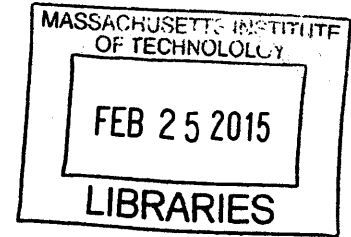


ARCHIVES



Disturbance Grounds:

An Inquiry into Non-Equilibrium Architectural States
by
Tyler D. Crain

Bachelor of Arts in Architecture
Washington University in St. Louis, 2010

SUBMITTED TO THE DEPARTMENT OF ARCHITECTURE IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF ARCHITECTURE
AT THE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
February 2015

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Disturbance Grounds:
An Inquiry into Non-Equilibrium Architectural States
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SUBMITTED TO THE DEPARTMENT OF ARCHITECTURE ON JANUARY 15, 2015 IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE
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Abstract

Fundamentally, this project pursues the concept of construction from destructive forces. It presents architectural opportunity at the physical scale of the mega-city and the time scale of the geological, advocating for a manipulation of our environment that extends architectural operation beyond our life-span, human labor, and predefined architectural program.

From nature's perspective, mass material movements are one of the ways in which it deconstructs; in the case of a natural disturbance, one can observe the rebirth of material from one form to another. Geological timelines witness the entire re-composition of materials. Materiality has always been at the heart of many architectural issues, from assembly to phenomenological and economics discussion, informing the way we construct. In architecture, aggregation of material is a wide-ranging topic, but can most traditionally be thought of as stone or concrete. This thesis takes on the issues of aggregate materials at the edge of a balanced state. As this non-equilibrium state begins to suggest the very pressing concern of environmental hazards, the project speculates on a scenario that is more frequently encountered by urban populations and is increasingly well documented as instrumentation becomes more widespread and risks increase.

Perhaps we can find a way to construct an architecture that changes material phasing as a response to natural geological processes. Abstracting conditions to a lab-like studio setting, the project explores the subject of aggregation and accumulation.

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Title: Professor of Architecture

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all the guys at MARCH

For Gerald Curtis Crain

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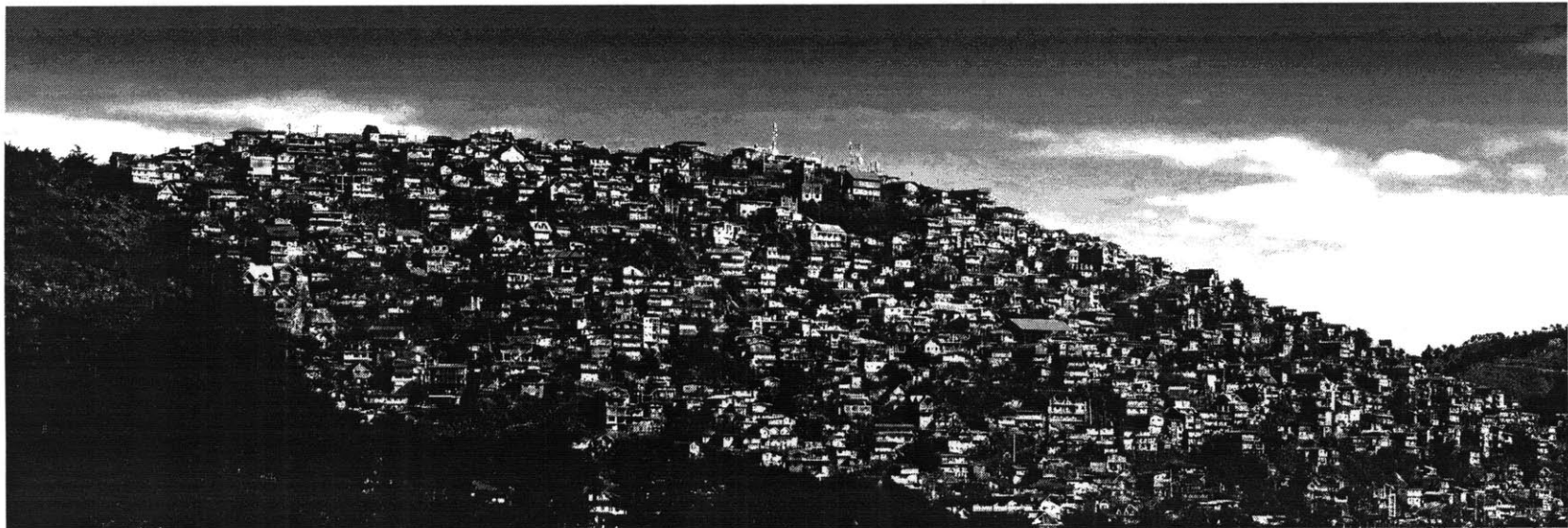
I. Introduction

This project asks how destructive forces can be used for construction. It seeks out latent potentials in aggregate materials and forces, situating itself within a dialogue of new landscape methodologies, aggregate material formations, phase changing processes and alternative development strategies.

From a geological perspective, mass material movements are a method of simultaneous deconstruction and reformation. They are a continuous phase-change process. While we might see them typically as hazards, this project sees them as opportunities for analog actuation of a hillside, forming a field or a scattering of spatial instruments. The thesis essentially seeks to build with debris material in a landslide disturbance scenario.

Drawing from many diverse disciplines, the project attempts to coherently synthesize a landscape modification, a soft, multi-purpose infrastructural geoprosthesis architecture. It investigates a geotechnical solution in the form of an architectural strategy and the potentials of aggregate materials in the context of environmental turmoil.

Materiality in architecture has always been at the heart of many of its driving issues, from assembly to phenomenological and economics discussion, heavily informing the way we construct. From nature's perspective, mass material movements are also the way it deconstructs; in the case of a natural disturbance, one can observe the rebirth of material from one form to another. In





“The absence of simple, low-cost, human-scale methods of disaster preparedness and mitigation is a significant weakness.” - Disaster Preparedness Network Nepal

architecture, aggregation of material is a wide-ranging topic, but can most traditionally be thought of as stone or concrete. This thesis takes on the issues of aggregate materials on the edge of equilibrium. As this suggests a concern of environmental hazards, this is an issue that the majority of the planet, urban and rural, will need to consider on an increasingly regular basis. It presents architectural opportunity at the physical scale of the mega-city and the time scale of the geological, advocating for a manipulation of our environment that extends architectural operation past the human life-span, beyond human labor, and extending predefined architectural program.

The goal was to create a new process of construction, focusing on control over the accumulation of parts. Hence the liquifaction of aggregate materials became the source of exploration. Aggregate materials, in concept, are already the source of both construction and destruction. Stone and earth have been used for construction by architects throughout history, from the Ifugao rice terraces or Borobodur to Herzog and de Meuron's Dominus Winery, Winsun's 3D printed houses, or Foster Partners' 3D printed moon shelter. We have witnessed new conceptual tools for processing materials in ways that are more efficient and humane in terms of labor and material efficiency as we continue to search for local material latencies. Physical processes have become the tools with which we can not only build, but design in accordance with. Simulation technologies are becoming robust enough to use in a designer's process, while beginning to take into account larger physical contexts. This is to mean potentials in modeling matter, liquid and atmospheric flows. We can begin to sketch out scenarios that mimic these processes close enough to plan for the rebirth of our architectural sites.

