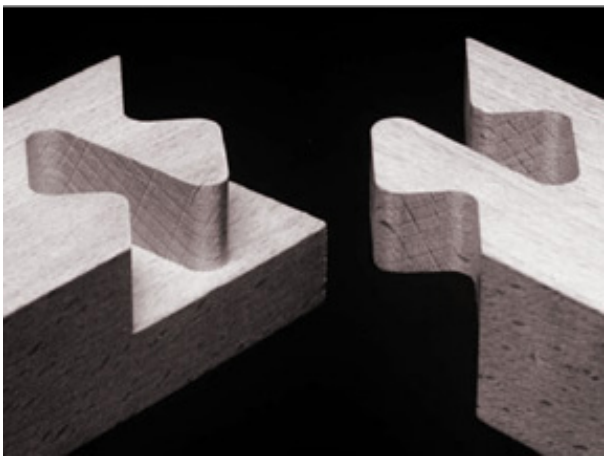




As we deal with construction details, often material is the basis for which we consider them. Barkow Leibinger, an Architecture firm out of Germany, explores various materials through digital processes to establish possibilities of both the machines and the materials. They have various built spaces but also completed many materials studies as to understand how each process and material is able to establish a possible design. This method exploits how far architects can transpose the digital fabrication machines, which were initially created for the aerospace industry, and repurpose them for architectural implications. Barkow Leibinger has shown that using multiple processes are also viable in establishing various design possibilities. Their inflatable metal process shows how material that retains shape after forming, such as thin gauge steel, can be laser cut and welded, then inflated to the limit of the material. If this were a stopping point in the design, the surface can be filled with a fluid and applied as a wall surface and be a thermal mass. If instead the process is to be two steps, the inflated and billowed steel can then be reinserted into a laser cutter to which it can be further subtracted from to establish a desired result. One component example on a small scale is door handles Barkow Leibinger have created. This technique or concept of applying various processes and methods now can be applied in a much larger scale for various desired effects and details of construction.

With these thoughts in mind, how can we now bond digital fabrication to a process of analog making? The use of one process typically supports itself in the act of making but once they are combined there are

issues of tolerance and scale. These issues not only base themselves around ideas of building and construction but also conceptually with social and economic issues. A fine line resides between social and cultural traditions of making and current technologies. While current technologies have implications to empower the user and lend a sense of uniqueness, there is a shift of how items are produced, now by machines, and with it our past and cultural traditions of making are pushed aside. Generally speaking now, when there is demand for product, the best choice is to stream line production and often machines take place of skilled workers. There is a direct relation between demand and production and architecture is no different. As architects continue to explore non-standard forms in our built environment, with it comes the necessity to provide solutions for these designs. Just to reiterate, this current request is one of digital based drawings and highly technical building and digital fabrication solutions. The solution no longer has desires based on skilled trades but more of a universal worker, for example, can provide service and run a CNC machine then if necessary assemble these components into a larger piece of the building puzzle. Although there is still a need for some type of skilled worker, the digital fabrication process has taken over what is seen historically as our skilled tradesman. Thus the change in our technology has greatly impacted our lives. Our desire for originality and "one-off" objectivity as well as an "on-demand" lifestyle really changes how our culture runs. The few skilled tradesmen that are still around today are older and most of the up and coming young people have moved to a computer based lifestyle. This has been progressive over the last fifty years.



The joint produced when two components come together is seen as tolerance. Digital fabrication is appropriate for use with high tolerance applications. Equally, the machine or implemented digital design file has the ability to be accurate to the requested size, which means it can have a high or low tolerance. When components used in an architectural application, there is an opportunity to enhance or experience these joints and details at various scales. Designed or inherent tolerance through the digital process can provide details on a small scale such as reveals or gaps on a surface. Tolerance exploited through the process on a larger scale has implications to create inhabitable space. William Massie's American House '08 begins to talk about this concept. The roof of the '08 house curves down to the base of the floor of the exterior and on the interior it allows an experiential space. This taken to the next level such as this form transposed on to other various surfaces would enhance the space. Massie seems to be exploring non-traditional details and allow them to interact with space in ways we would not normally see them. The valley of the roof that curves down also allows water to drain off the front. Inside the space, it visually breaks up the plane of glass that wraps most of the exterior with an organic drop from the ceiling. This design detail allows us a new experience and interaction from interior to exterior space as well as functionally furnish the interior another wall that can be used for projecting visual images.

The initial use for digital fabrication in architecture was purely structural, as shown in I.M. Pei's Louvre. The glass skin and extruded channel frames in this application was standard sized while the structure was full custom and digitally fabricated for this application. Through the late 90's and early 2000's digital fabrication was used to produce building skins which were applied to standard frame structures. Currently, the application for using digital fabrication in architecture is in holistic structure in skin. The progression to this method is most appropriate because it lends itself to enhance structural applications into a skin surface. A relevant example of this is seen most dramatically in Gothic architecture. Large vaulted exposed ceilings in these applications display each structural force within a structural rib. These spaces provide precedence on how skilled tradesmen of their time exploited structure into design details and how it now can be utilized for the process of digital fabrication.

Understanding materials is the groundwork for this thesis. Understanding a materials limits and strengths allows a greater opportunity for design. Knowing it's tolerance to which the material can be designed to if it is to yield or not, can set a baseline for scale and application. Restructuring the way we consider building has possibilities to explore and exploit the limitations of resources in hopes to continue to push technology further as well as explore new methods of the designed environment.

There is a constant struggle that occurs in our culture that base themselves around a sense of uniqueness. This is everything that occurs in our daily lives from the shoes we wear, the car we drive to the house we live in. Mass customization and uniqueness that is inherent in that process is the root of which our society thrives upon. Our industries have responded as the techniques of mass customization are largely capable of this production style. Machines pump out various slightly changed versions of products where variation is usually not stylized differently but merely color, material, or print change. That brand 'X' shoe, is still the same style as every other custom made shoe. This has greatly affected the way we live our lives as it seems there is a struggle in trying to be individualistically unique and in turn is merely fitting in and being common. When everything around us is unique, does that become the background and the common is now what is seen as the uncommon?

That is an example of two types of people, each not fitting perfectly into any category. Do our machines control our culture or is it because we are very much interested in these processes that we must use them to their fullest extent or until they bore us when the next cool thing comes around? It is true. Digital fabrication is somewhat of a "grown-ups" toy, and unless taken seriously, we will not advance the technology and instead end up with a lot of objects that are merely for fun.

Concrete

Concrete is still a fairly new material, or at least more recently being explored through various admixtures. Through these admixtures, craftsman and builders alike are able to achieve at times lighter or thinner built sections, which decrease the overall dead load that the component has to carry. With this ability to change the weight and strength of concrete, also comes it the social views in how to use concrete in ways it normally wouldn't be able to. Typically, concrete is seen as big, cold and heavy. It still can be used in this way but it opens a new discussion of material capabilities in which I am exploring on a conceptual level. Detailed, warm, thin are all possible through various methods and techniques. Many of these special concretes and admixtures are of very high expense so much of my experiments use a more affordable wet cast admixture that is used in the making of concrete counter tops.

Derek runs a business making concrete counter tops. With this business come exacts and requirements to consistently produce high quality finished products each time, every time. Concrete is a natural material and at times can act various ways but still can pass the quality necessary to produce a product for his market. Derek is also interested in the arts, but at times can be limited by his role as a quality production piece versus a sculptural and conceptual experiment that I am conducting. I am the designer considering everything capable while he is the real world constructor, guiding me on what is feasible, and breakthroughs happen when materials are challenged. This dichotomy is a healthy one, which is also typical for any designer or architect has with their contractor or construction crew. The real world always expects the standards, while the designer has a push towards new material form while also challenge the typical production and construction methods.

Magic

A standard method of the digital process is to build a digital component model, then send it to the CNC, laser cutter or your choice of digital fabrication machine. This can be seen as magic. Now the machine itself is not magic nor is it any hocus-pocus, but the process is unseen. This quote from Arthur C. Clarke, his third law begins to talk about technology in that way.

"Any sufficiently advanced technology is indistinguishable from magic."
Arthur C. Clarke, *"Profiles of The Future", 1961 (Clarke's third law)*
English physicist & science fiction author (1917 -)

It is not possible to experience or visually see this technology as it is invisible. The signature of the machine is the layering, hyper-tolerance and various issues that identify when a component is digitally fabricated. When exploring this concept of being indistinguishable from magic in a design outcome, if digital fabrication can be integrated appropriately into the process then the result is a component that resembles craft, poetry and beauty without the signature of the machine. That's magic. Again, this can begin to reassert the craft and craftsman of architecture which have social implications.

Michael Harrington : "If there is technological advance without social advance, there is, almost automatically, an increase in human misery, in impoverishment."

Once the process and product can allow the worker to produce these items of beauty/ craft/poetry, it has implications to reinstates the "craftsman" title to workers that either design and build, machine or produce these architectural components. At the end it is the craftsman who has produced that component and the digital fabrication is merely a vessel for the reinstatement of the craftsman. If done properly this translates to cultural ability universally as it re-introduces and empowers the craftsman as a valued worker and infuses the technology in culture itself; through architecture & spatial applications.

Without this investigation of detail, crafting and materials, there would be no reason to invest into the digital side of technology. One wheel turning on a car will only make you go in circles. Materials & the "magic"/digital process must be explored hand in hand to effectively promote the technology as a whole. The architectural implications of investing in material research not only is an appropriate way to increase a base of knowledge and understanding about a system or material, but sets a standard of building details and methods to advance architecture into necessary technical realms of both design and production.

This thesis also directly challenges it's components as a tool of research by producing them and making them available commercially. Visually we can have an architectural discussion based on these components and how something that looks and feels of a high quality is theoretically more attractive. Clients want spaces such as what I just described and seeing these components here today show that they can be implemented into architecture. Challenging these components in the real world as representations of industrial design elements available commercially can translate to how they would possibly be accepted in architectural applications.

Enrico Dini, D-Shape

Stone Printing
Scaled Digital Printing Machine

"Enrico Dini dreamt of buildings, construction and impossible shapes. He was particularly inspired by Gaudi's architecture and loved his fantastic(in every sense) work. He became a Civil engineer and later branched out into making machines. All the while dreaming of those impossible shapes.

Traditional building methods tend to reel in dreamers outlandish dreams though. Building with concrete and brick require scaffolding and a lot of manpower. This creates constraints. These constraints limit the way in which buildings can be constructed and limit the shapes and forms that architects can use. Rather than accept these constraints as a given Enrico set out to completely remove them. In 2004 he invented and patented a full scale 3D printing method that used epoxy to bind sand. Enrico could now 3D print buildings." - Shapeways Blog 04.22.09

Critique:

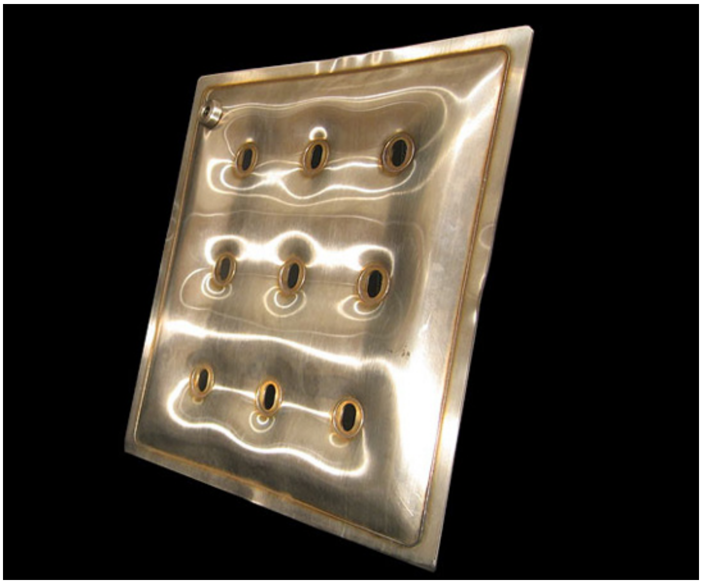
Dini shows how the additive process can be applied to human scale projects. The system uses sand and inorganic binding ink, fabricating stone in a day. The CNC has been scaled up to suit the current projects needs. Larger scale projects would still need to be completed in pieces but is a basis for creating custom stone pieces versus pouring concrete in a mold or milling marble.

"d-shape process is four times faster than conventional building, costs a third to a half as much as using Portland cement, creates little waste and is better for the environment. But its chief selling point may simply be that it makes creating Gaudiesque, curvy structures simple" - Dini

Barkow - Leibinger Architects

Inflated Panels

Neither a factory nor an office building this freestanding pavilion introduces a new typology to the factory campus. Urbanistically, the new restaurant helps to complete the entrance courtyard spatially. Formally, its crystalline pentagon plan is a continuation of the crystalline ground plans of the new (existing) office building it is adjacent to. This structure is low lying and integrated closely with the campus landscape Neither a factory nor an office building this freestanding pavilion introduces a new typology to the factory campus. Urbanistically, the new restaurant helps to complete the entrance courtyard spatially. Formally, its crystalline pentagon plan is a continuation of the crystalline ground plans of the new (existing) office building it is adjacent to. This structure is low lying and integrated closely with the campus landscape Neither a factory nor an office building this freestanding pavilion introduces a new typology to the factory campus. Urbanistically, the new restaurant helps to complete the entrance courtyard spatially. Formally, its crystalline pentagon plan is a continuation of the crystalline ground plans of the new (existing) office building it is adjacent to. This structure is low lying and integrated closely with the campus landscape



Mark West

Fabric Formwork for Structural Concrete Panels and Beams

Enrico Dini dreamt of buildings, construction and impossible shapes. He was particularly inspired by Gaudi's architecture and loved his fantastic(in every sense) work. He became a Civil engineer and later branched out into making machines. All the while dreaming of those impossible shapes.

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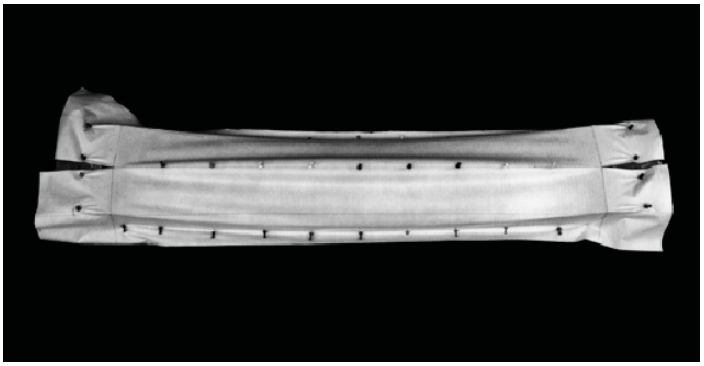
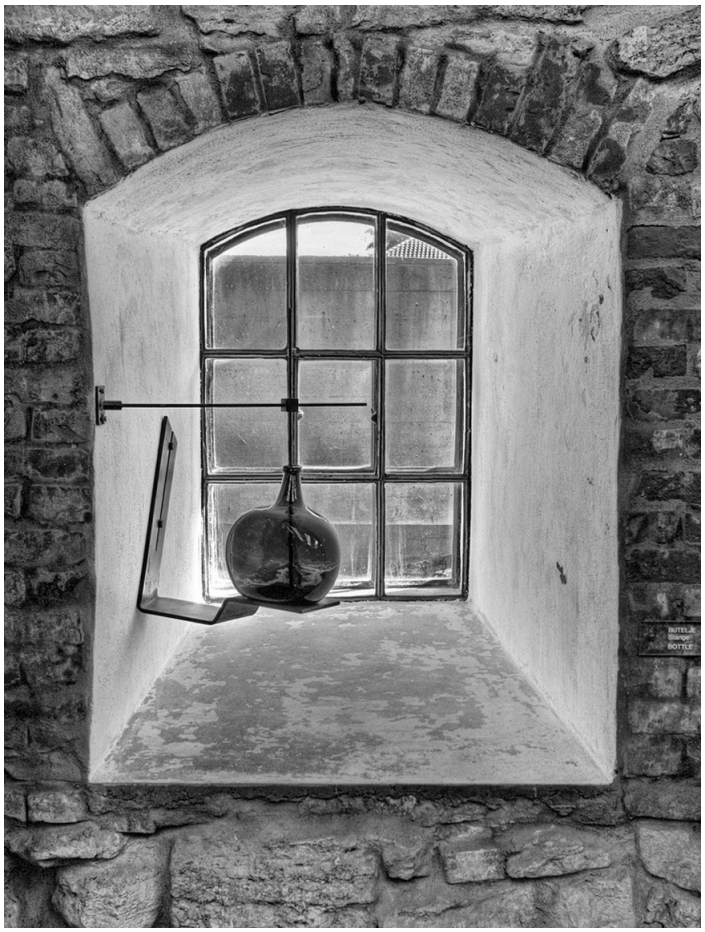
As Shapeways community members who have experimented with resin molds know, epoxy resin can stick to virtually anything. This lead to high maintenance costs for the machines as well as inefficiencies when they were used. Enrico went back to the drawing board to invent anew. In 2007 he got a



Sverre Fehn

Archbishopric Museum of Hamar
Display

Fehn establishes a system of displaying objects discovered in the archeological dig. This system of display delicately exhibits these objects in a manner that allow the viewer to study the object in full.



Madlener House

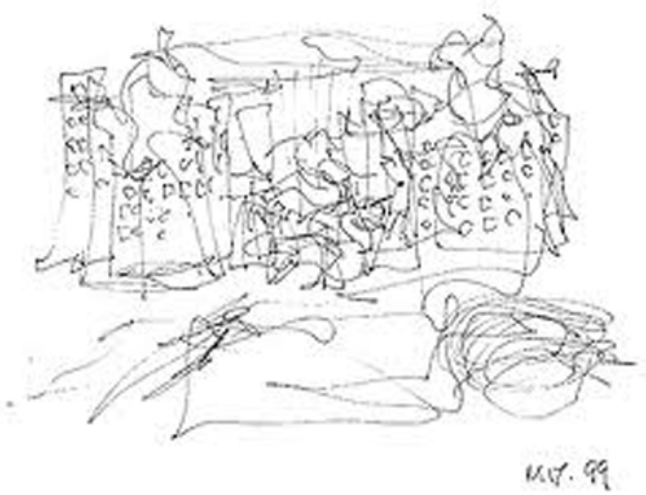
Graham Foundation - 1973
Architect - Richard E. Schmidt & Hugh M.G. Garden
Designed Radiator

The radiator in the Madlener house starts to break the standard design rules of a steam heat system. The lower than typical height and matching window length provide design cues and exposes how craft was removed from this type of system. This example explains how to reinsert craft into a typically under designed component This precedent is used in the Radiator investigation.

Ray and Maria Stata Center - Building 32

Massachusetts Institute of Technology, Cambridge, Massachusetts - 2004
Architect - Frank Gehry
720,000 sq.ft.

The Stata Center project combines an analog process in parallel with digital modeling. The digital models are used to figure value engineering to keep track of project costs in the design phase. Digital reference points on the complex structure were used for part of the construction phase which allowed proper alignment for the digitally fabricated panels based on the 3D drawings. The Stata Center shows the method of which digital fabrication can be used, along with other digital and analog methods, to construct a successful project. The use of digital fabrication enabled panels and skins to be created off site then applied to the concrete and steel structure which had cost and time benefits.