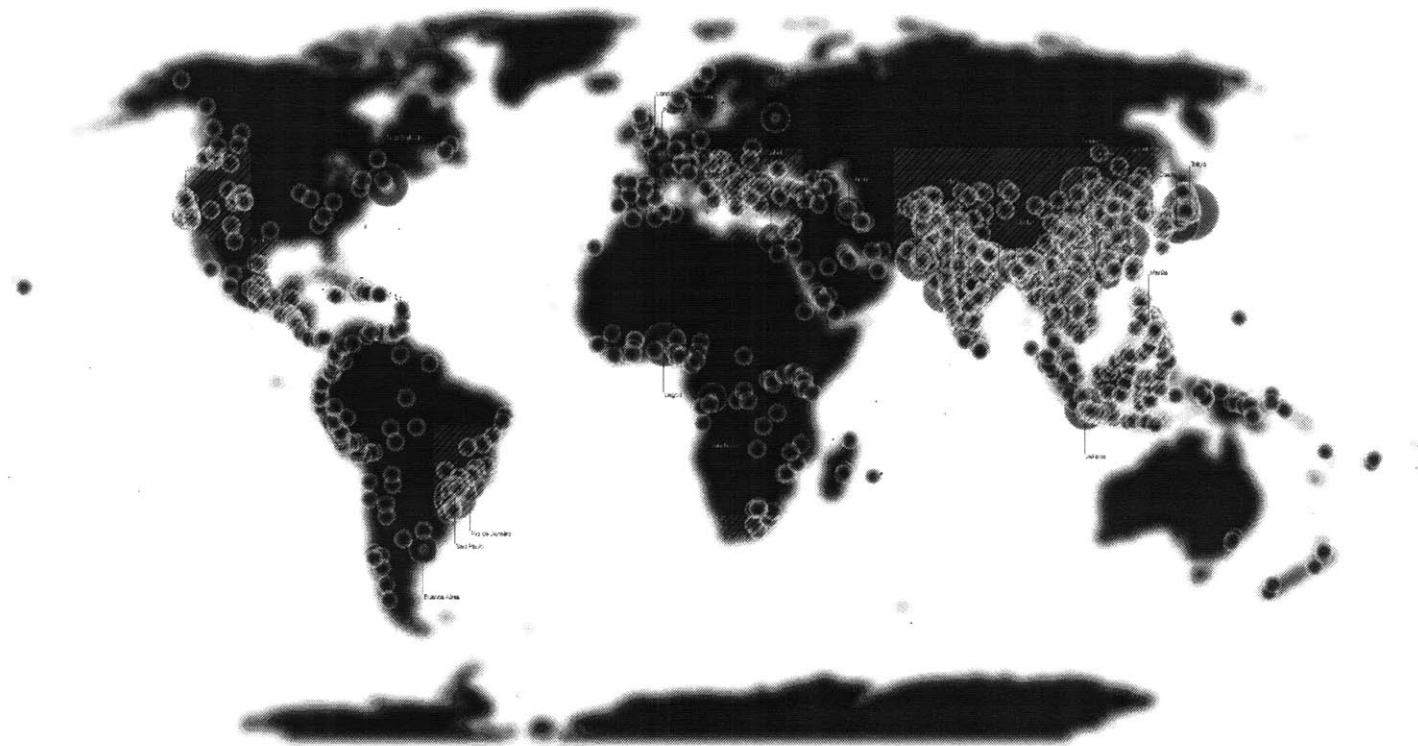
Research on material flows from many aspects have immensely proliferated over recent years. In the case of landslide and mass movement hazards we can observe not only the dramatic increase of the amount of recorded data available, but the enlightened realization of the real numbers of mortality

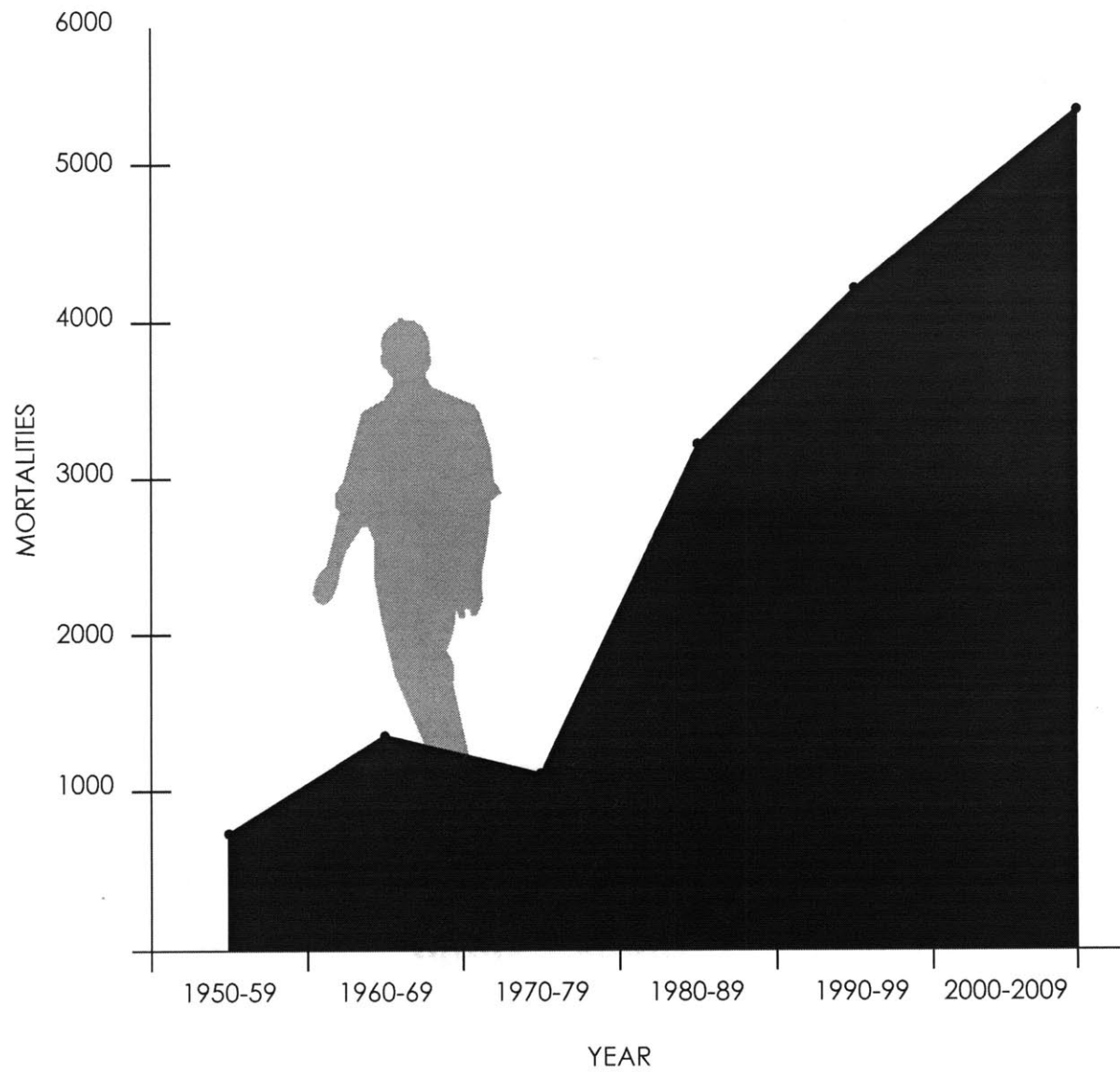
rates and economic losses. This trend, in consequence has been paralleled by the number of publications on the subject. This is not uncommon given the increased interests for all environmental hazards in the same time frame.