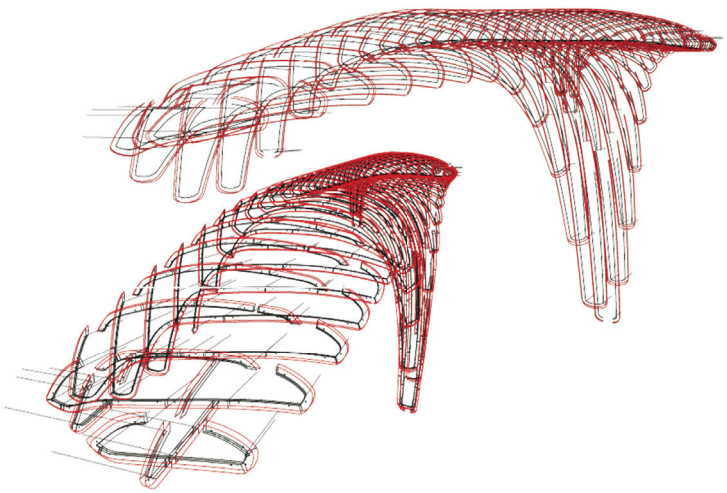


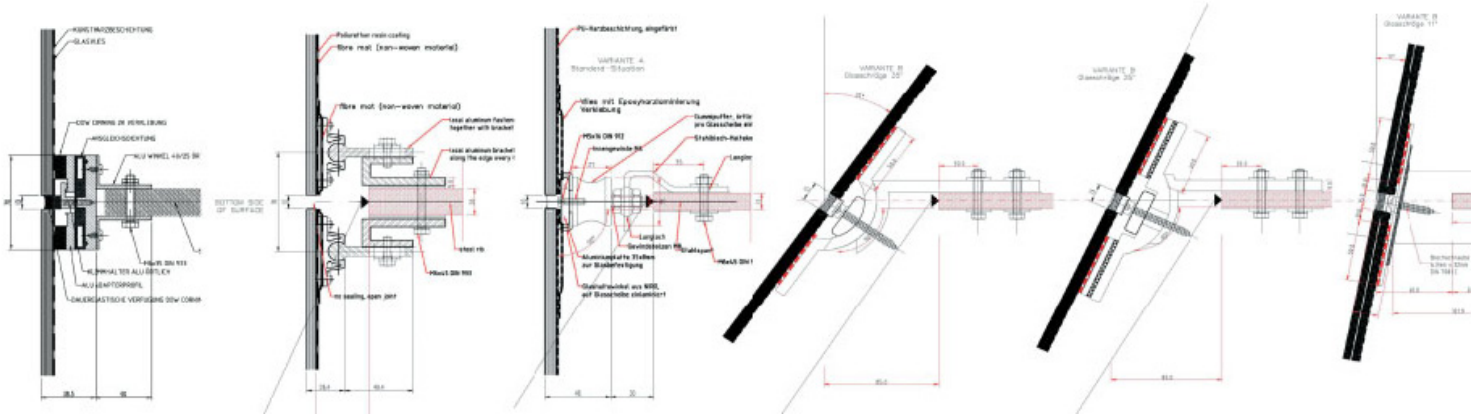
Alpenzoo Station

Innsbruck, Austria - 2007
Architect - Zaha Hadid
1.8 km long Nordpark Cable Railway

"Once a manufacturing method had been established for the glass panels, each uniquely shaped, and an appropriate construction method developed for the load-bearing steel structure, the way in which they were to be joined was considered. The usual method would be to design and make metal adjustable joints, an expensive process that also requires every single joint to be adjusted before the panels are mounted, resulting in extensive measuring and fine tuning during the assembly process." - JW&S

"The solution used an inexpensive material which was simple to manufacture, and required no onsite adjustment. Individual profiles, each cut from polyethylene boards to its own specific angle, sit on the steel support ribs, and metal strips are glued to the glass panels and fixed to the profiles with simple screws." -2008 John Wiley & Sons Ltd

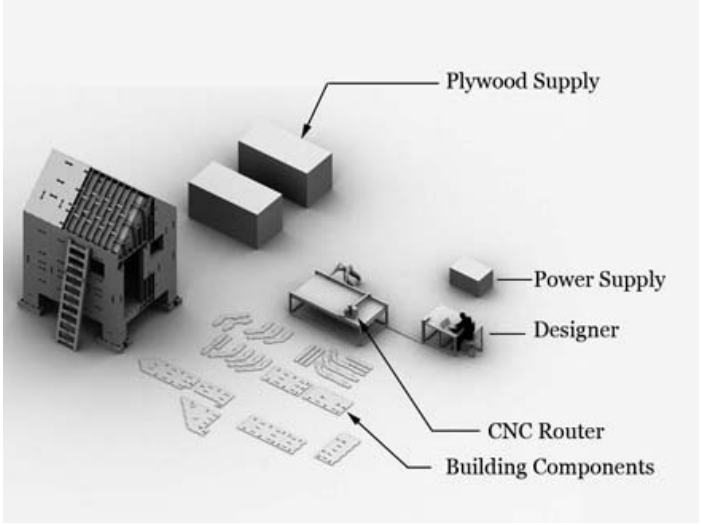




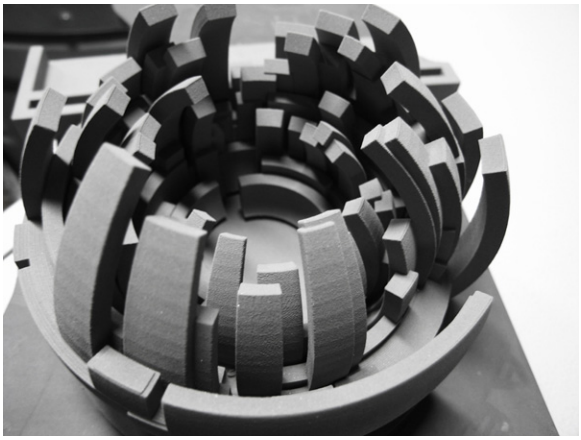
Instant Cabin

MIT Digital Design Fabrication Group 2008
Directed by Larry Sass

The Instant Cabin utilizes the standard building material pallet and reconsiders the creation of a housing structure. With four by eight foot sheets of plywood, the two dimensional CNC router cuts out components like a puzzle, that when snapped together, become structural wall partitions. Only held together by friction, the Instant Cabin utilizes flat sheet stock and reconsiders the standard 2”x4” wall stud section for housing development. In this digital production exploration, a new method of joinery had to be explored to establish a three dimensional final form from it’s original two dimensional supply and cnc cutting source.



Digital Fabrication Typologies



DIGITAL FABRICATION HISTORY

The Louvre

Guggenheim Bilbao

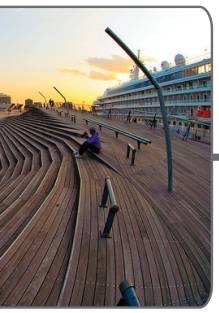
1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999

Yokohama Port Termi

Korean Presbyterian Church

Stone Printing D-shape

1999 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010

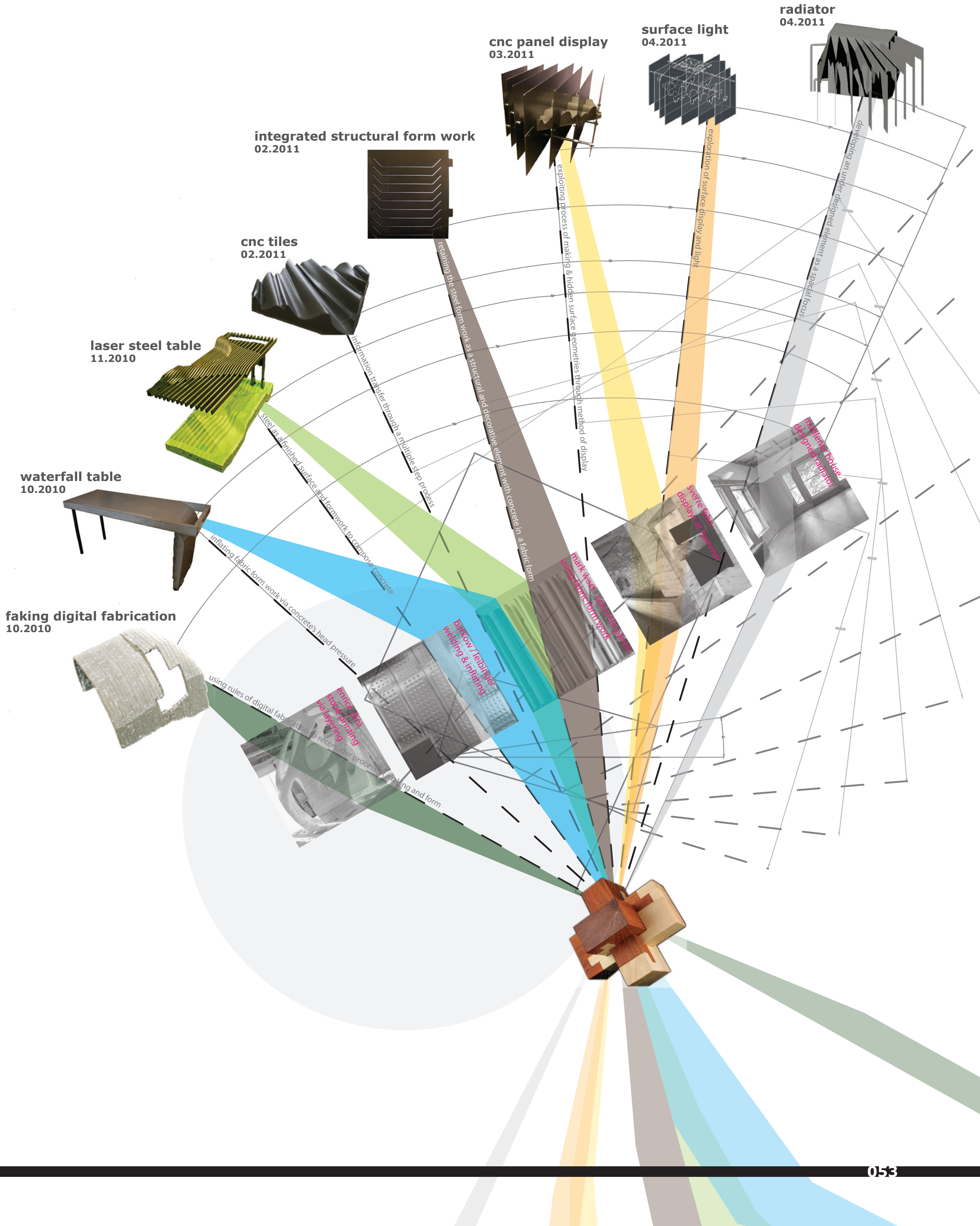


nal

Alpenzoo Station

Crafting the Thesis Exploration

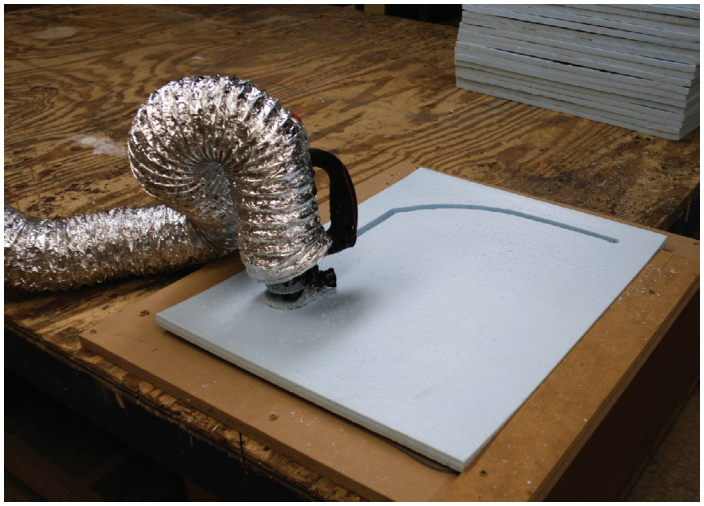
The only way to properly explore in this type of thesis is to fully divulge into the concepts, ideas, tools and devices that investigate *architectural techne'* in our built environment. This investigation attempts to interact with and work through various concepts of *architectural techne'* with the production of components in the full size furniture scale. Ten pieces were designed and crafted throughout the two semester thesis project. While being a non-linear investigation, each exploration deals with at least one concept but often builds on various concepts, precedents and uses past investigations to influence the design and production of that particular component. The intent is to gain a larger understanding of *architectural techne'* and how it can reveal a new process in the way we design and build in the arcitectural realm.

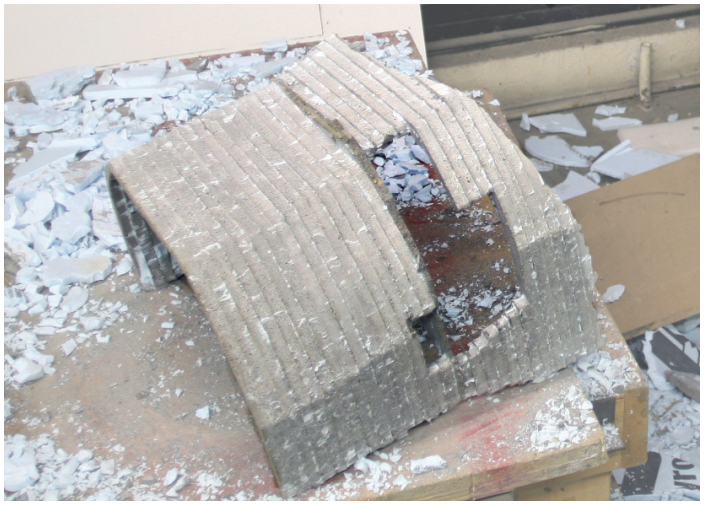

radiator
04.2011
surface light
04.2011
cnc panel display
03.2011
integrated structural form work
02.2011
cnc tiles
02.2011
laser steel table
11.2010
waterfall table
10.2010
faking digital fabrication
10.2010
developing an under designed element as a spacial focus
exploration of surface display and light
exploiting process of making & hidden surface geometries through method of display
retaining the steel form work as a structural and decorative element with concrete in a fabric form
information transfer through a multiple step process
steel as a finished surface and formwork to compose concrete
inflating fabric form work via concrete's head pressure
using rules of digital fabrication to reconsider process of making and form
madlener house
designed radiator
sverre fehn
displays at hammar
mark west - concrete panels
using fabric form work
barkow / leibinger
welding & inflating
enrico dini
stone printing
via layering

FAKING DIGITAL FABRICATION

reconsideration of digital methods through an analog process

How can one rethink a process of making based on rules of a different method? This is what was asked when attempting to introduce a more informed process in faking digital fabrication. The inherent digital process rules of layering were used and reprocessed through analog methods to "fake" digital fabrication. The finished component visually shows a better understanding in the process of making while exploiting elements inherent in digital making of layering and tolerance. Due to differences in the router bit size and the pattern width, there was allowable but unplanned tolerance in the design that exploited itself in the final product. Unless the "errors" were designed into the form, they would not show up in a fully digital fabricated component. Working through digital methodology in an analog process can exploit digital in a way to push the design process. In this particular case, part of the design is based on an increased tolerance in the initial form.

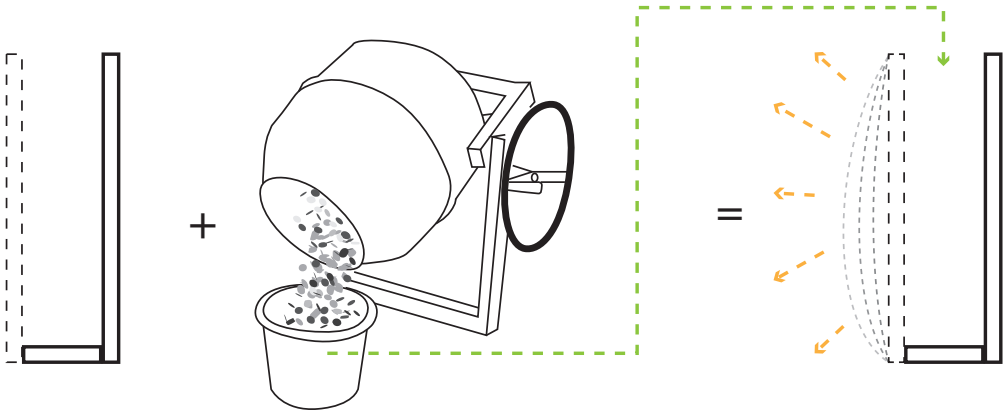


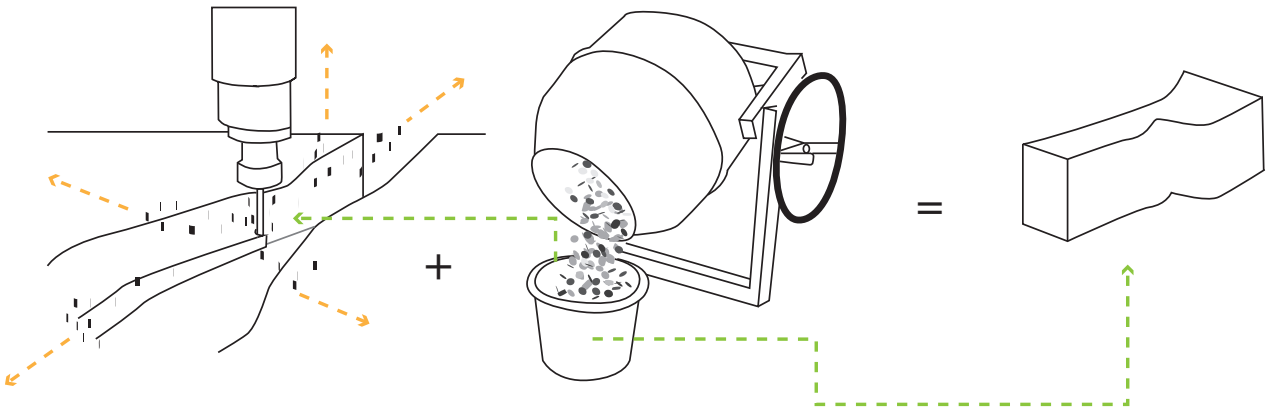


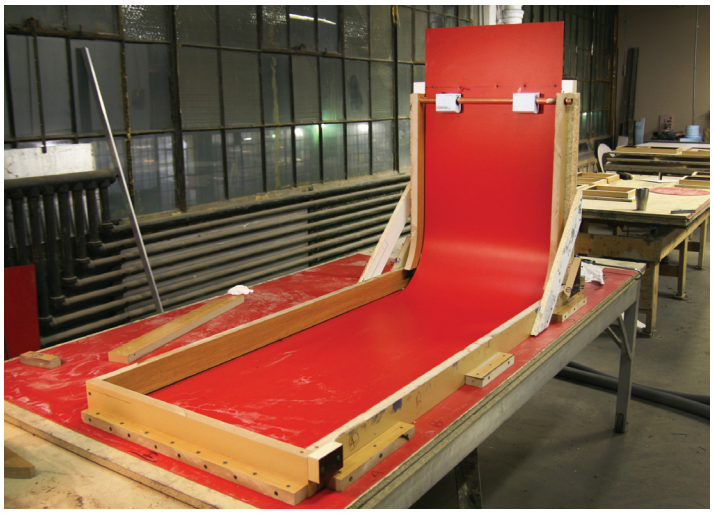
WATERFALL TABLE

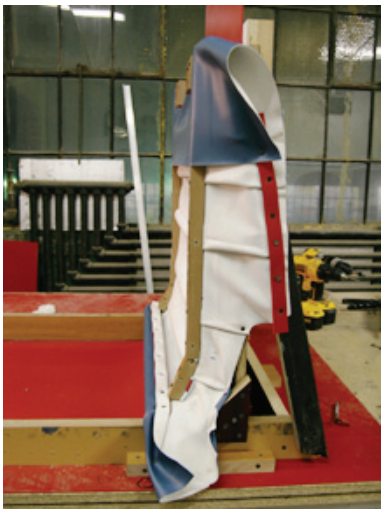
material exploration of concrete
reation in fabric form work

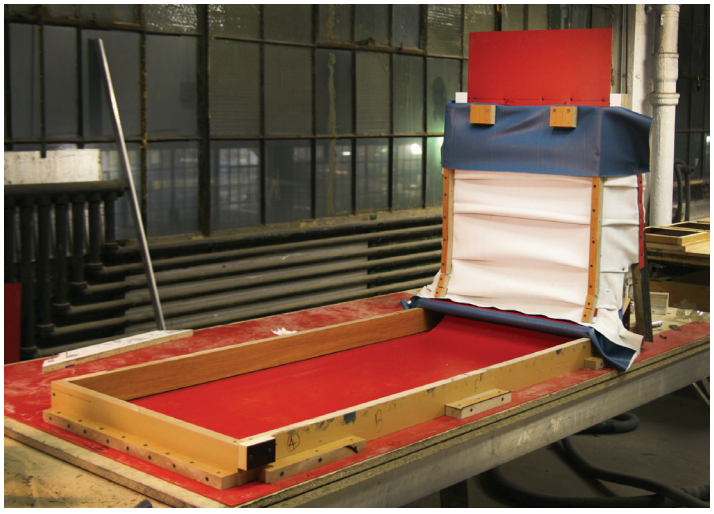
Concrete is a fluid but aggressive material. It has very good imprint and flow properties to test in a fabric mold. Often times in digital algorithmic design, there is an expansive number of designs that attempt but fall short of being "organic". The fabric form allows the design to be established and once filled, flow and expand to its natural state based on concretes head pressure and the material stretch characteristics.