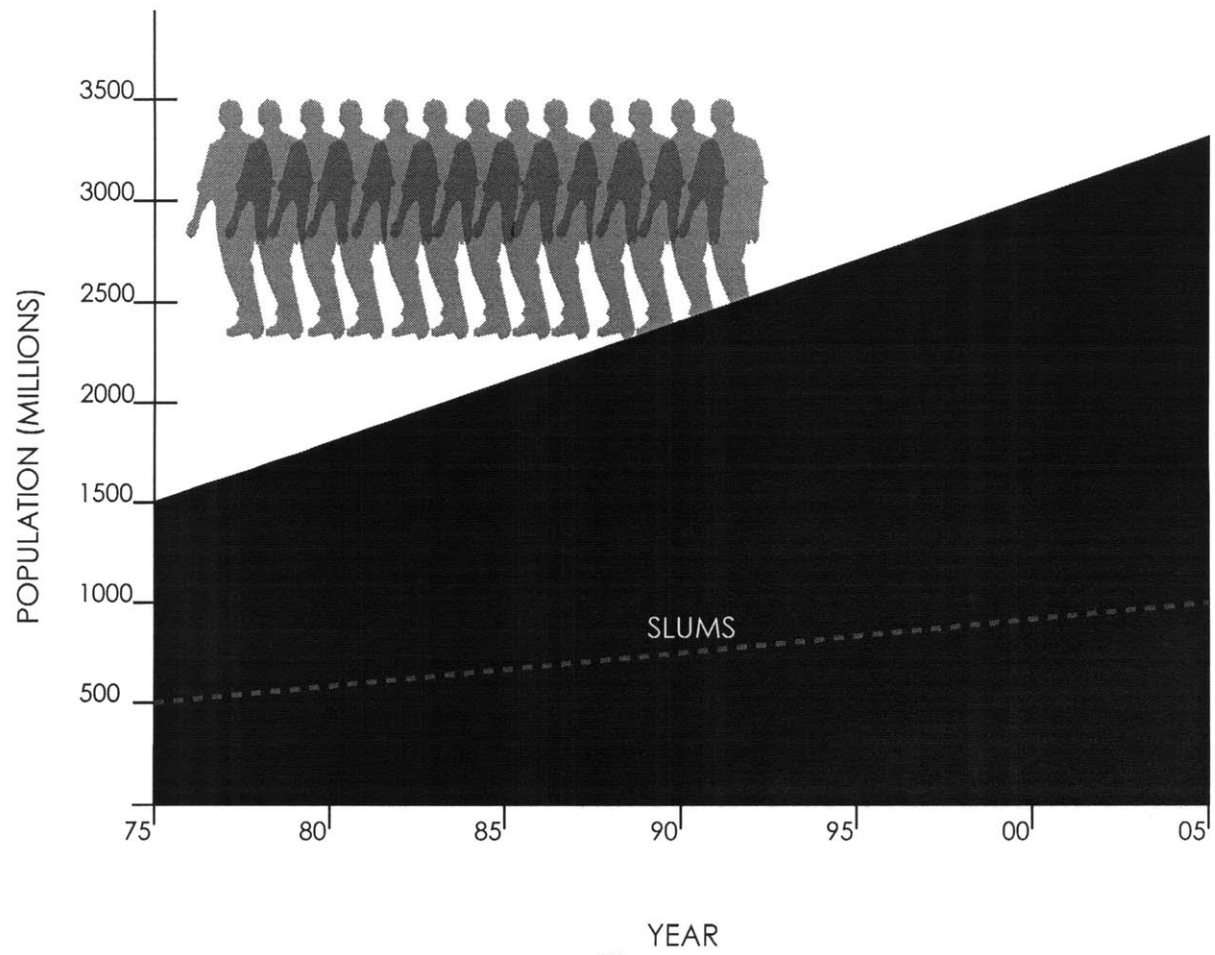
This thesis takes an issue that is prevalent throughout the majority of earth's land, dramatically affecting many urban fringe areas across the world, and proposes a new design approach based in physical and digital simulation processes for taking on the problems in disaster scenarios. Landslides are an unfortunately common issue in many dense informal urban settlements, especially common in mountainous, rainy areas in south and southeast Asia. The mortality rate as well as economic loss have recently proven to be much higher than originally thought. This can be attributed to the fact that data collection is getting more accurate. Simultaneously, cities and haphazard developments are expanding at exponential rates.

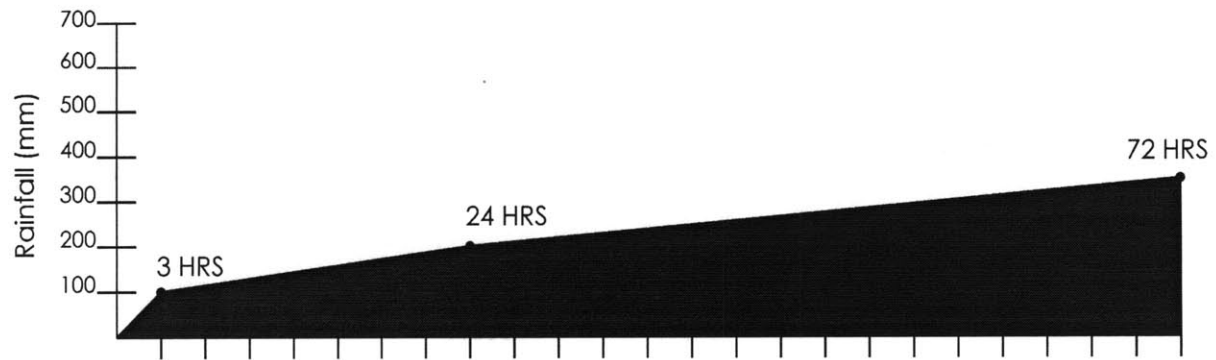
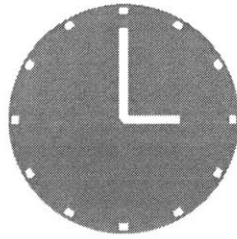
Research was gathered for many locations across the globe, therefore emphasis was given to the process rather than specific location. The site becomes an invented testing ground for digital and physical simulations, creating the platform from which cities in the Philippines, Nepal, India, China, Pakistan, and Venezuela and many others can draw from. The work's trajectory, however, could have the potential to expand far beyond these places. From this scenario, the project attempts to extract a method of construction from destruction. It seeks a new, rapid system of building that takes advantage of the geologic forces that are already inevitable in most areas on earth. By abstracting the scenario to an invented ground acting as a full-scale geotechnical lab setting, we can begin to extract architectural qualities out of the reconfiguration of the landscape. It is hoped that in the end, one can begin to imagine the latent architectural possibilities in what is typically considered a destructive force. In effect, the ground is turned into a medium for spatial writing and re-writing that contains the foundation for future development possibilities.

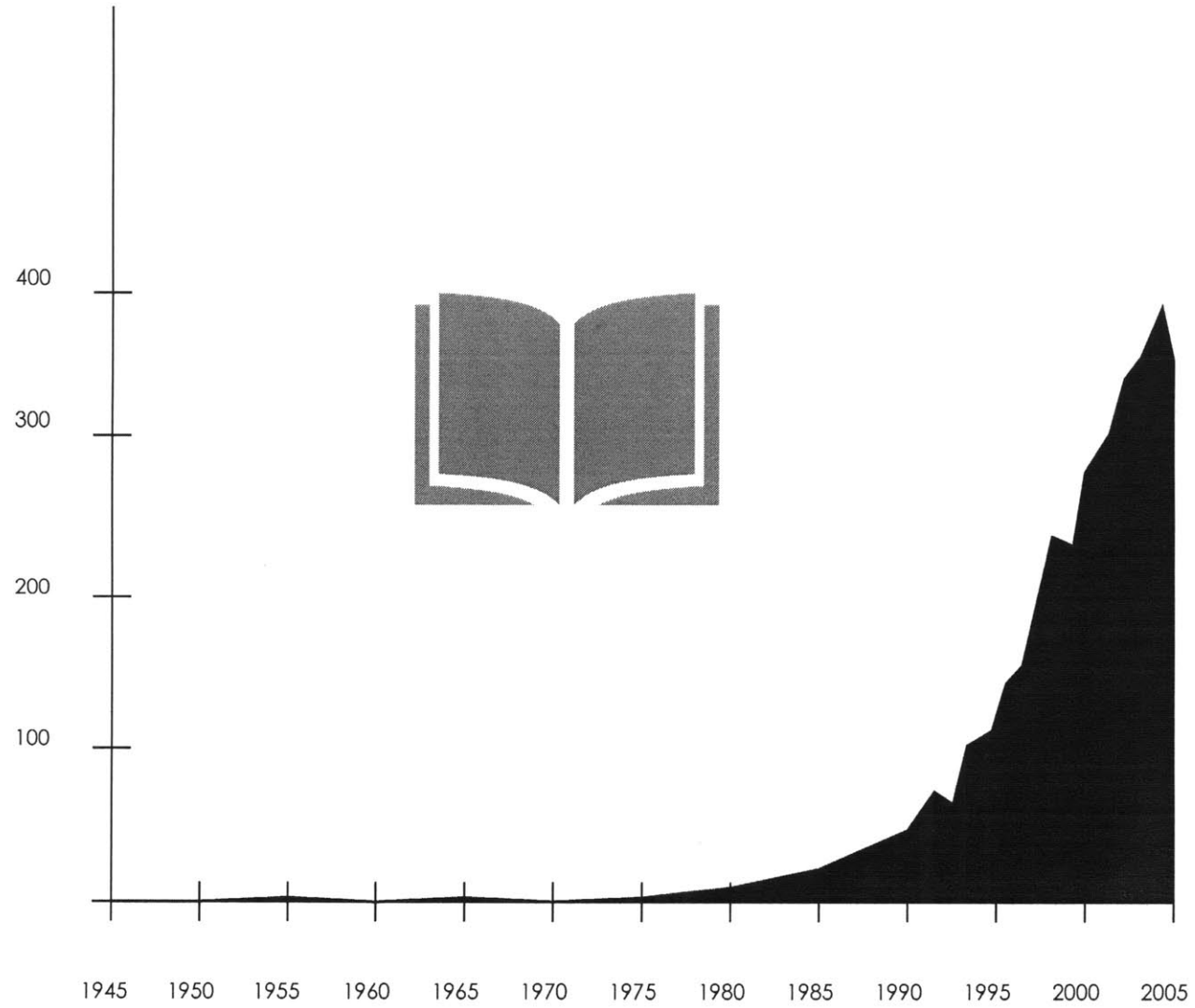








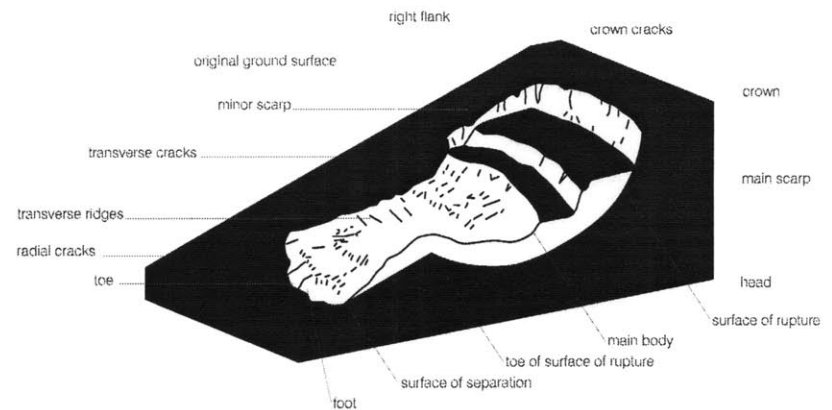




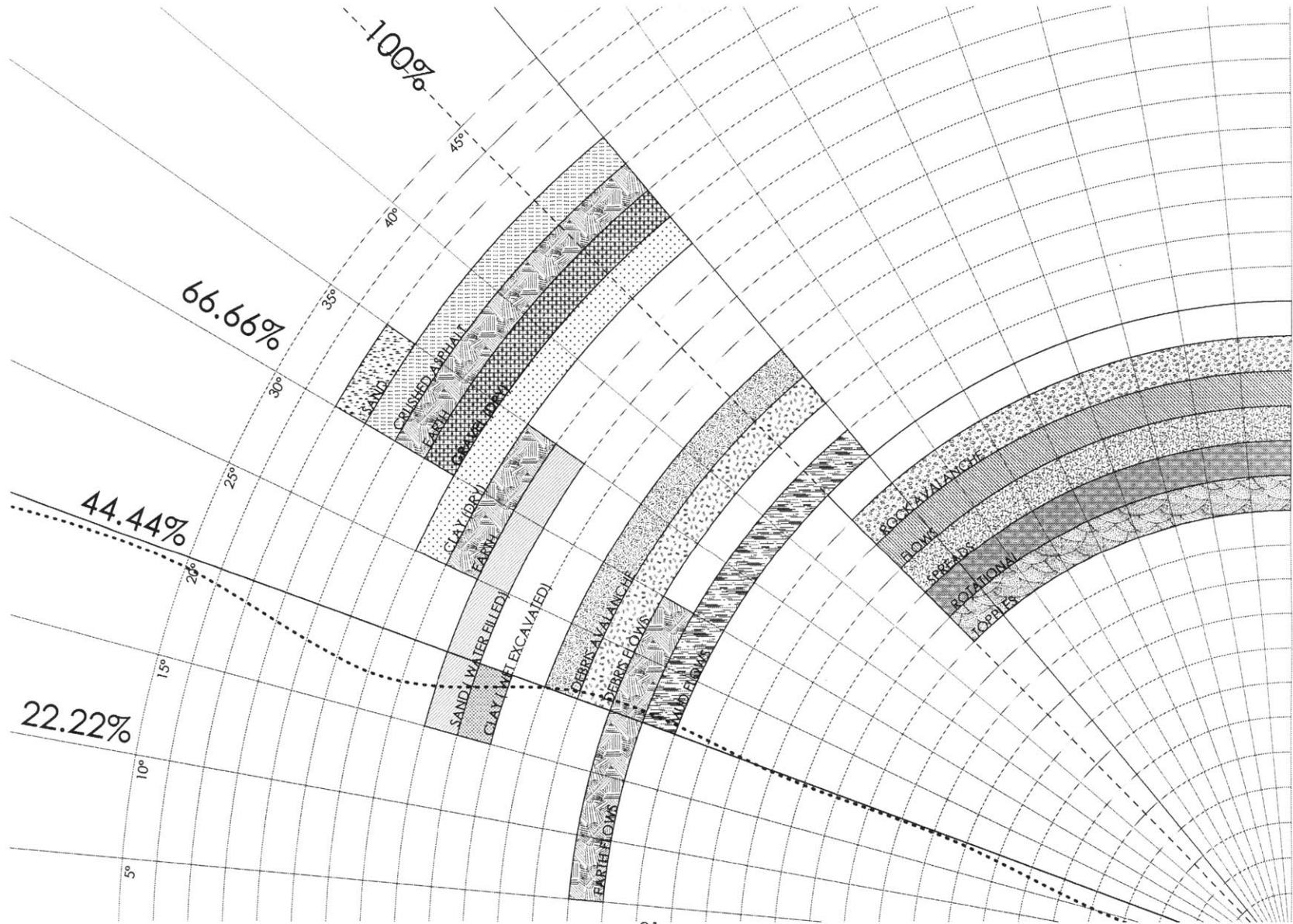
II. Geotech

A crash course in geotechnical engineering was necessary to provide a basic understanding of landslides and their causes. The types and causes of landslides are typically distilled into the following categories, providing a guide to begin deploying the design in scenarios that focus on the appropriate soil and slope conditions. The conditions that would make the most sense seem to be slides and flows.