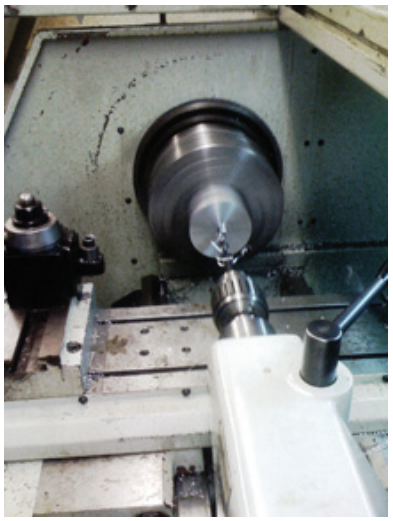
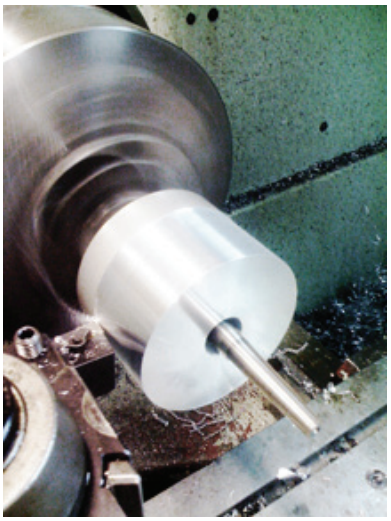
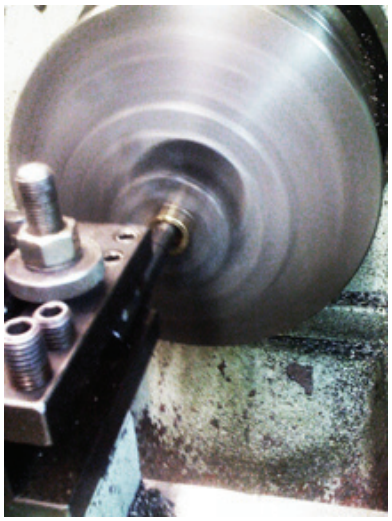
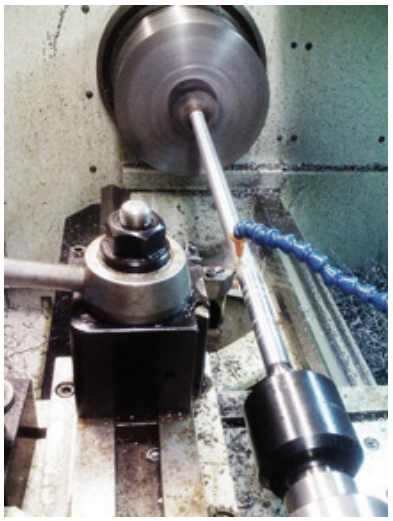










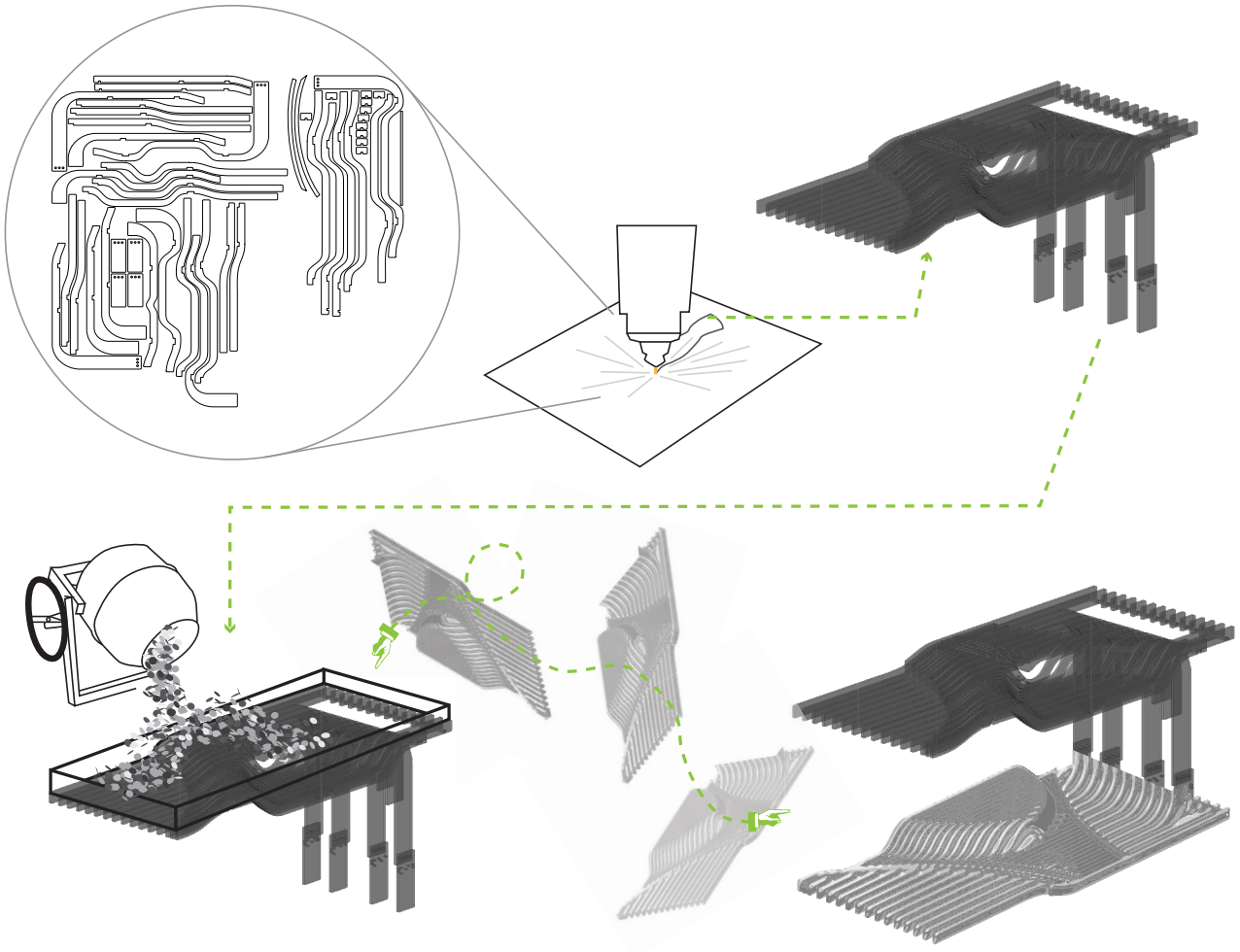
One strategy to overcome the weight and ability for one person to roll the table is the implimentation of the wheels. The 400 pound table rides on three inch by three inch solid aluminum rollers. Each wheel uses oil impregnated brass bushings to keep smooth rolling action that is all held together and rides on a solid through axle. Each part in this process was machined on a CNC lathe.

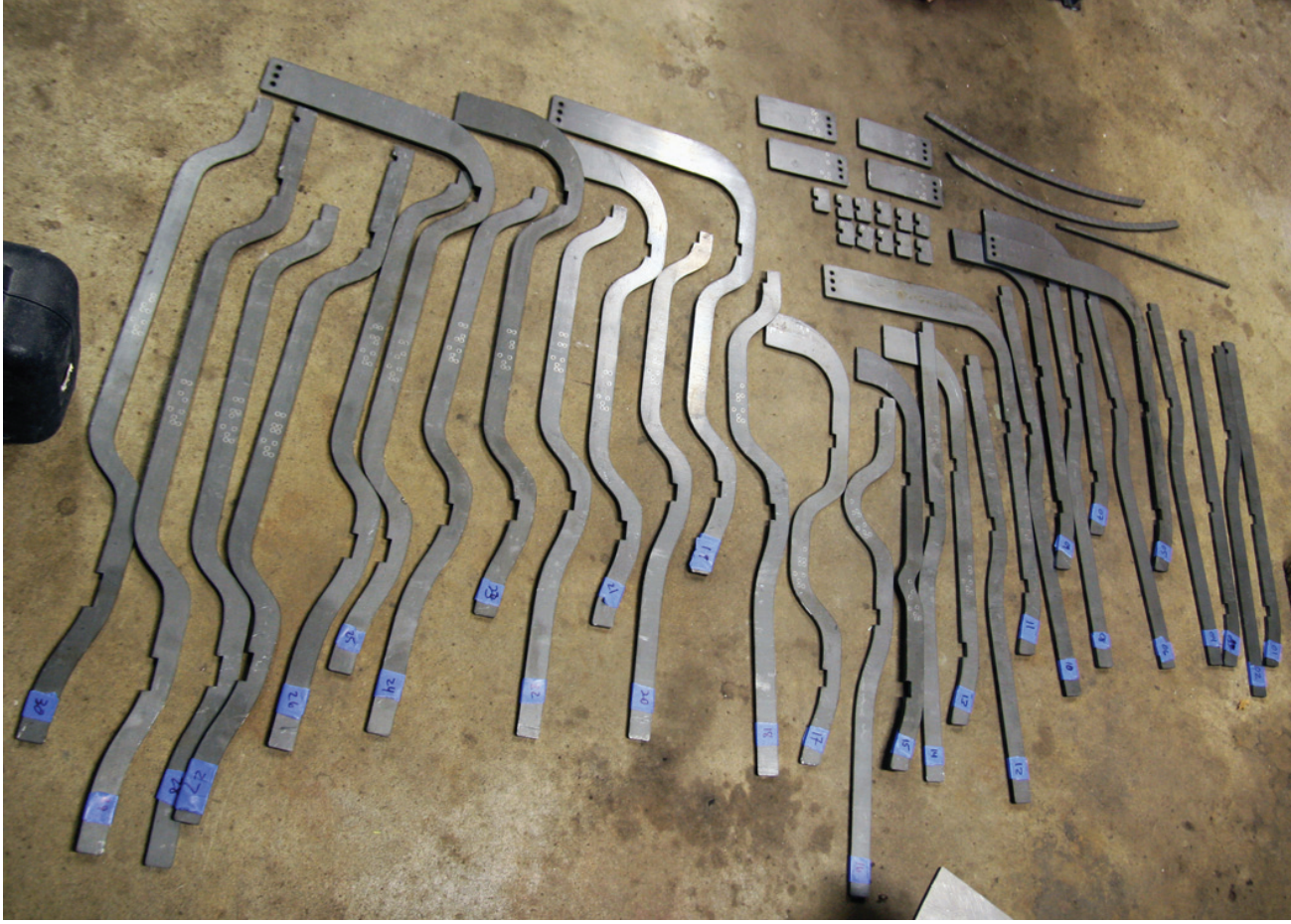
STEEL LAYER TABLE

technology transfer process

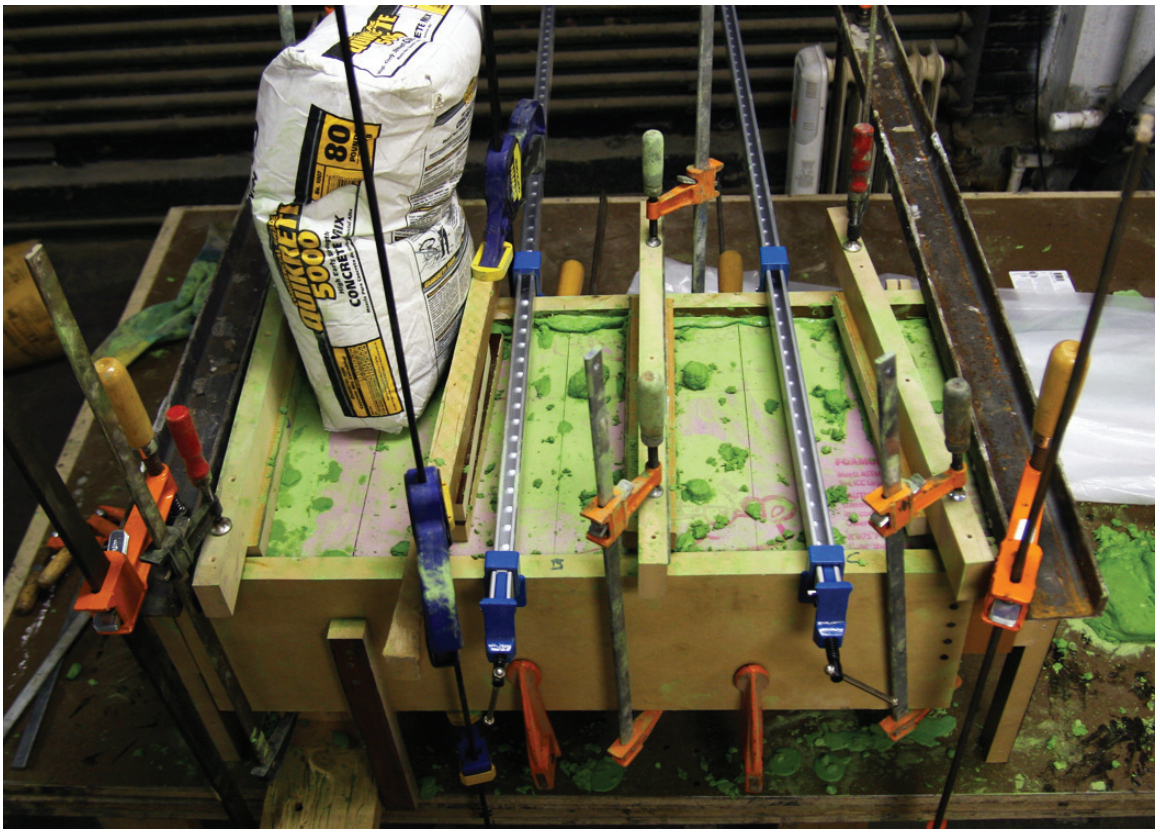
Once fabricated, the steel table was covered in textured vinyl. As proven with the waterfall table, the concrete will transfer the form it is poured into. This investigation searches for the direct technology transfer between each material and how tolerance of surface is affected. A plug was hand formed based on the initial table design and will act as a cap and form the concrete into a similar designed profile as the steel top. The results speak towards a scalable architectural process.

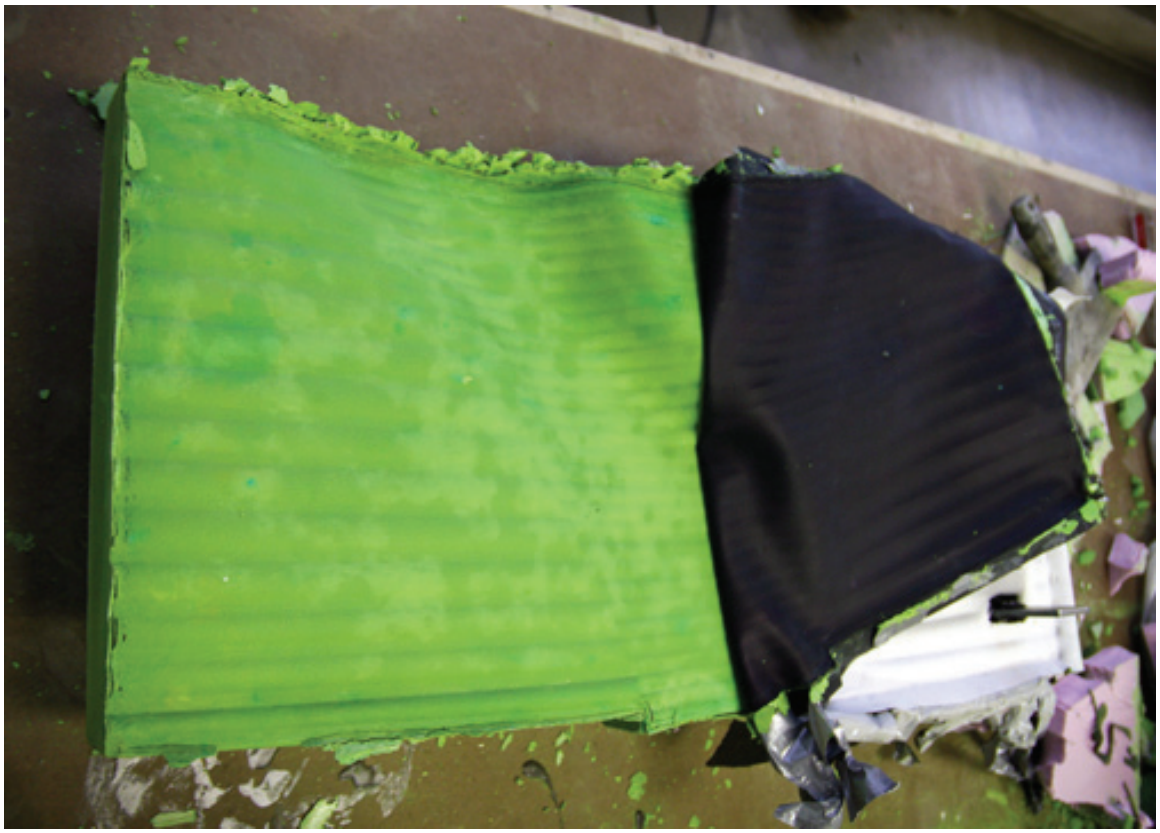
...we have to break down the conventions of the profession,
and rebuild it, piece by laser-cut piece.
-SHoP partner Gregg Pasquarelli