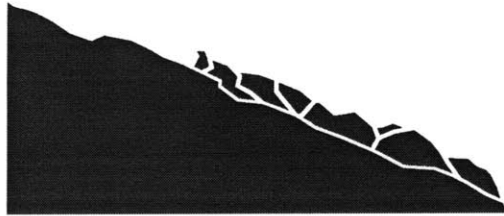
landslide - "the movement of a mass of rock, debris or earth down a slope". Varnes (1978)



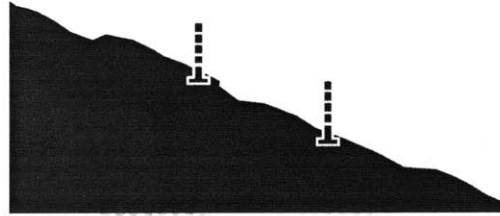




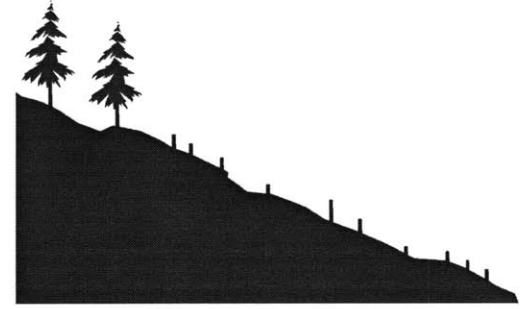
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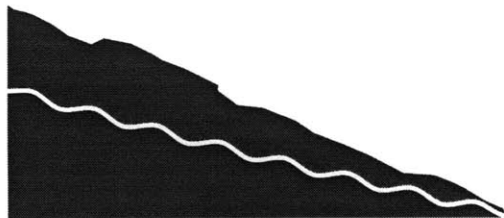
CONSTRUCTION



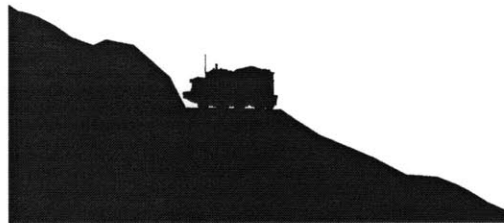
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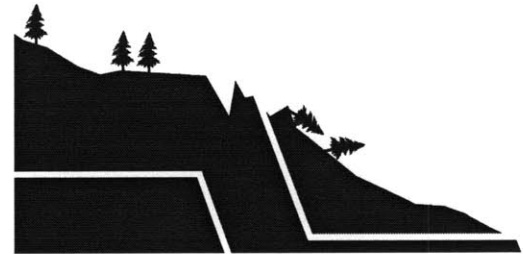
SUBSURFACE WATER FLOWS






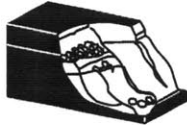



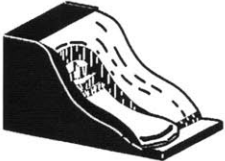









HEAVY MACHINERY



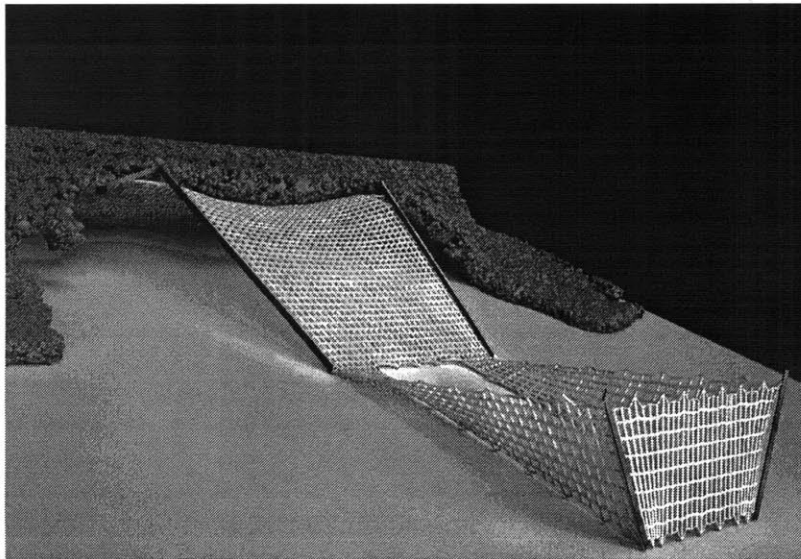
EARTHQUAKE

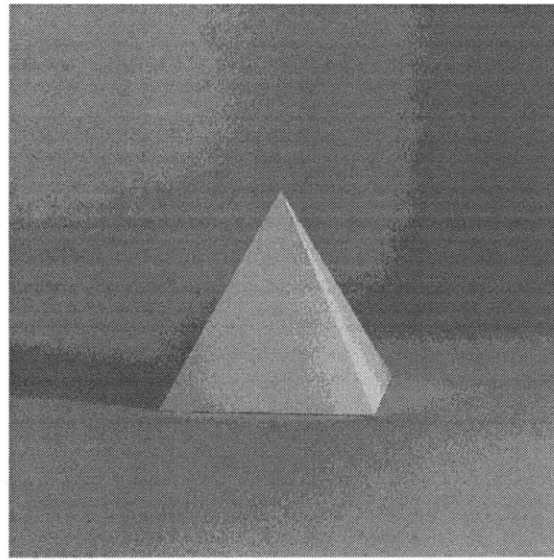
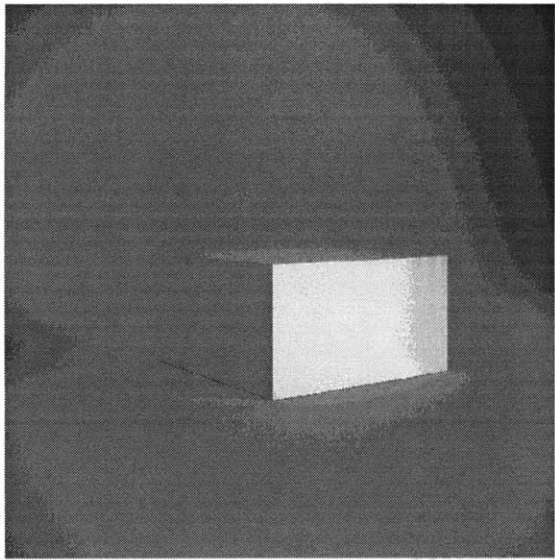


	FALLS	TOPPLES	SLIDES - TRANLATIONAL	SLIDES - ROTATIONAL	FLOWS	COMPLEX
ROCK						
DEBRIS						
EARTH						

III. Studies

A series of both physical and digital fluid dynamics studies was conducted as an initial set of experimental options to draw upon for further exploration. Primitive objects are scaled in x, y, and z axis and distributed in a variety of ways to guide, obstruct, or collect flows of granular debris material. The schemes become possibilities for micro urban spaces shown as both pre and post landslide potentials for space-making. A wide variety of topologies begins to inform the programmatic potential of the phase-change material manipulation.