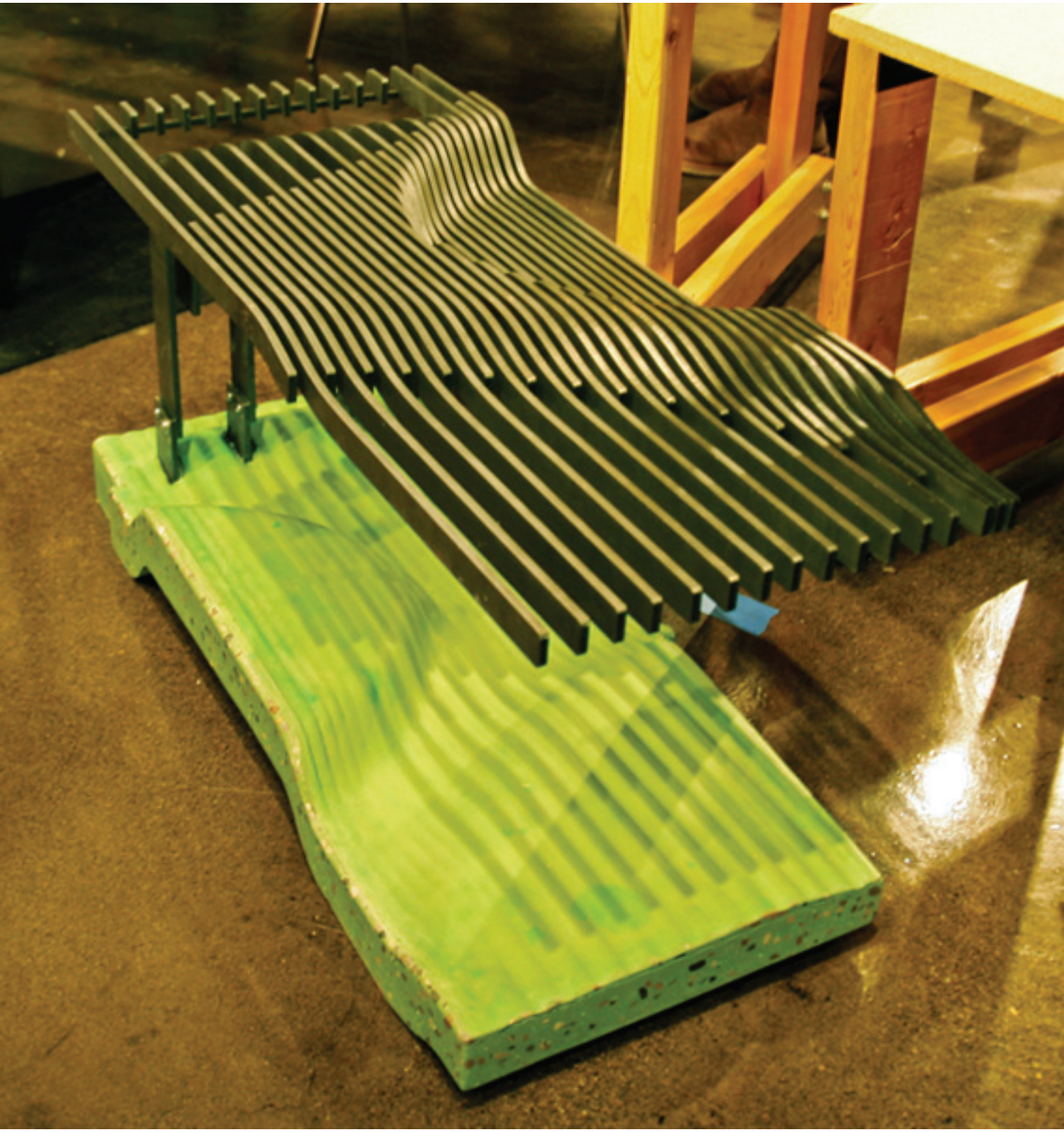





IRWIN
IRWIN

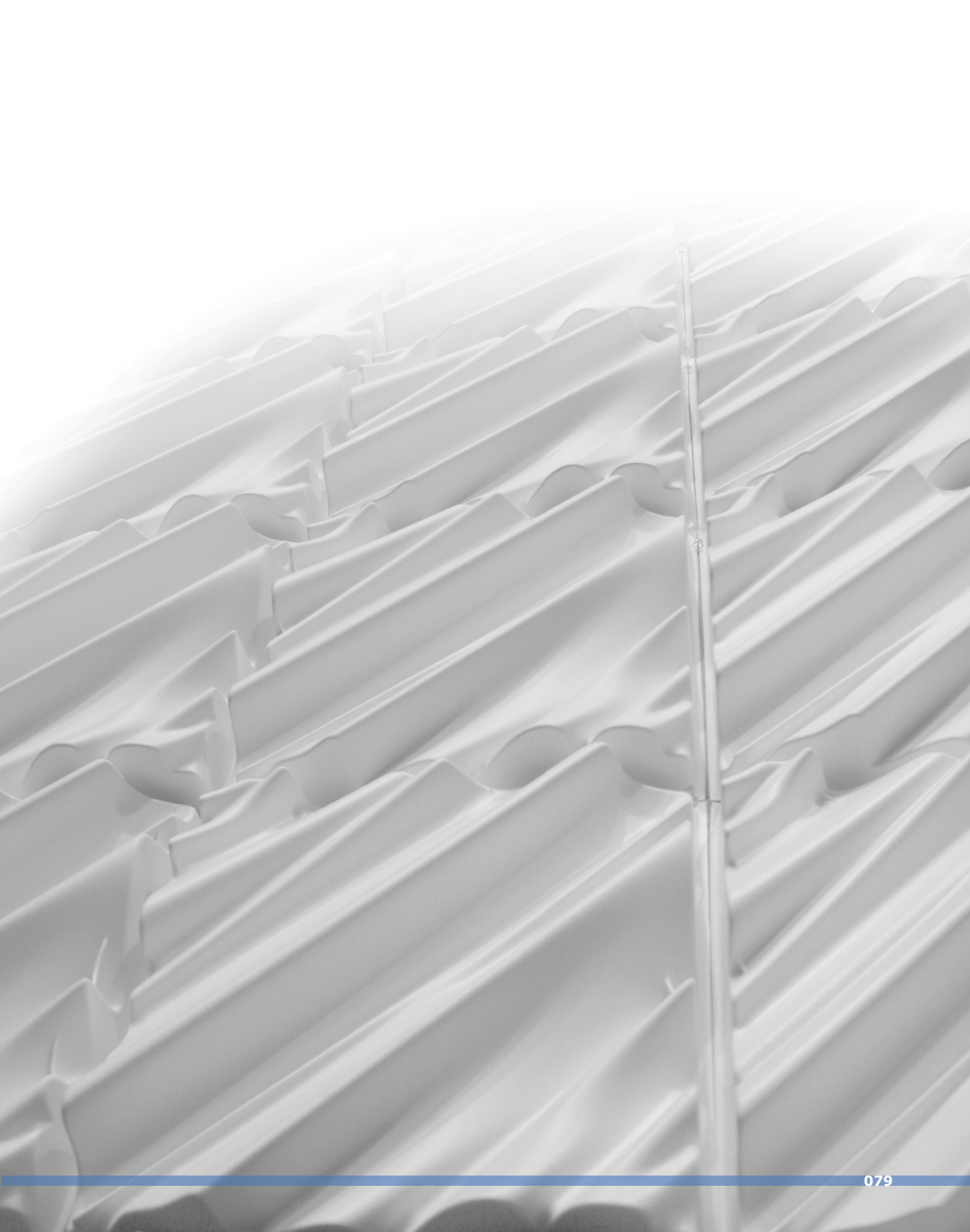

80
QUIKRETE
5000
CONCRETE MIX

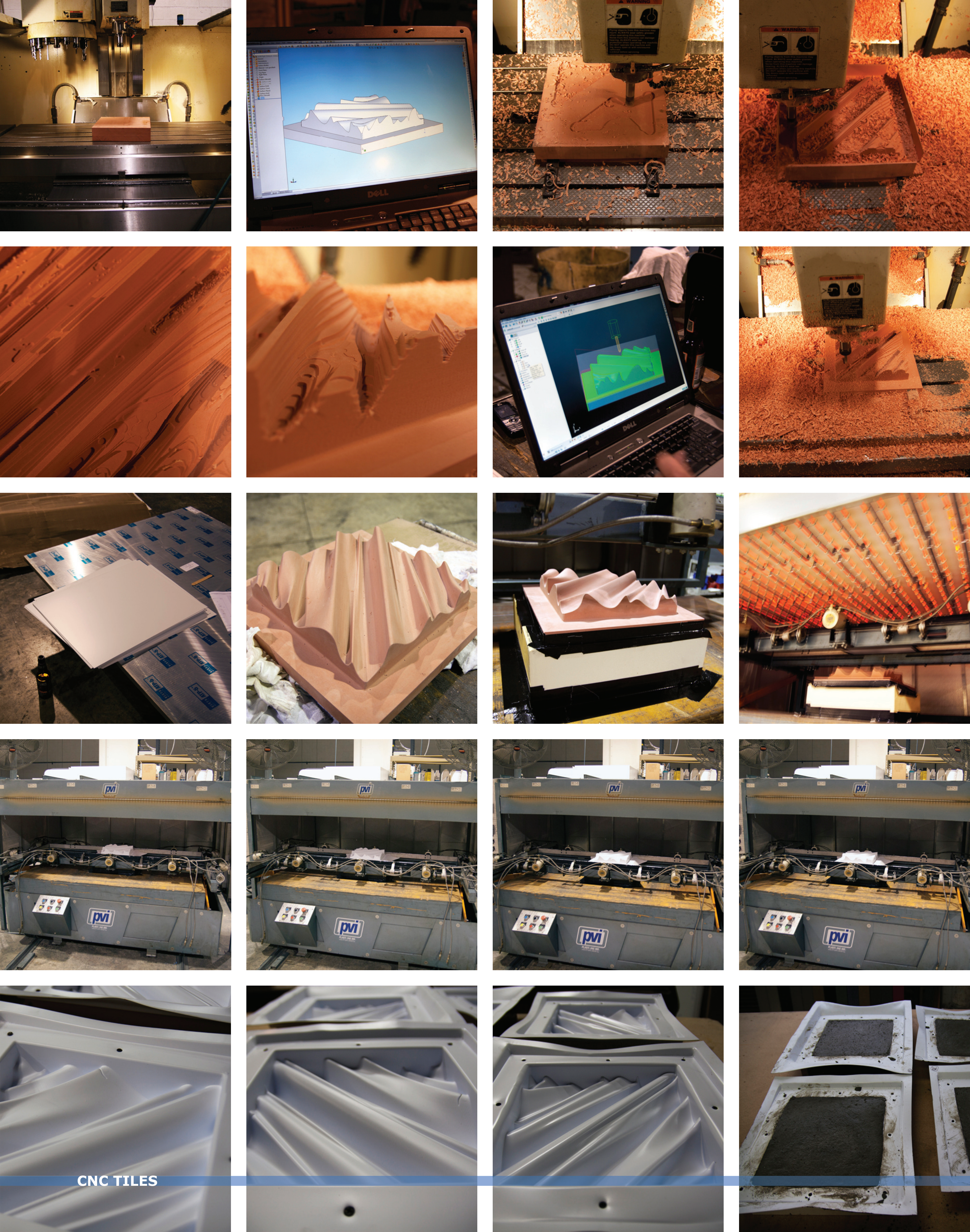




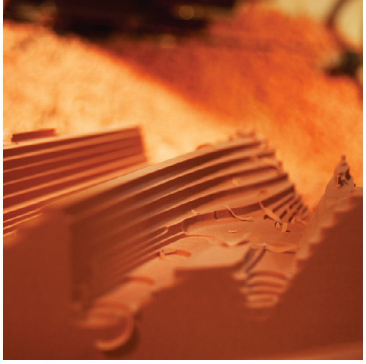
CNC TILES
digital texture

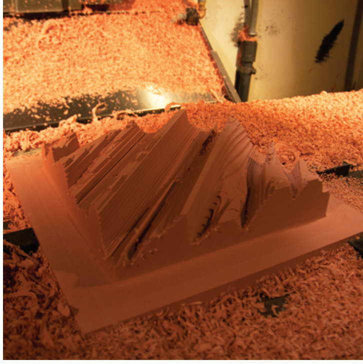
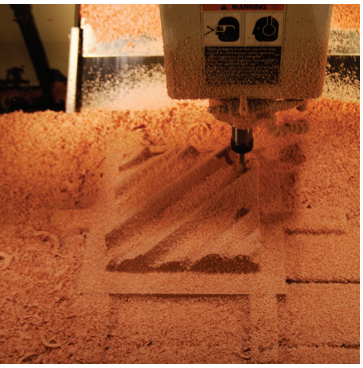
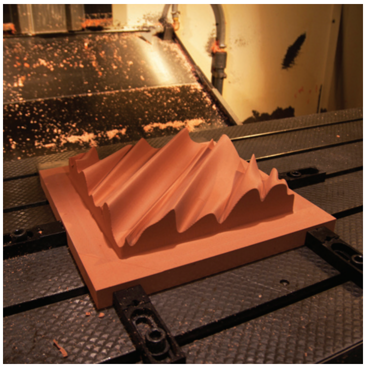
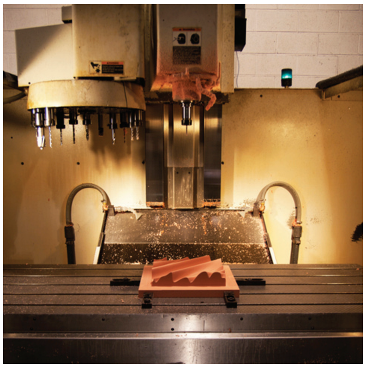
The initial challenge of the cnc tiles was to fully digitally design and fabricate a spacial component or wall cladding system. The "digital texture" can influence the way we experience and create a spacial language for a wall covering in a space. The investigation challenges the tolerance of the CNC machining process through the production of the plastic tiles and into the final concrete cast tiles. The precision to which the final component resulted as was very successful, when comparing it to the original digital modeled tile.



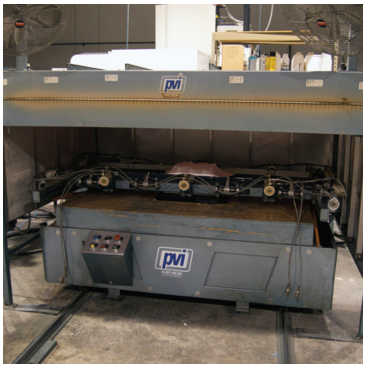


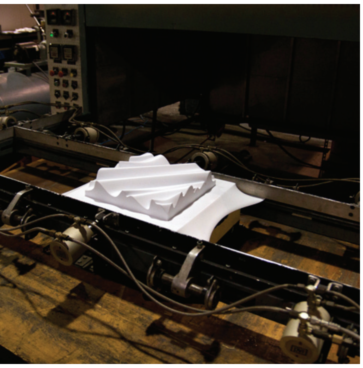
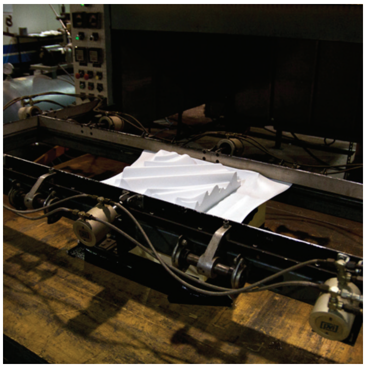
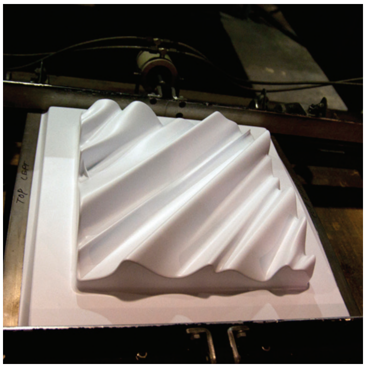
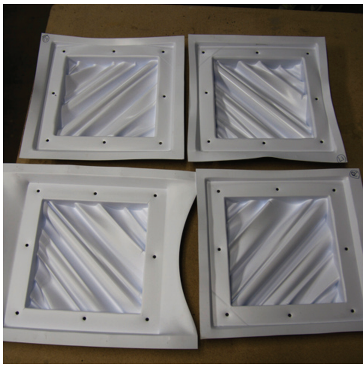
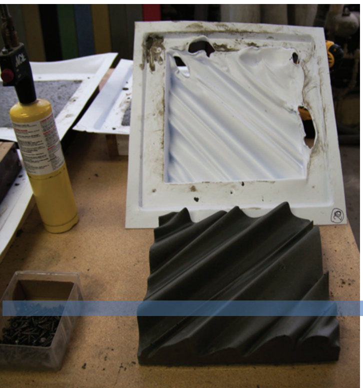
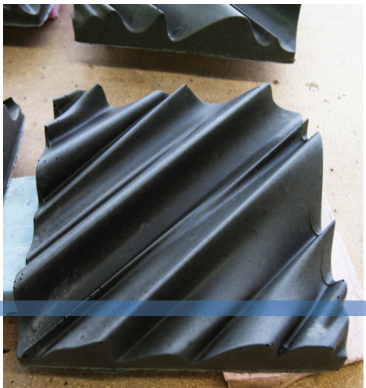
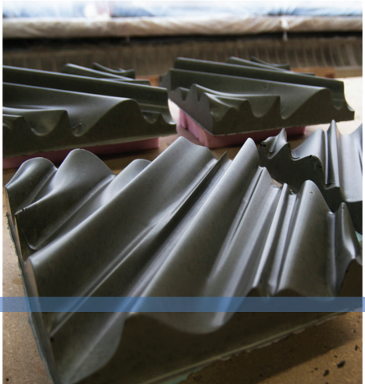
CNC TILES

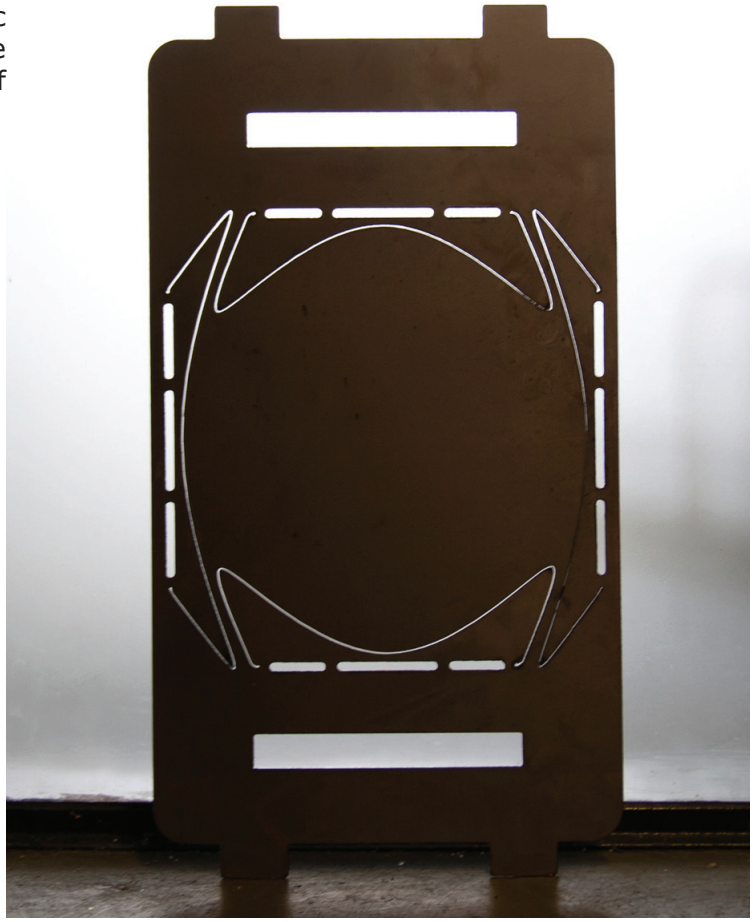


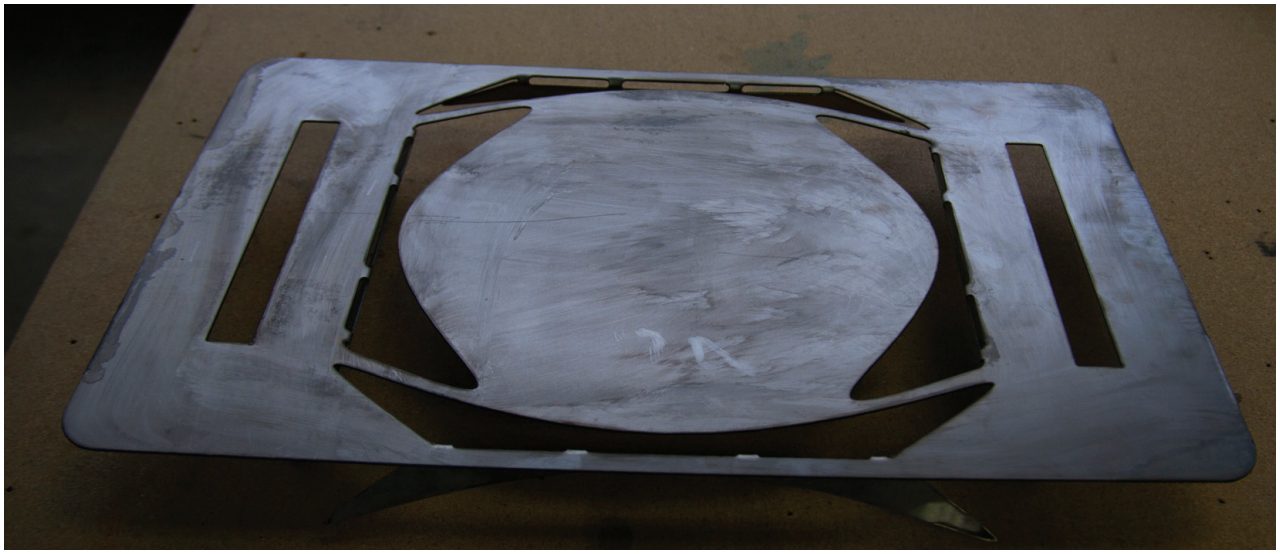


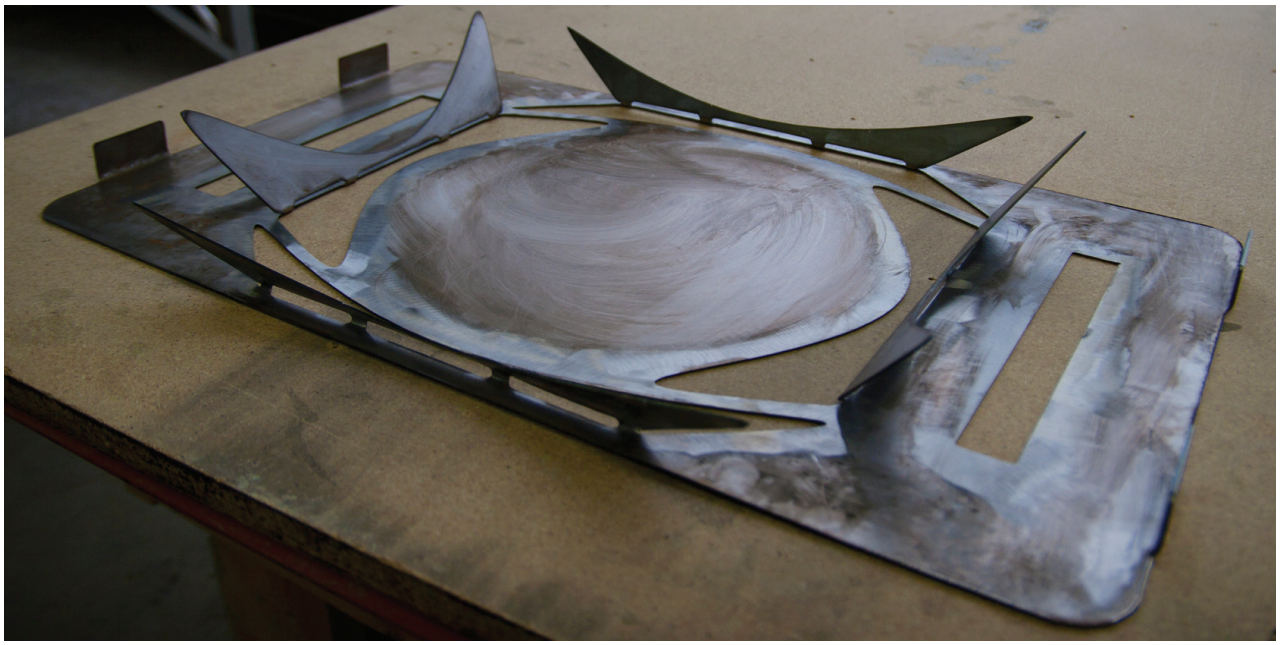








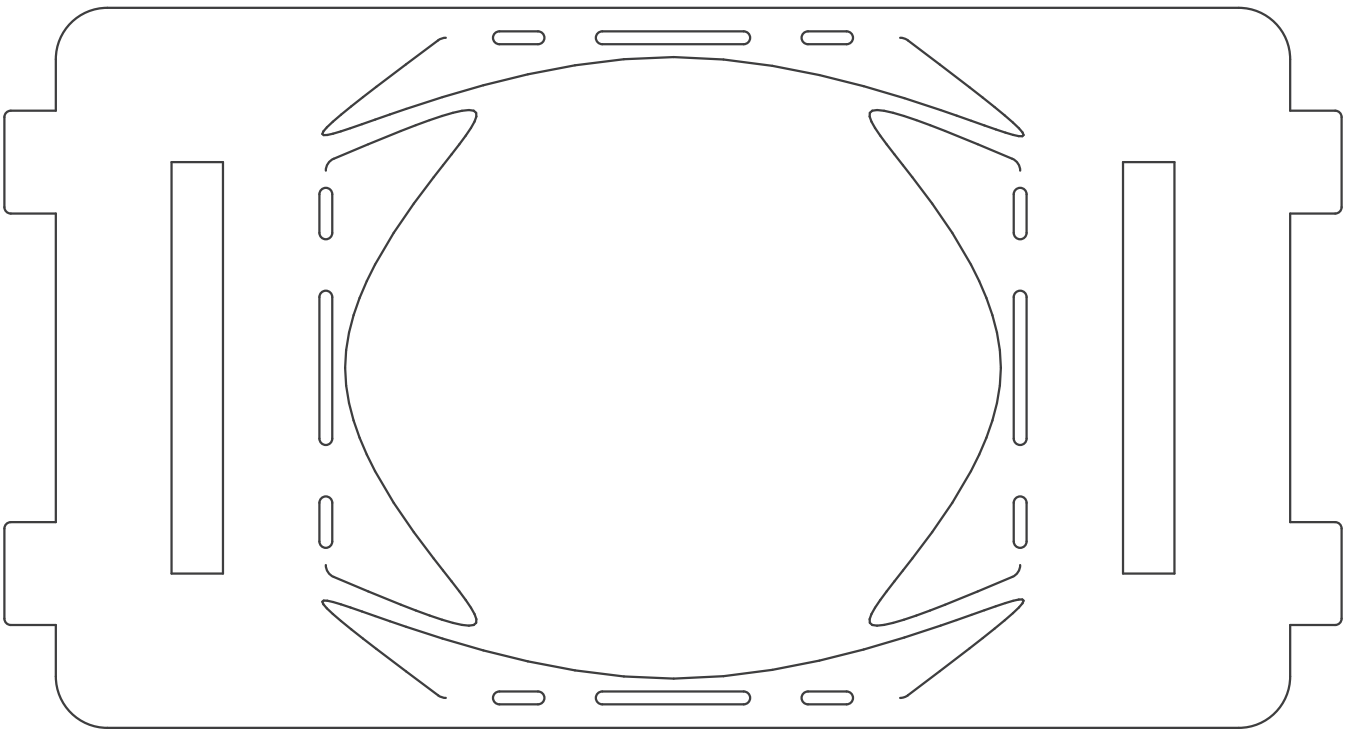

ISF V1
vault panel

Steel is designed and digitally fabricated to be the form work and the reinforcement that will remain as part of the component. The tabs direct the industrial shrink wrap into an inherently organic and structural piece while also locking into the concrete to provide the necessary structural reinforcement. The vault panel patterning applies structural design cues from Gothic architecture to visually reveal the structural forces through the design of the finished piece.



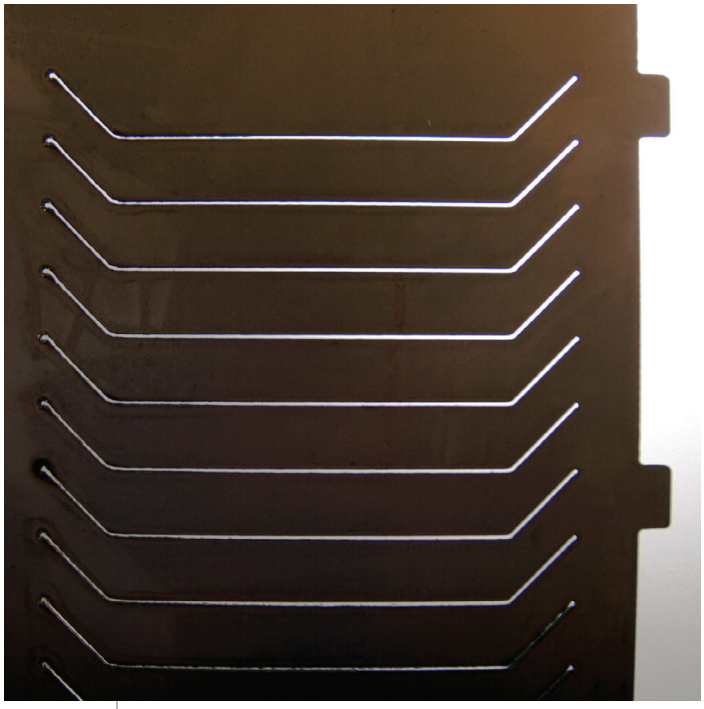


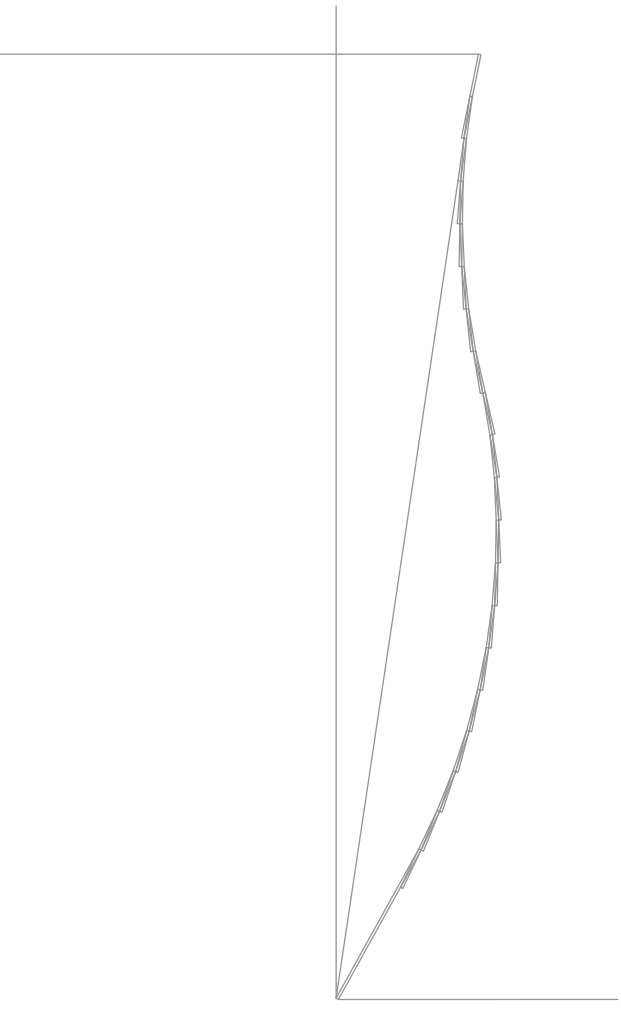


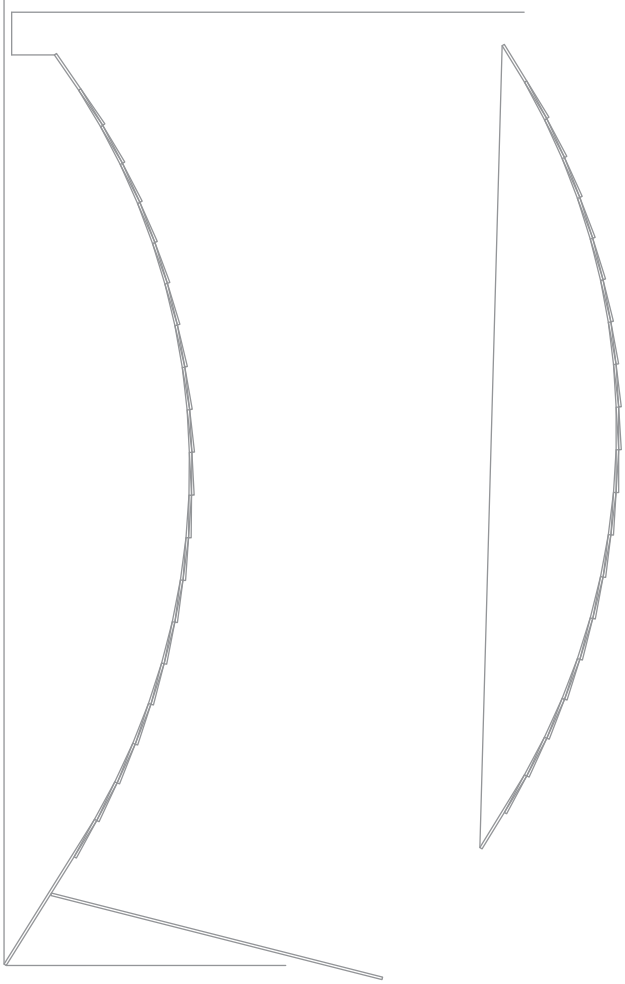


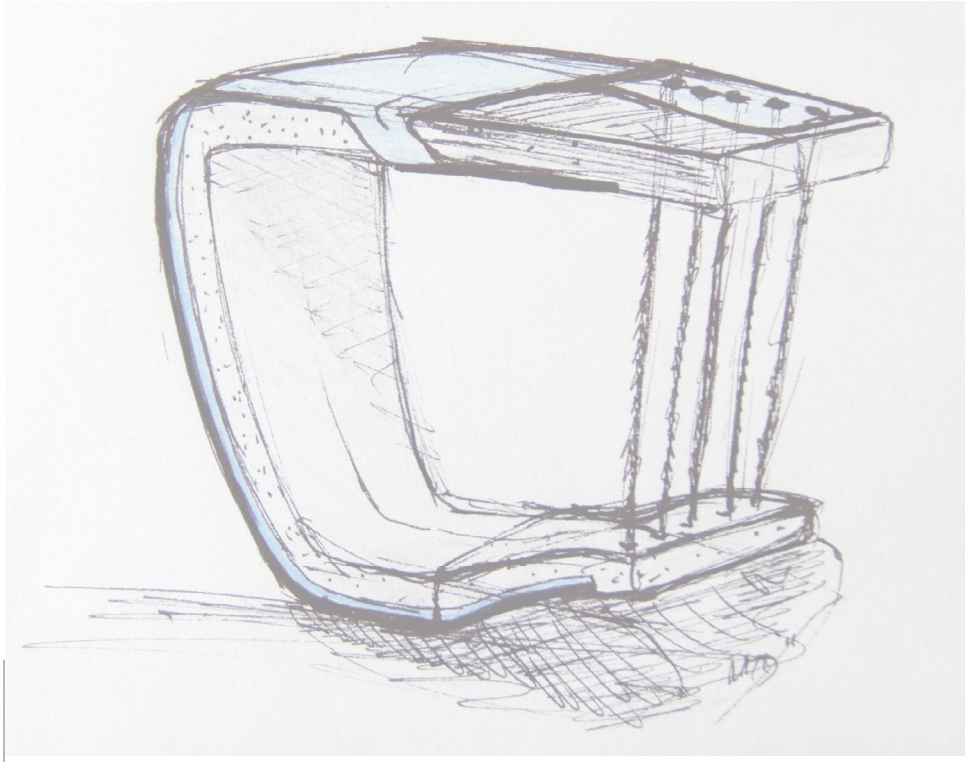
ISF V2
lamina table

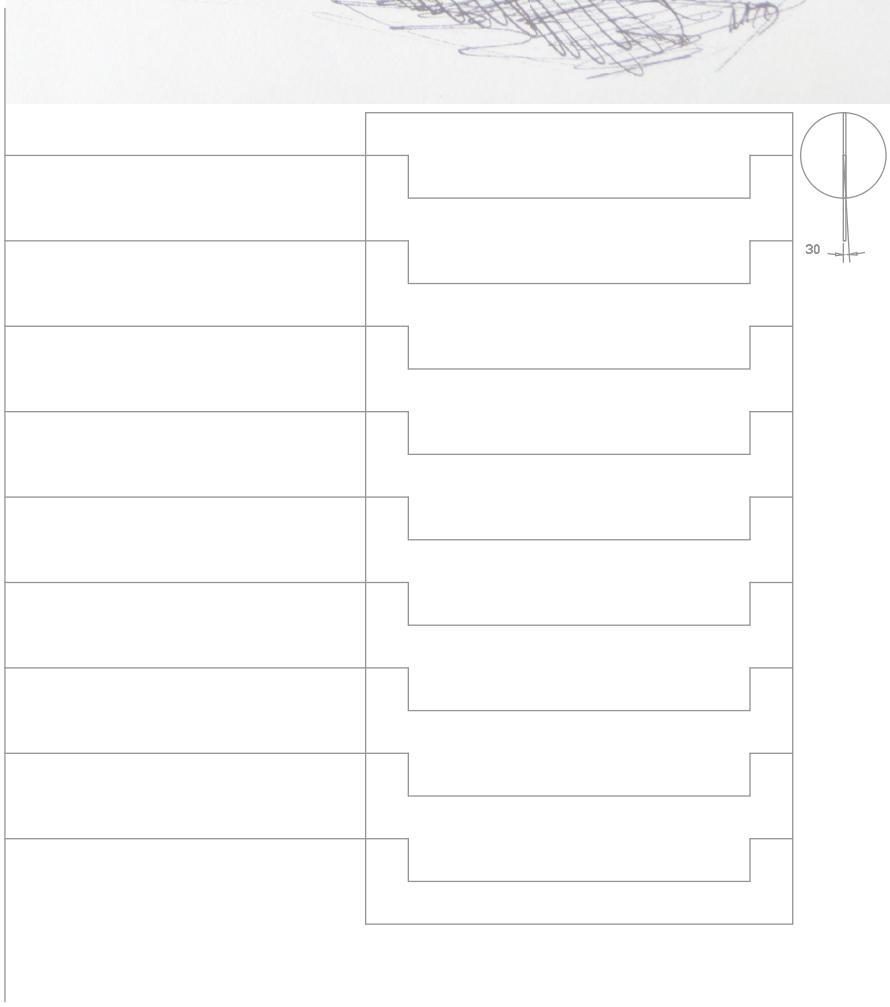
This side table conceptually challenges how the digital process can be used in collaboration with a standard building material to create form. The structural qualities of steel and concrete combined lend a thinner possible overall structural component. The finished component speaks of the architectural implications of the design and building process. This process can be scaled to become a structural cladding or wall system. Through this process, digital fabrication can assert standard building materials of this new crafting method.







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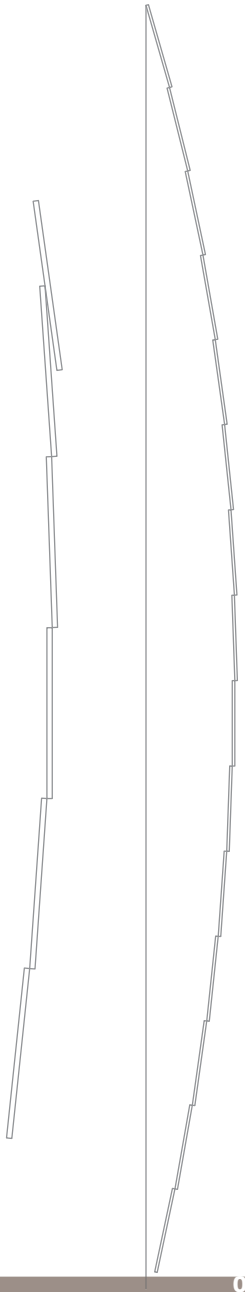
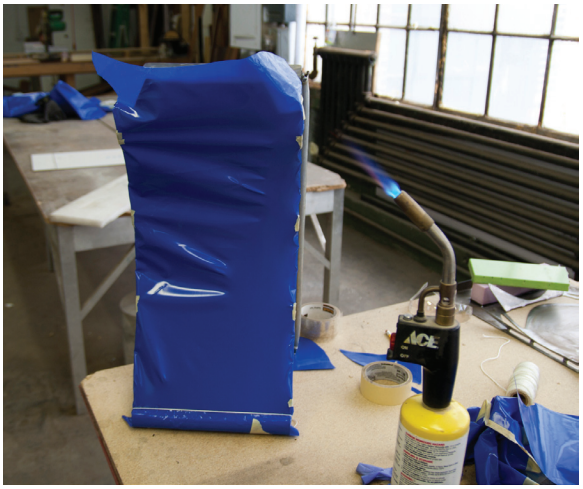
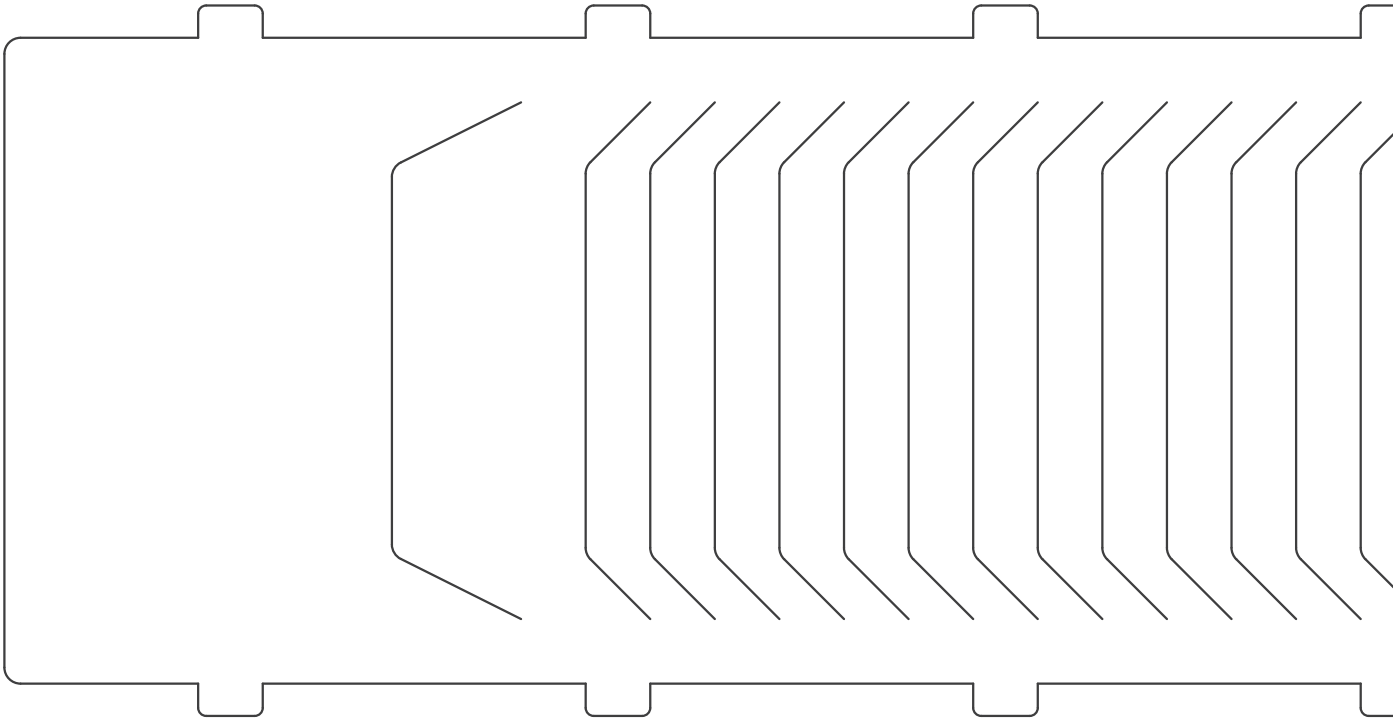
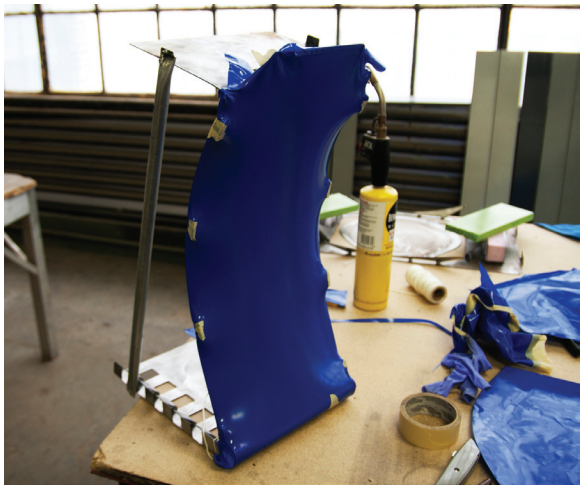
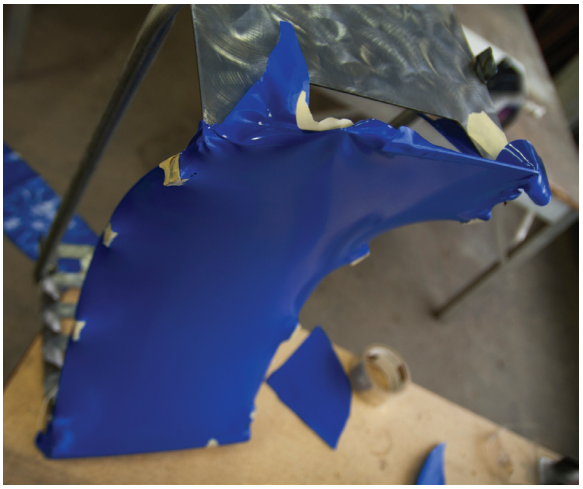
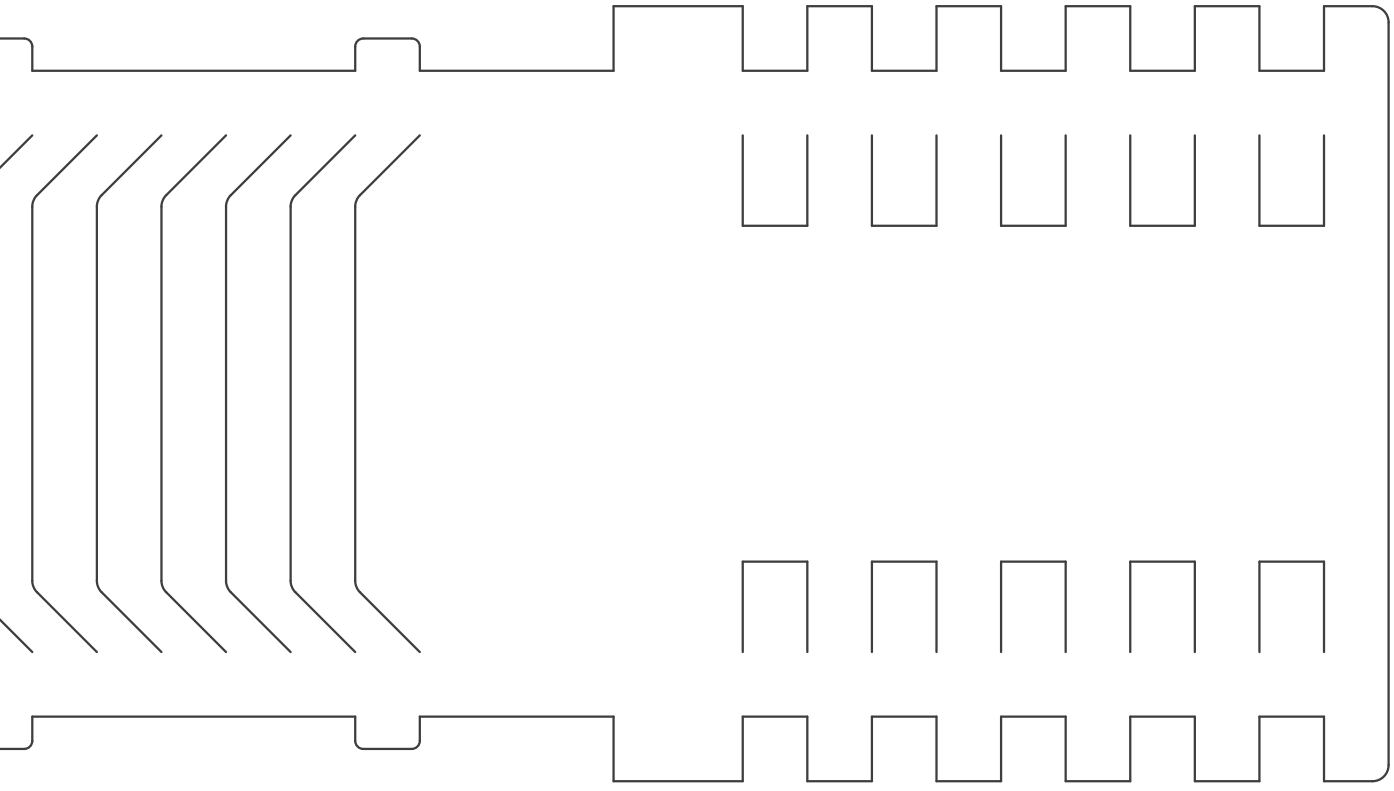