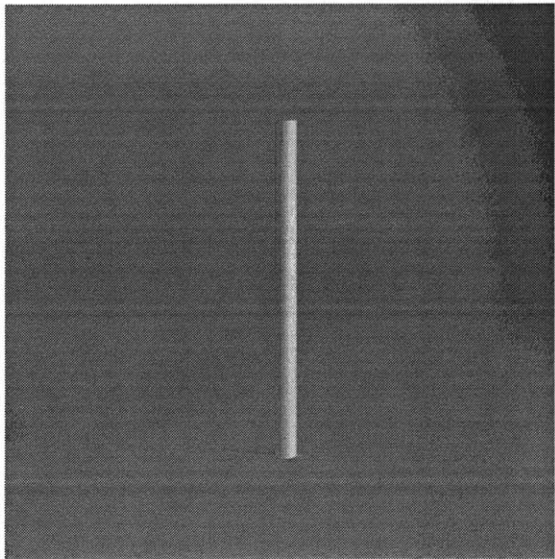




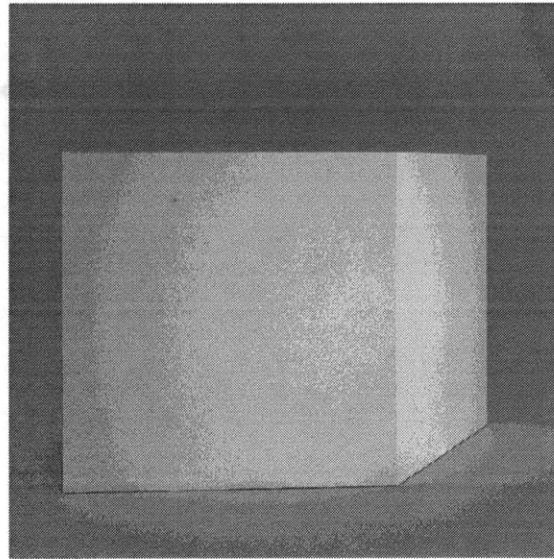
scale

distort

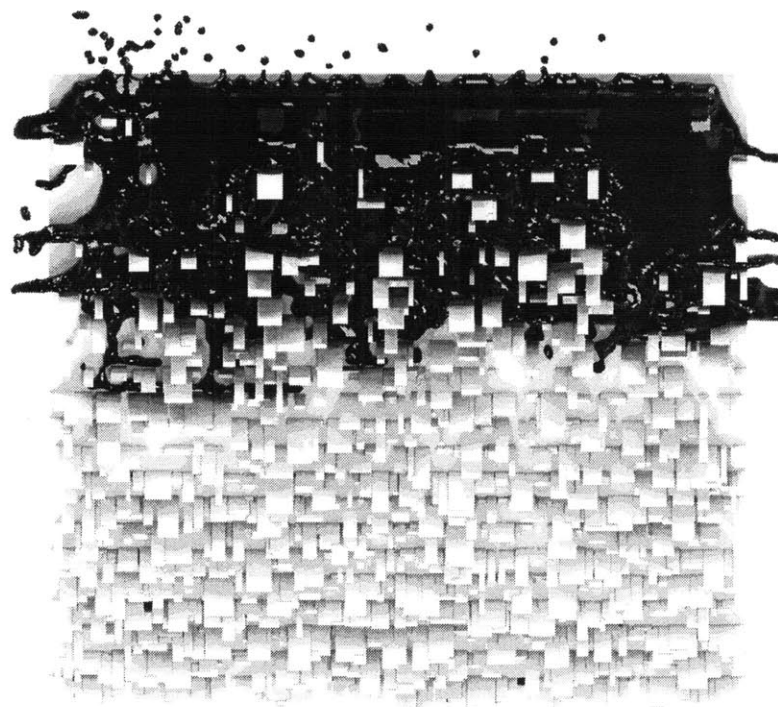
densify



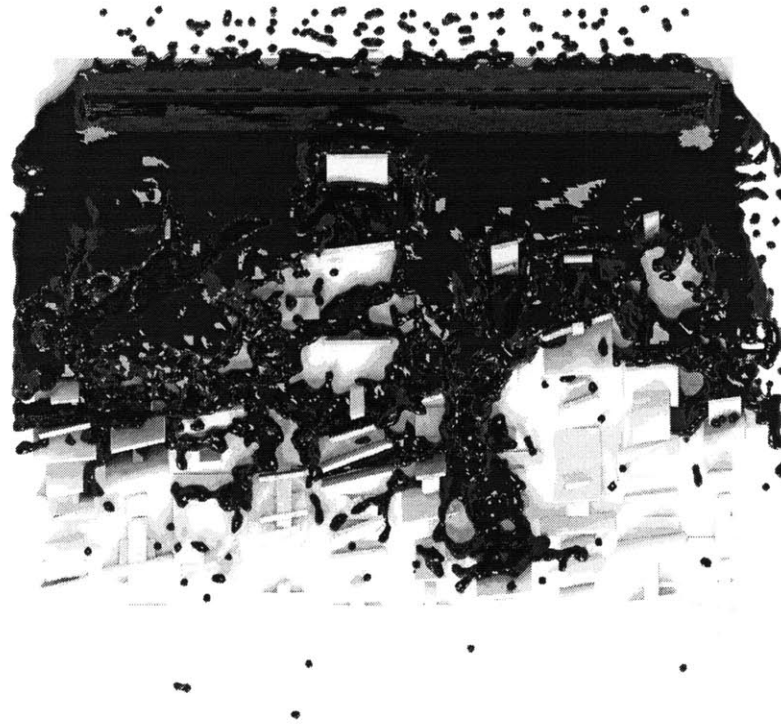
distribute



Frame: 60/200
Primitive: cube
Size: medium
Density: dense
Distribution: grid, x-shift
x-scale



Frame: 69/200
Primitive: cube
Size: medium
Density: dense
Distribution: noise, xyz
rotation



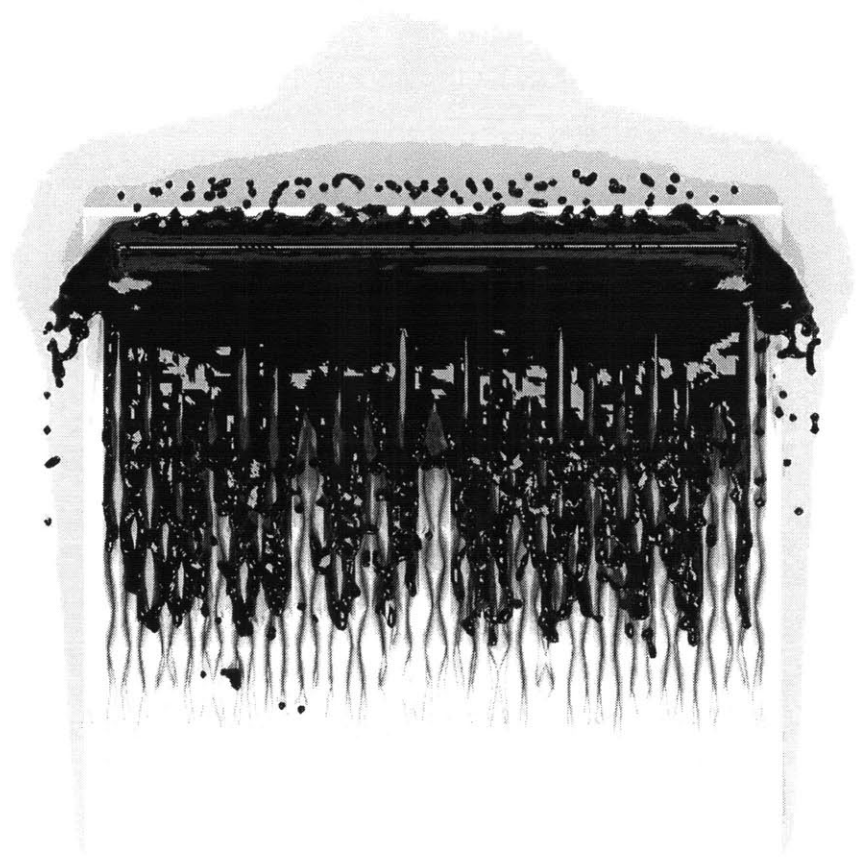
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Primitive: diamond
Size: medium
Density: dense
Distribution: grid, gradient
scale