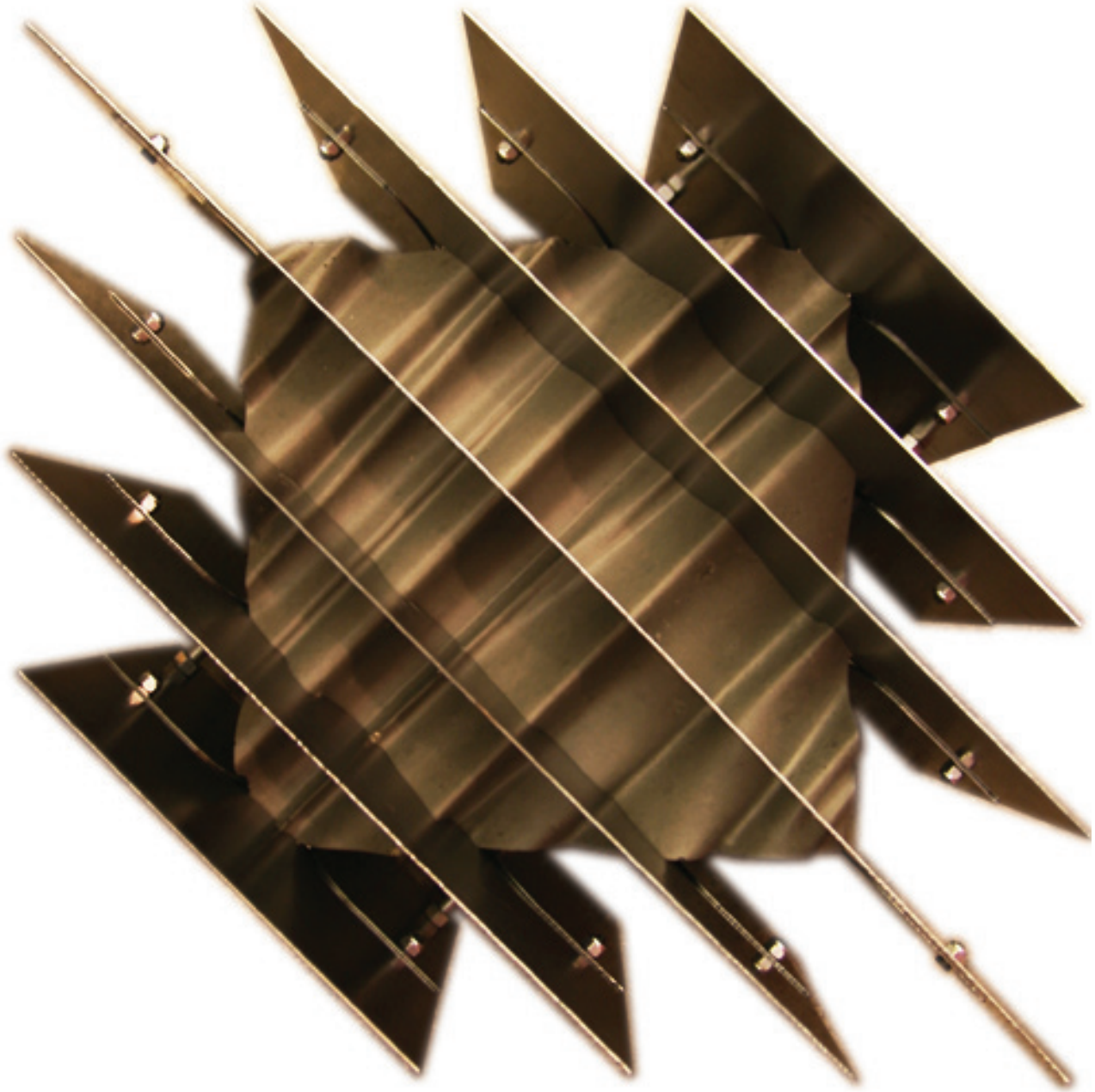


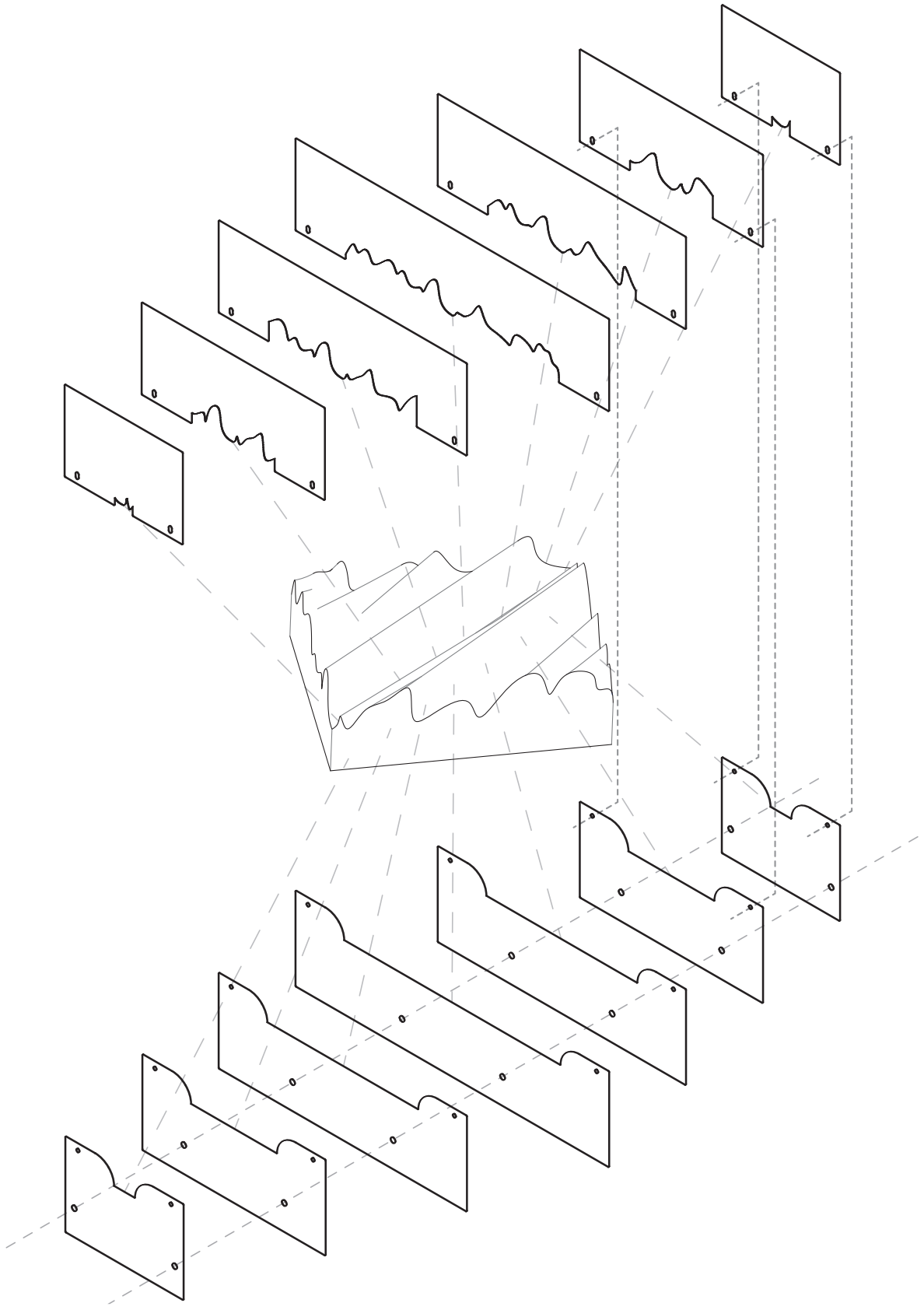


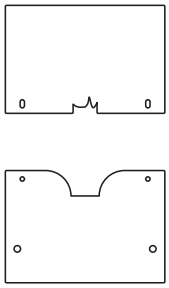
CNC TILE DISPLAY V1.0

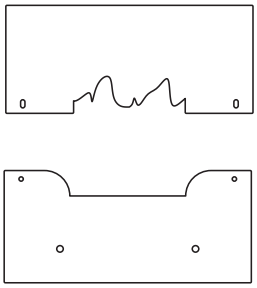
exploiting the process of making

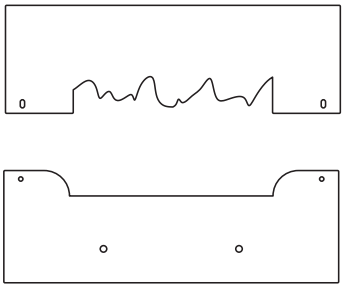
The program of display is applied to the cnc concrete panel. The design solution is based on how the component is produced and the section and surface geometry reveals itself through the laser cut panel design. The steel starts to define space and question if these planes ever existed in the component surface plane. This exploration further questions if the steel is only the display or now is part of the concrete surface.

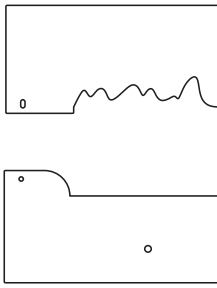


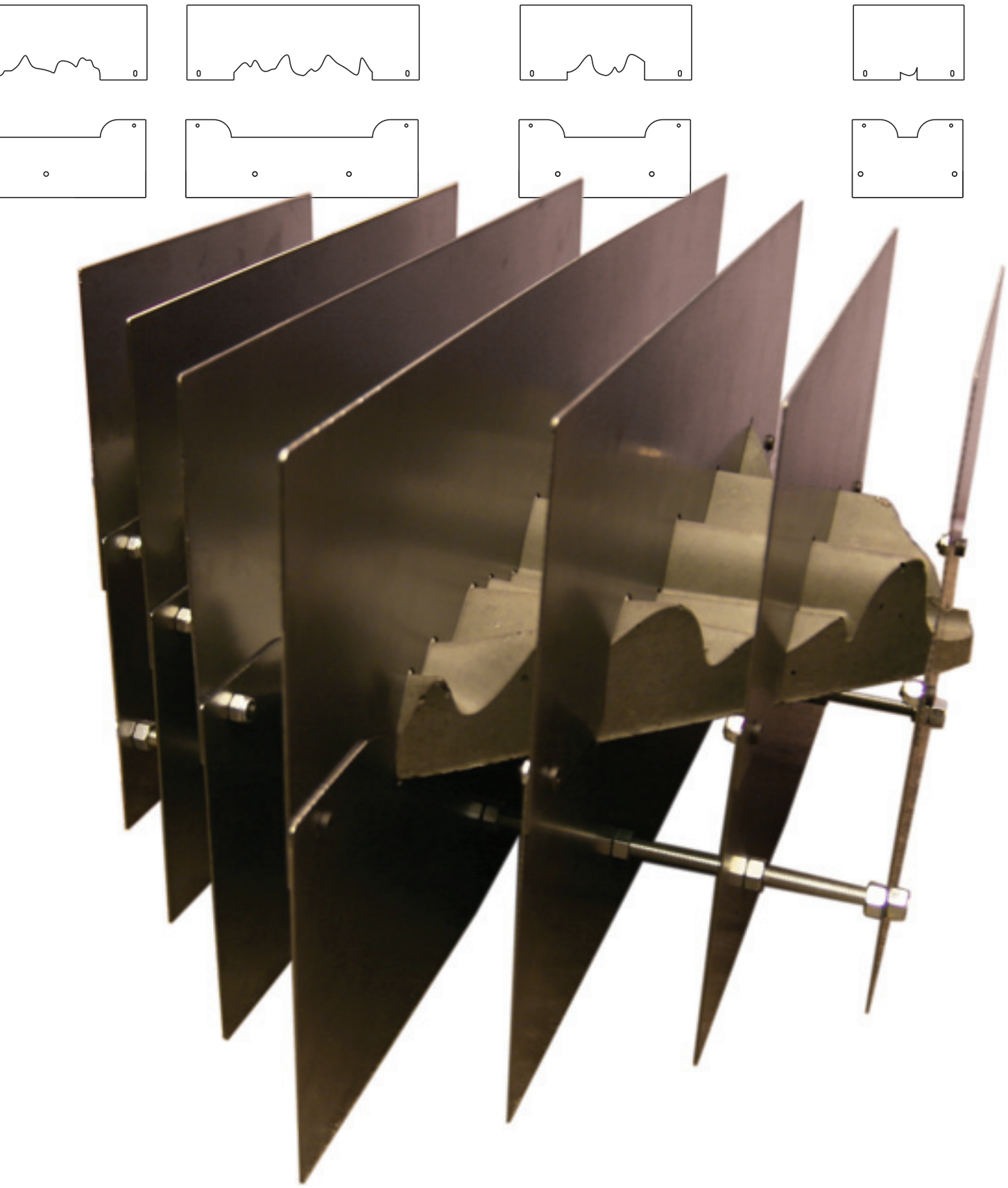








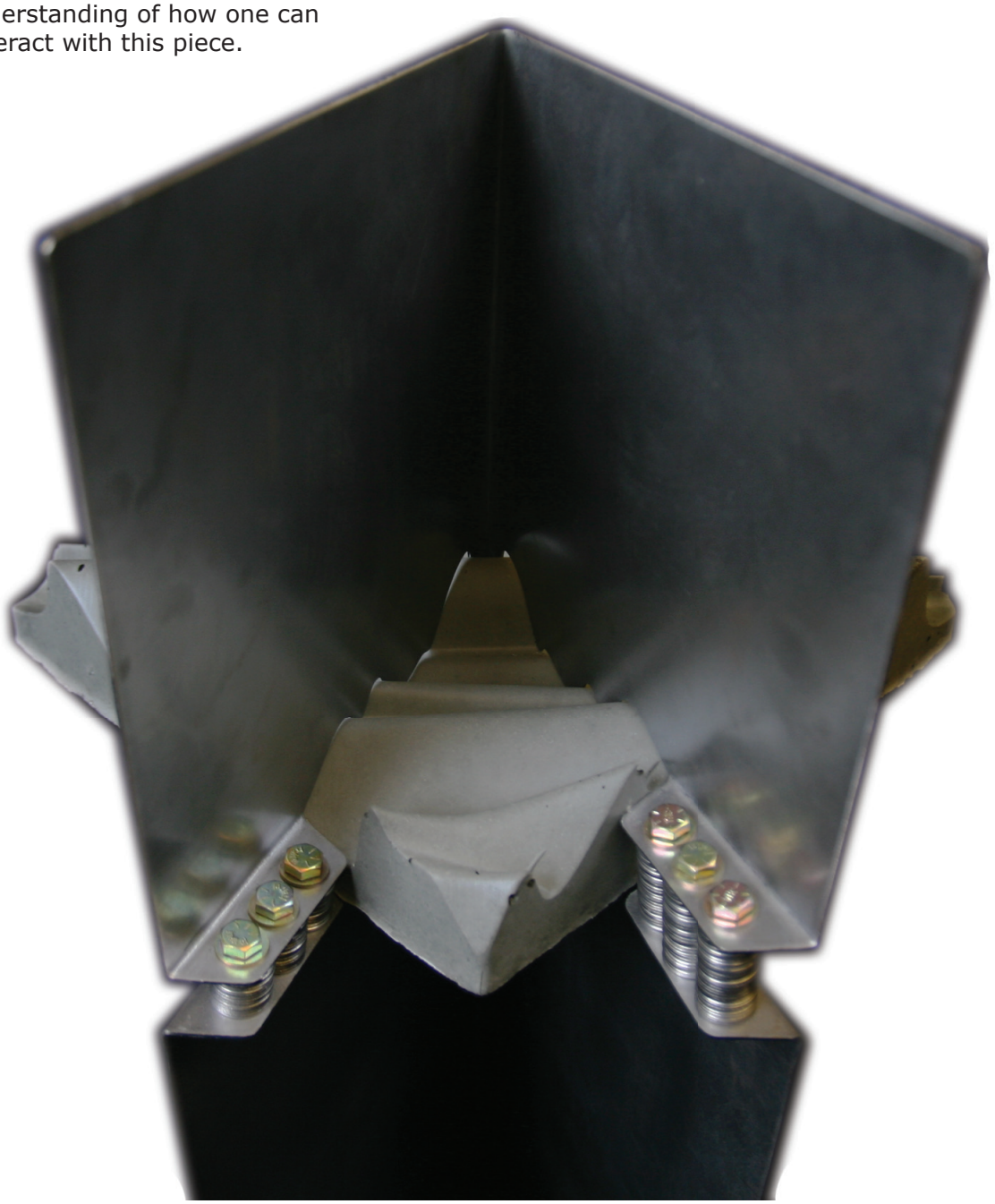




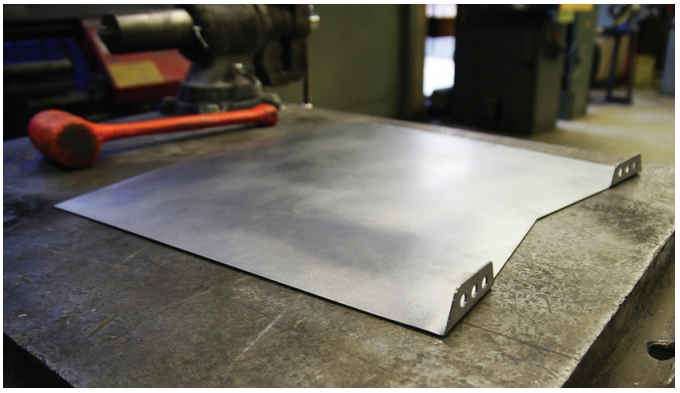
CNC TILE DISPLAY V2.0

abstracting the display

Display V2.0 is taking the initial display section and abstracting how a different interaction can spacially change how we experience and view the component. As similar in the first investigation, it reveals slightly different geometrical relationship and provides a different understanding of how one can view and interact with this piece.

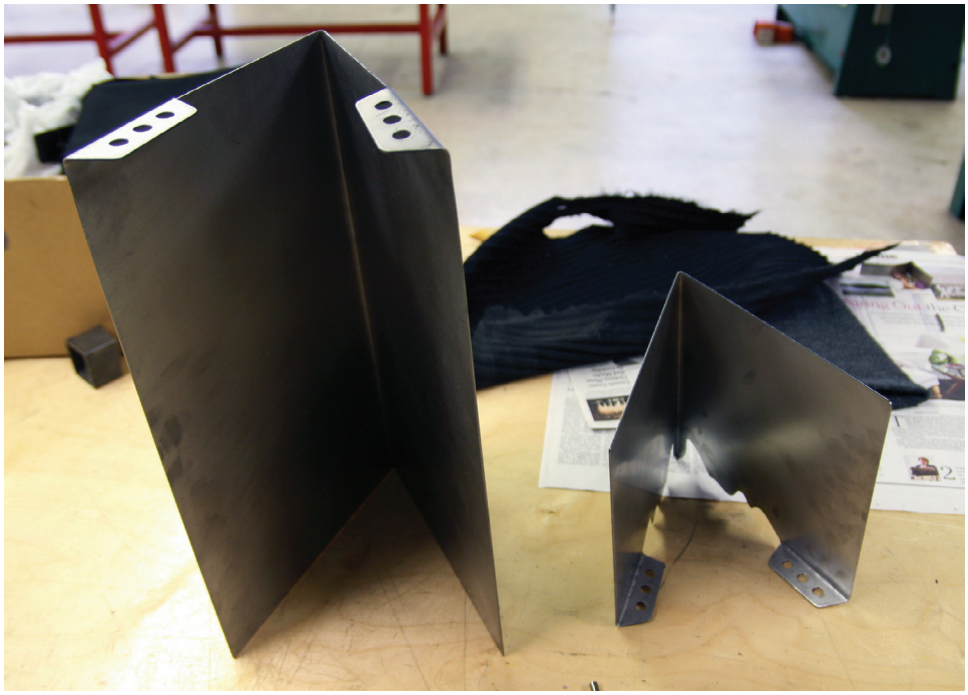


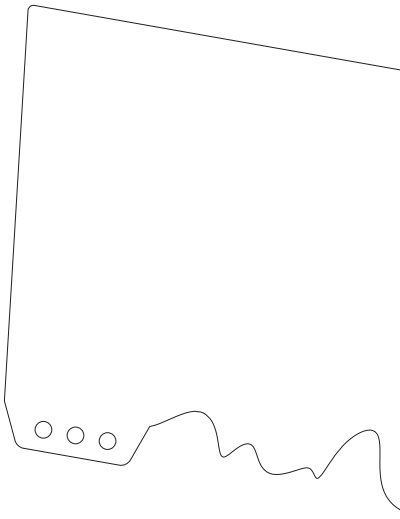

METAL SHOP

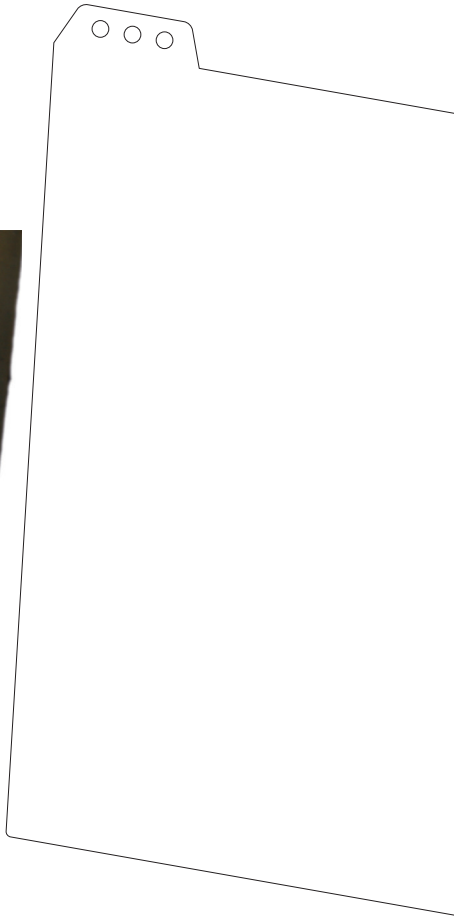


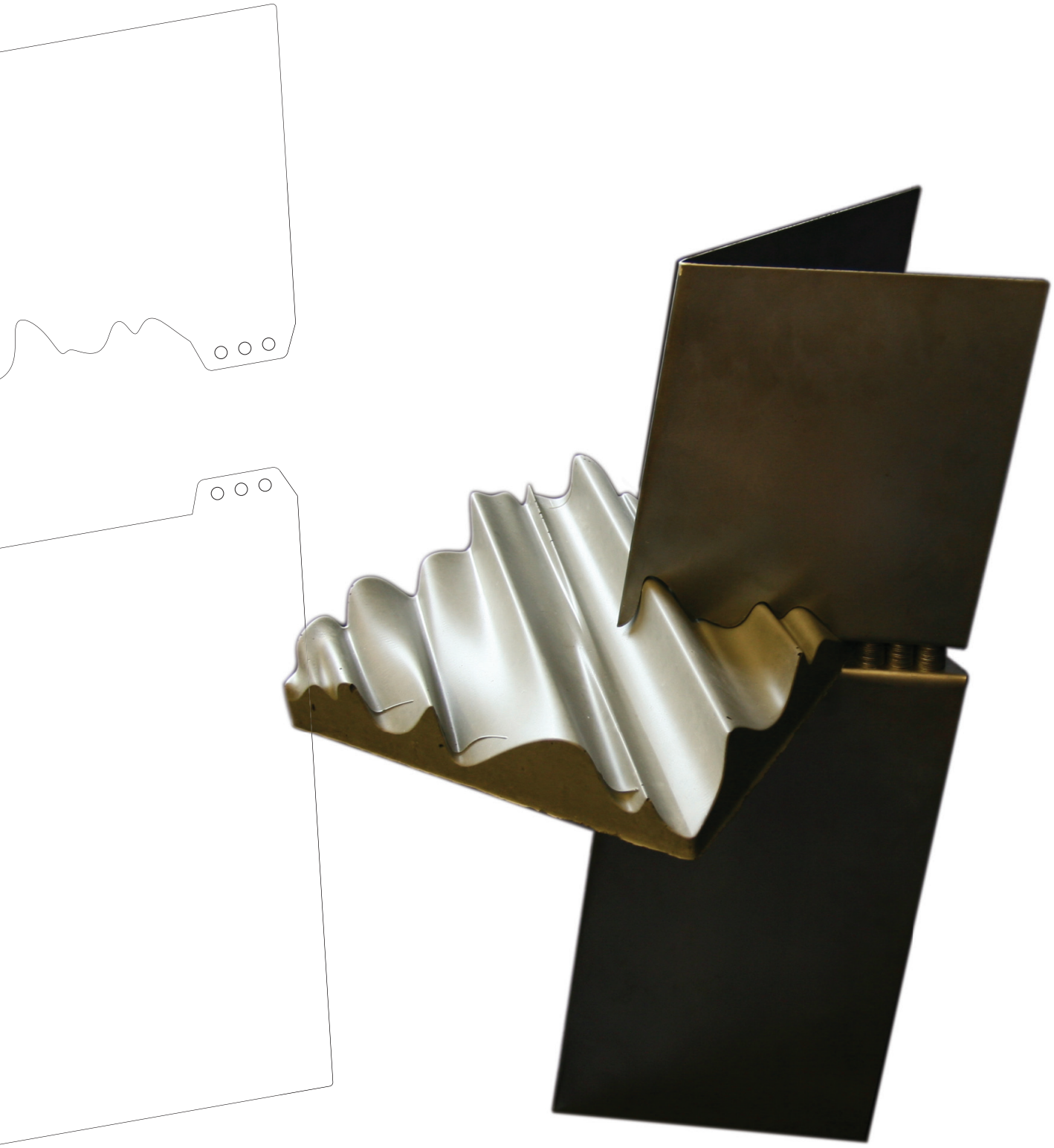

CAUTION


CAUTION
CAUTION



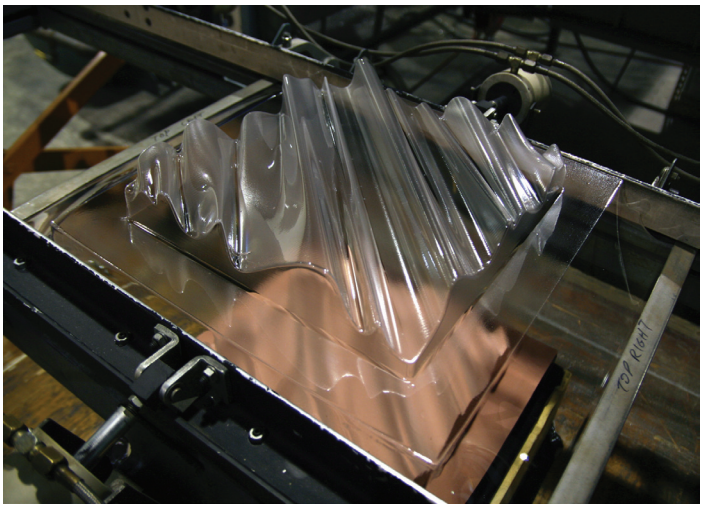


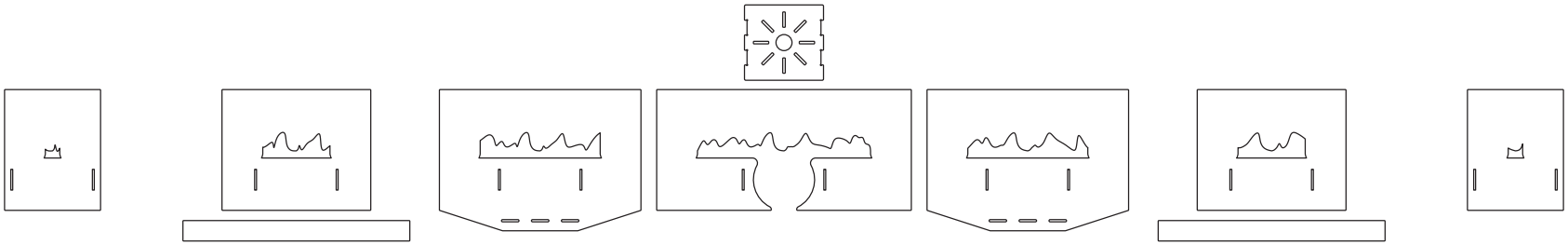


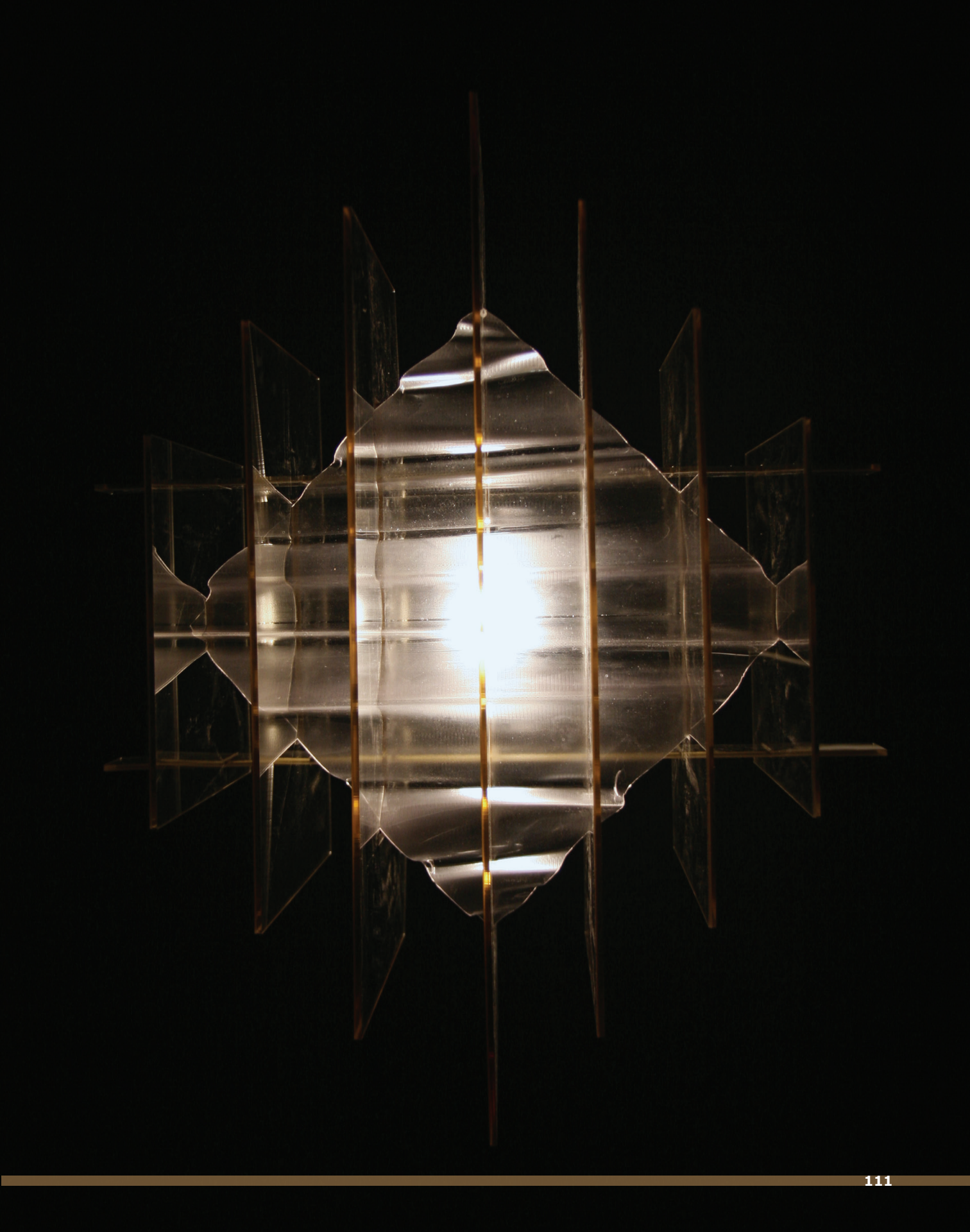


SURFACE LIGHT
translucent surface display

The translucent surface display is an investigation of the designed surface suspended along section profiles and lit to expose spacial relationships. As the translucency changes from its original form of concrete and steel, as shown in the display V1.0 investigation, new experiences occur with the change in material and format of display.