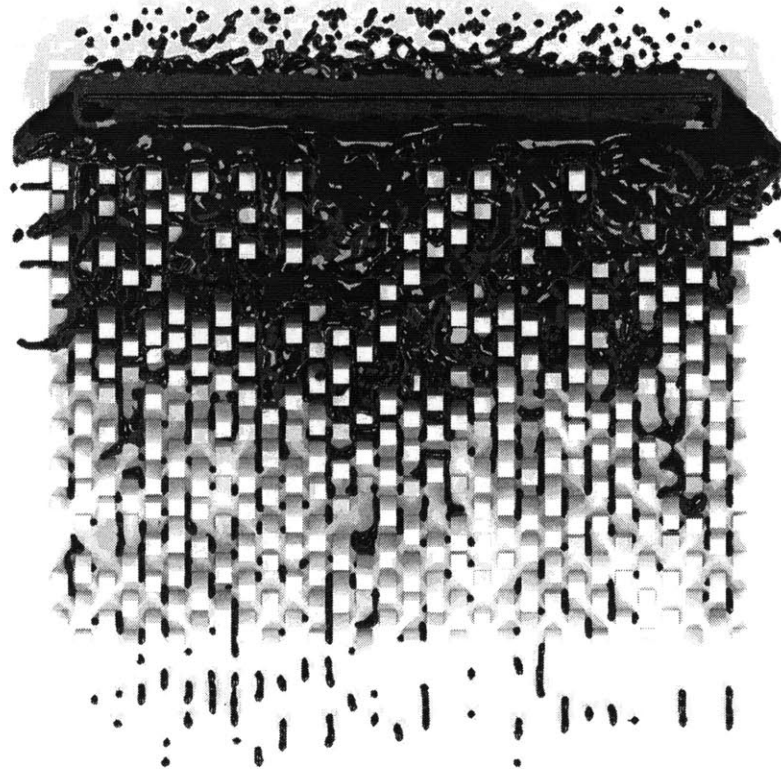
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Size: large
Density: sparse
Distribution: Grid, Y-shift



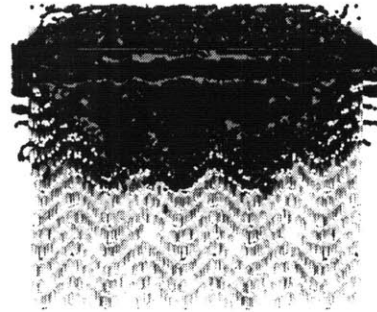
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Density: dense
Distribution: Y-Scaled



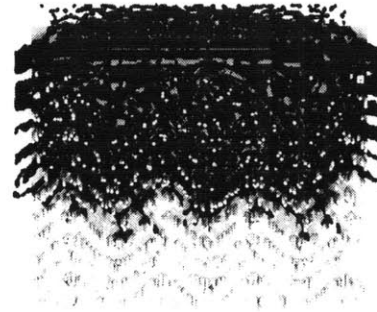
Frame: 85/200
Primitive: cube
Size: medium
Density: dense
Distribution: grid, z-scale



Frame: 150/200
Primitive: Cylinder
Size: small
Density: dense
Distribution: sine, noise



Frame: 150/200
Primitive: cylinder
Size: small
Density: medium
Distribution: sine, noise



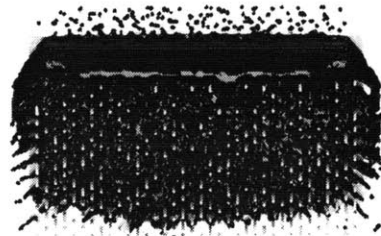
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Density: sparse
Distribution: sine, noise,
z-scale



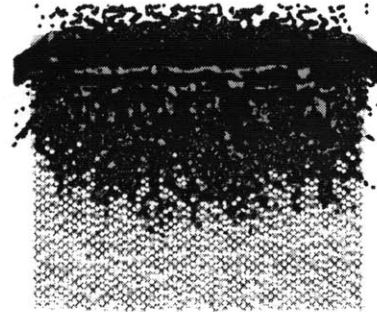
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Size: small
Density: medium
Distribution: noise, Y-scale



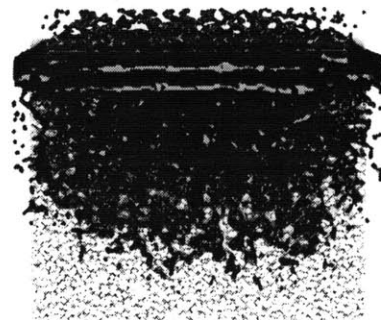
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Distribution: grid, shifted



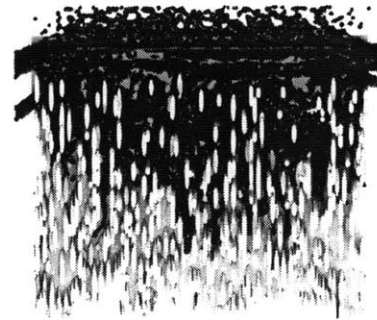
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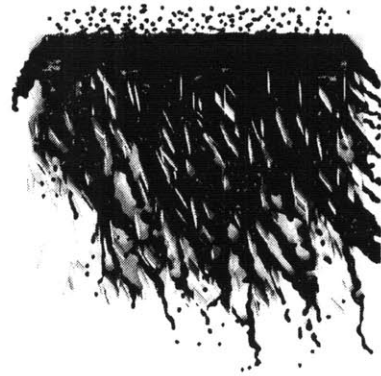
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Density: dense
Distribution: noise, z-scale



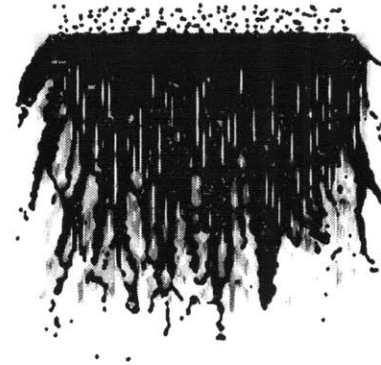
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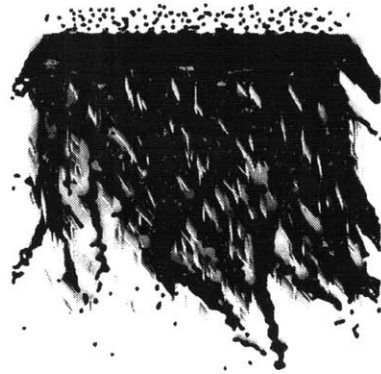
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Density: dense
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noise, z-scale