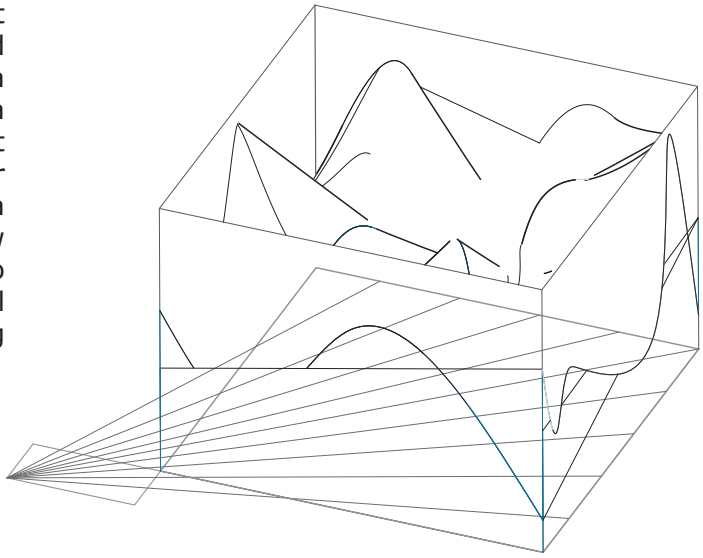


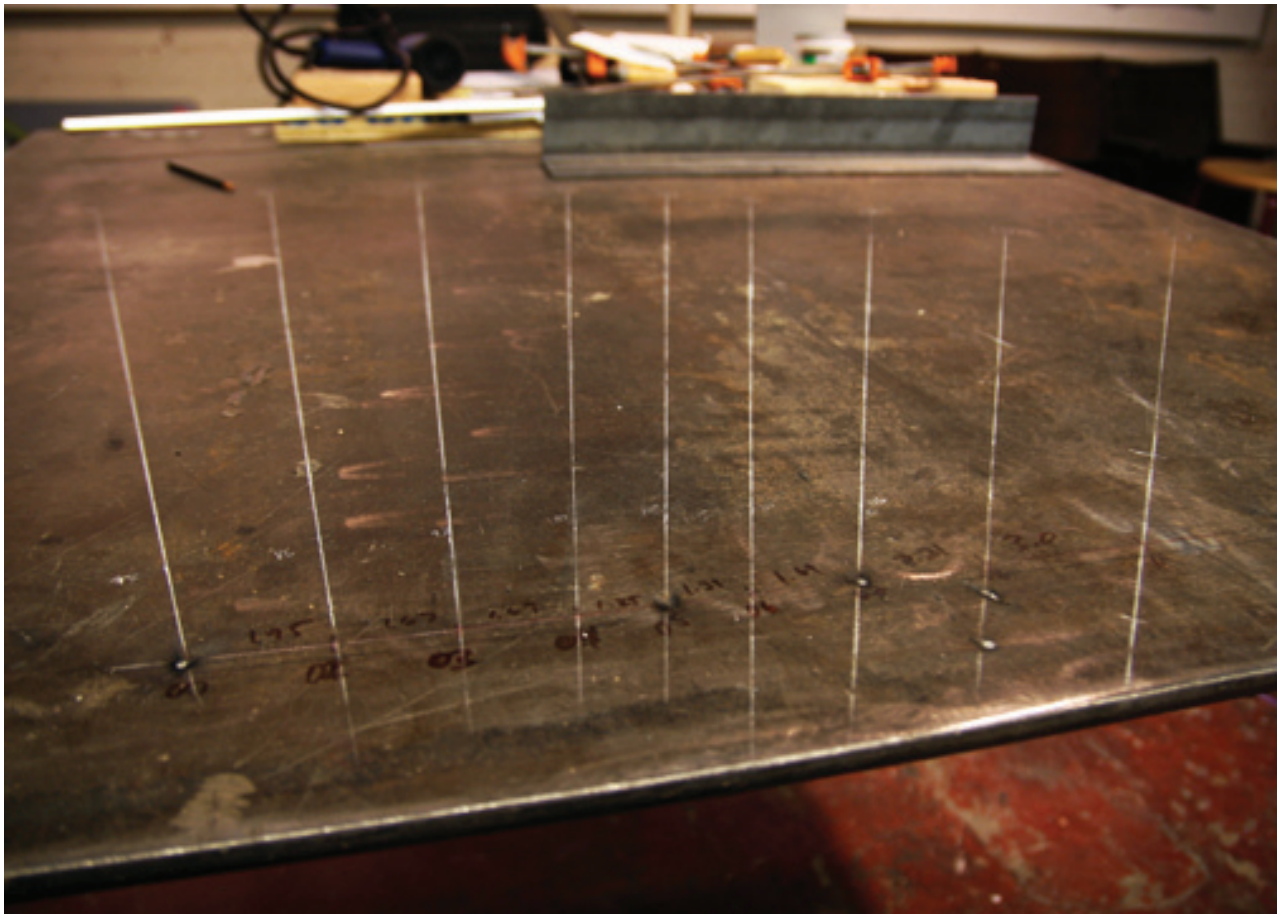


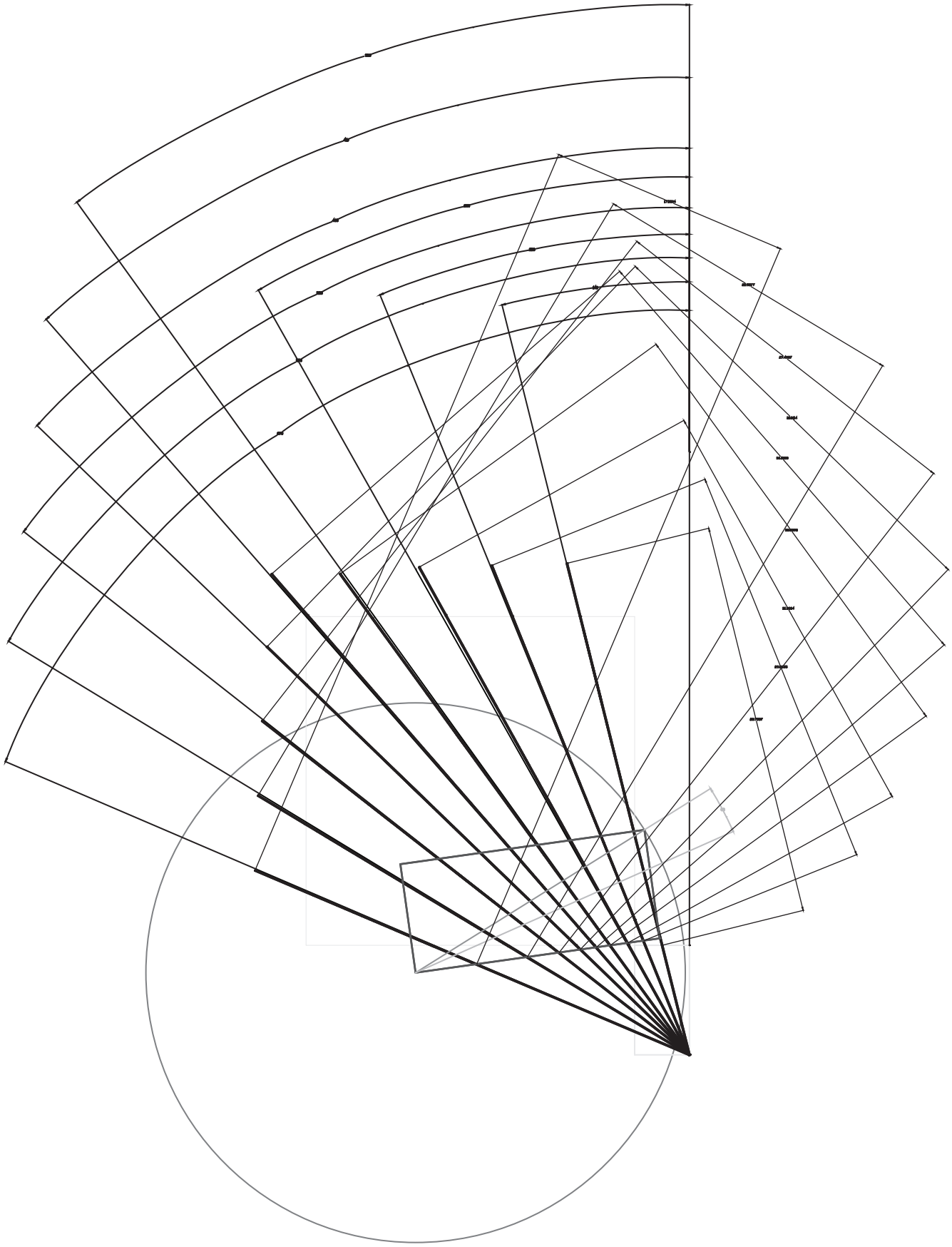


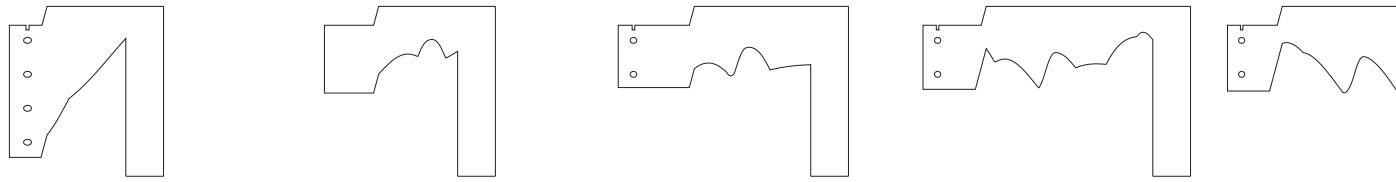
RADIATOR
designed spacial component

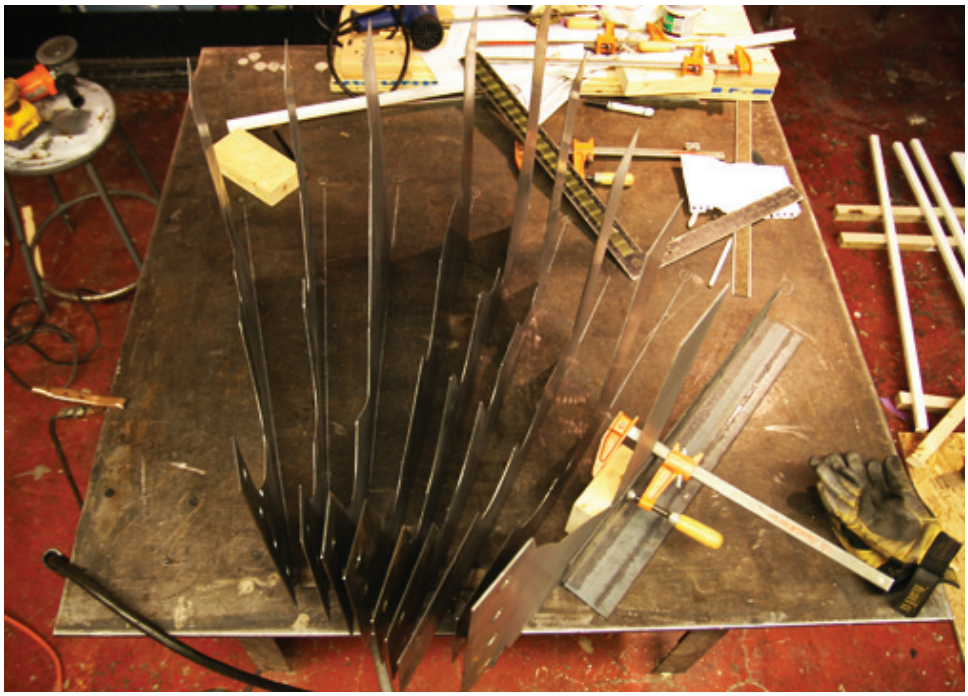
Heat is a basic element of life that is of great importance for its gathering and inviting qualities. The steam radiator is a multi-programatic system that plugs into a larger functional building system. Current choices are typically hidden and under designed. Focusing in on the radiator as a renewed and designed element that is now pulled away from the wall, it can begin to spacialy change the way we consider focal points and bring back social gathering aspects of a space.

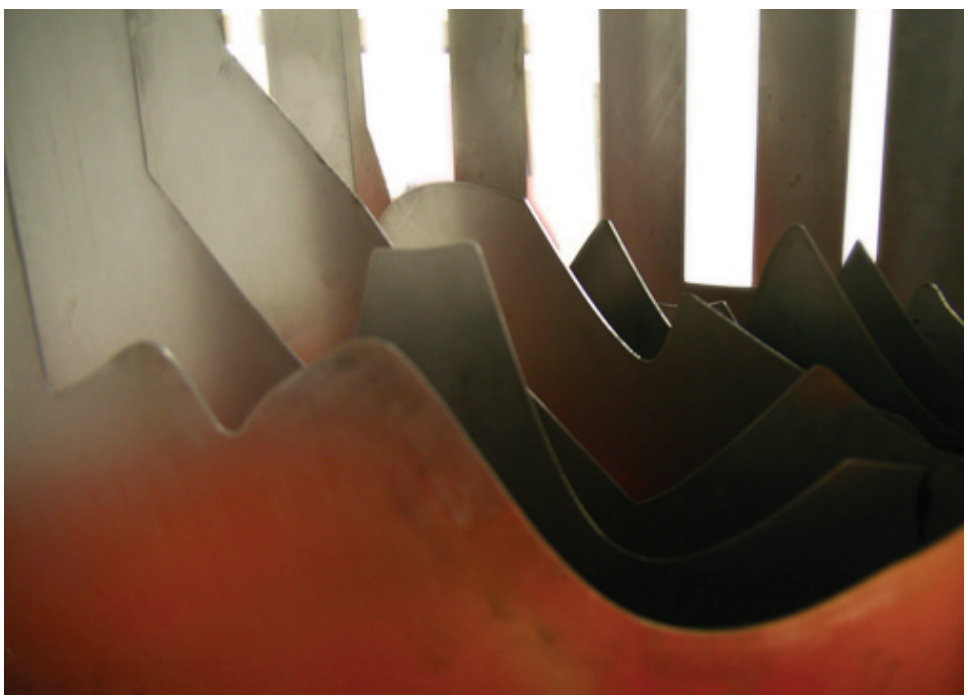


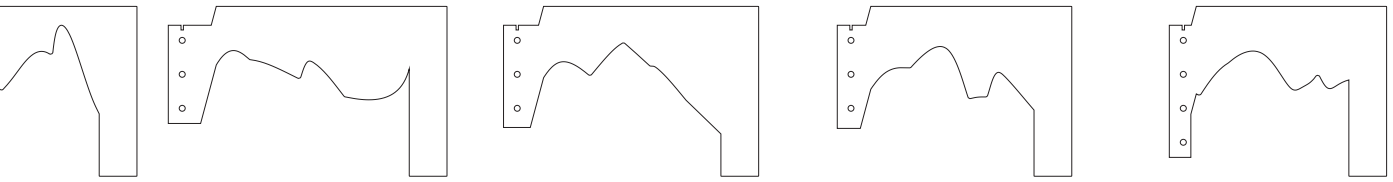


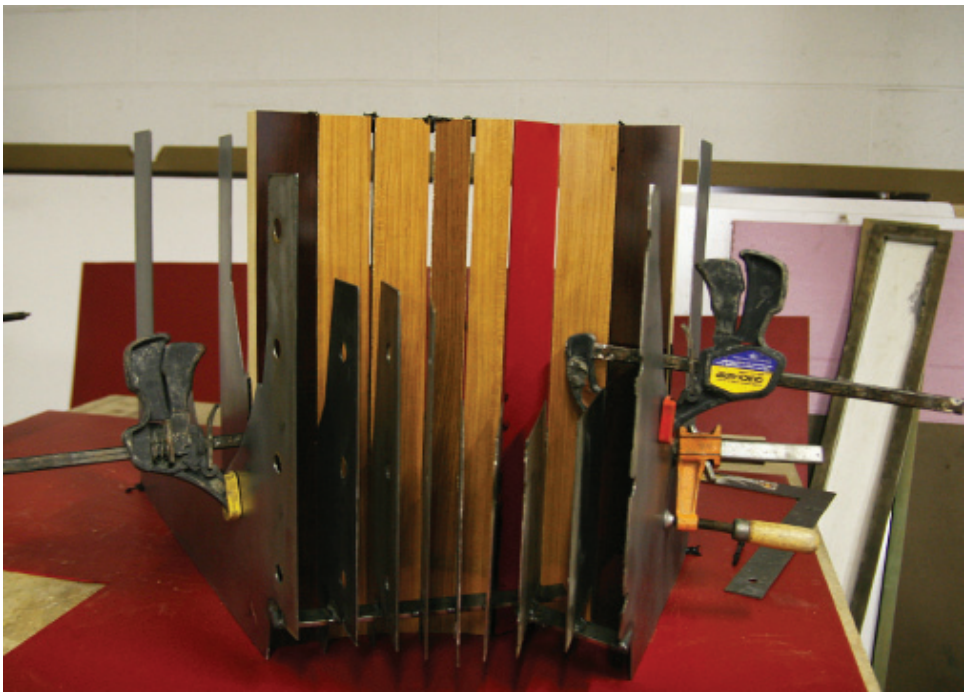


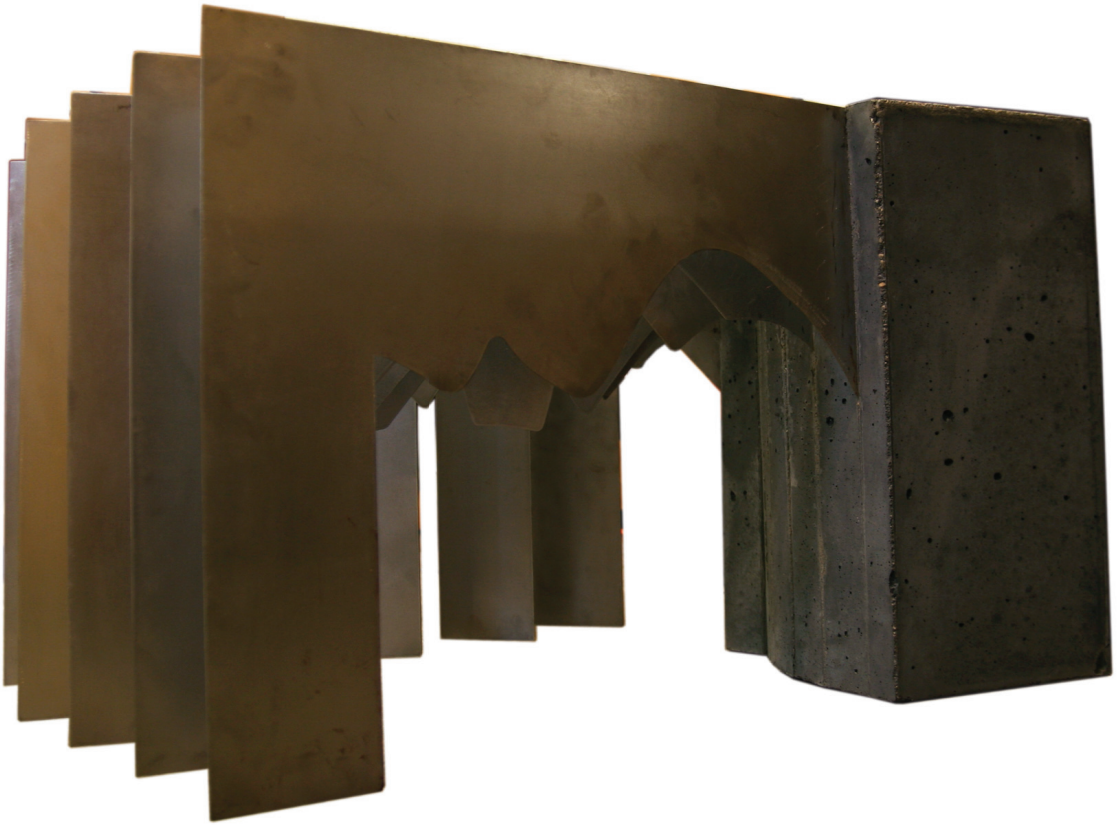


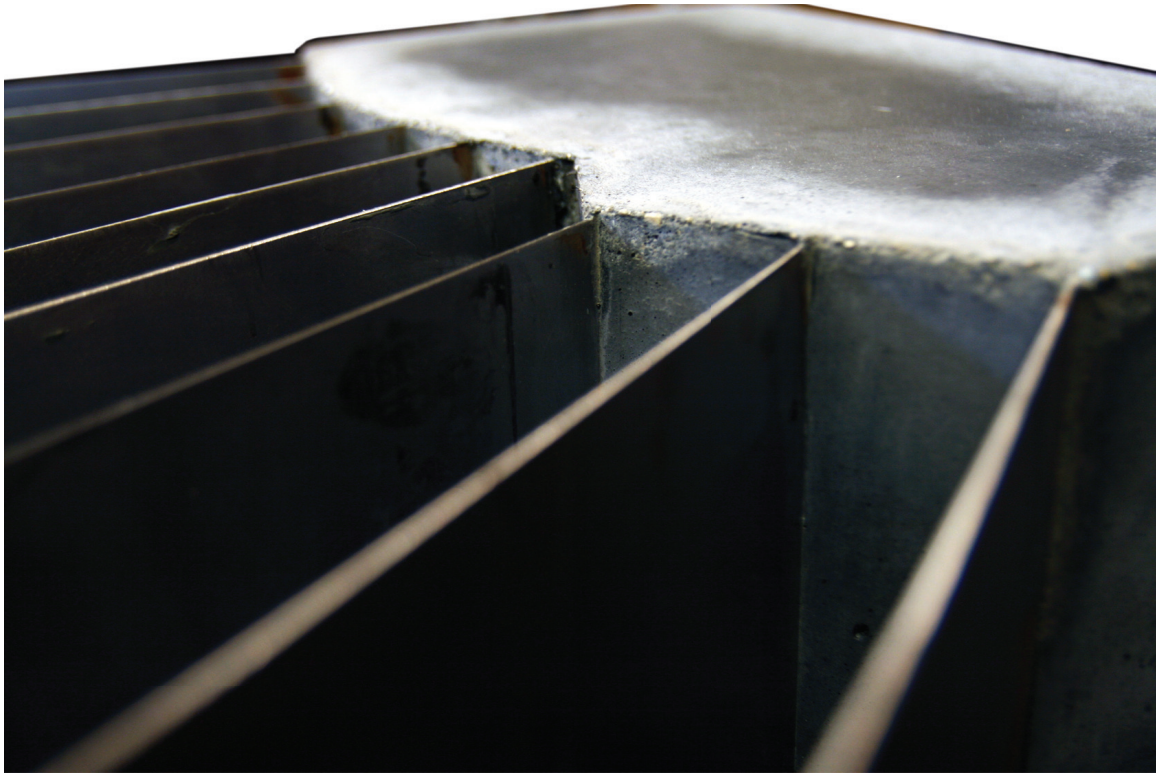












The goal of Architectural Techne' is to give incite into a different approach to design and production that architects typically would not consider. There is a large disconnect between how we as architects design and detail in relation to how a component, material or process is actually composed into a tangible element. The investigation brings hope to architecture as certain ways of digital design and crafting or fabrication has shifted and will continue to change as our process evolves through various digital and analog methods of design and production. Because this disconnect between design and the built environment was such a strong influence on the thesis research, Architectural Techne' sided more on the creation and exploration of concepts through built components. The downfall is the reverse of the critique as it may at times have turned its back on what most would consider architectural space and exploration. To err on the side of too much thinking can leave much to be desired. To err instead on the side of the creation can bring a more tangible conversation that has been provided here. As the Architectural firm SHoP states, "Building buildings is better than talking about building buildings" is one thought of consideration for this topic. The concepts that lie between these pages are still viable for consideration of design process through component production of architectural spaces and elements. These concepts and experiences is the starting venture that is paramount to the future success of how we consider architecture and push to explore how one can shift or change the way we dream, design, create, build and breathe the environment we live in.

Quotations

"building buildings is better than talking about building buildings." - SHoP

"Any sufficiently advanced technology is indistinguishable from magic."
Arthur C. Clarke, "Profiles of The Future", 1961 (Clarke's third law)

"If there is technological advance without social advance, there is, almost automatically, an increase in human misery, in impoverishment." Michael Harrington

"a search for an idea of an architectural prototype that emerges from the control of a technical system." Barkow Leibinger

"You are going to have to rewrite your whole thesis..." Noah Resnick

"The digital revolution has come and is here..." - Reed Kroloff

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