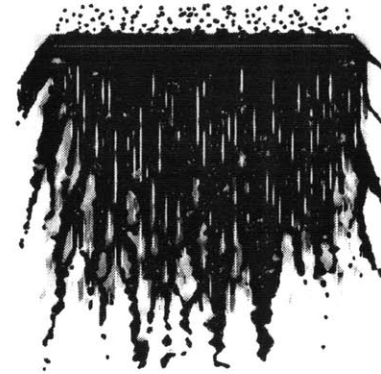
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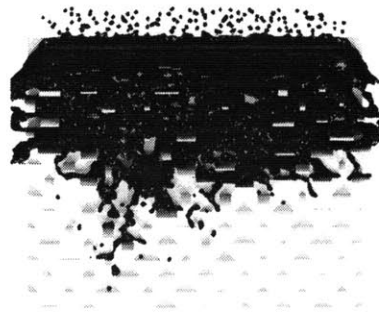
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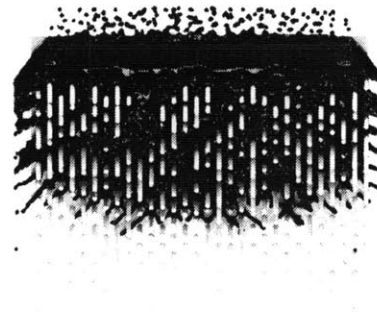
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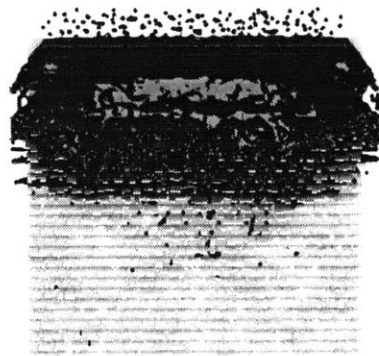
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Distribution: grid, x-shifted, x-scaled



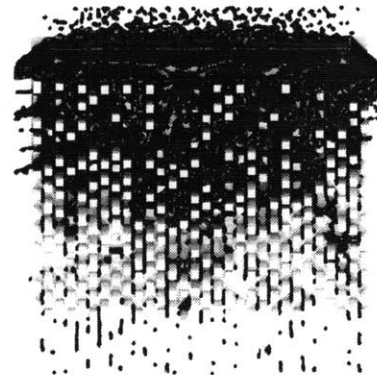
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Distribution: grid, shifted



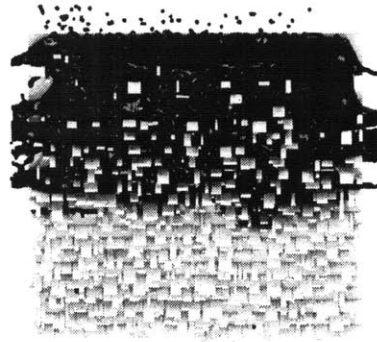
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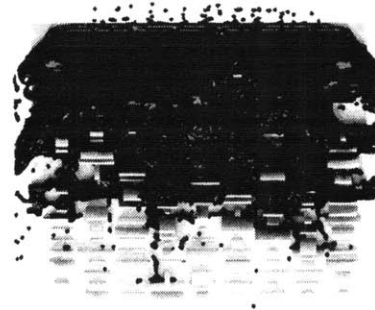
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Distribution: grid, shifted



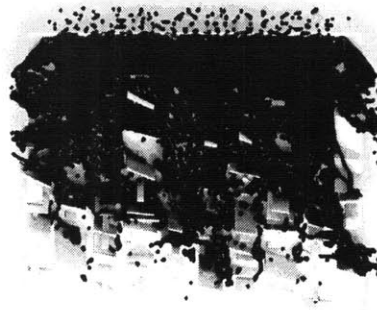
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Distribution: grid, x-shifted



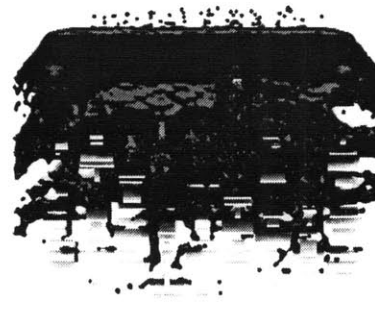
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Distribution: grid, x/y-shifted



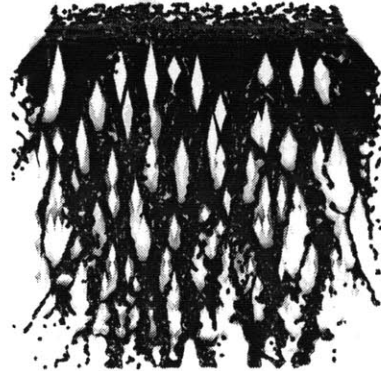
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Size: medium
Density: dense
Distribution: grid, z-scale



Frame: 85/200
Primitive: cube
Size: medium
Density: dense
Distribution: grid, z-scale



Frame: 80/200
Primitive: diamond
Size: medium
Density: medium
Distribution: grid, shifted



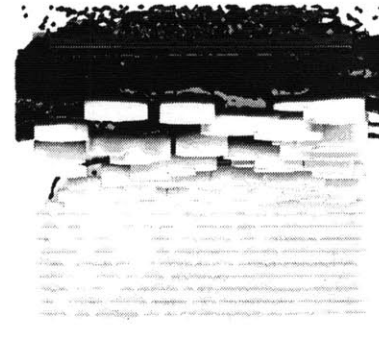
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Distribution: grid, z-scale



Frame: 50/200
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Size: medium
Density: medium
Distribution: grid, shifted



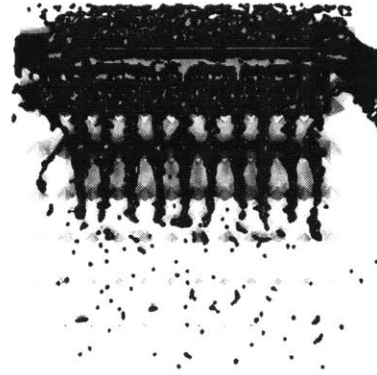
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Density: dense
Distribution: x-shifted grid,
gradient z-scale



Frame: 50/200
Primitive: pyramid
Size: medium
Density: dense
Distribution: grid, shifted



Frame: 60/200
Primitive: pyramid
Size: small
Density: sparse
Distribution: grid, gradient
z-scale



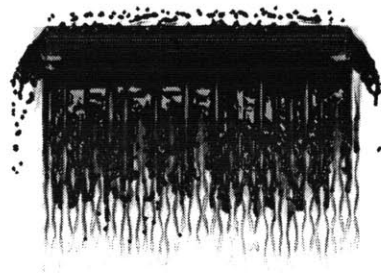
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Frame: 60/200
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Density: dense
Distribution: grid, shifted



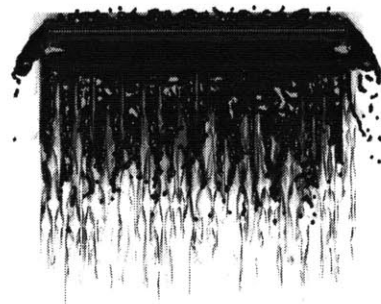
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Distribution: grid, shifted,
y-scale



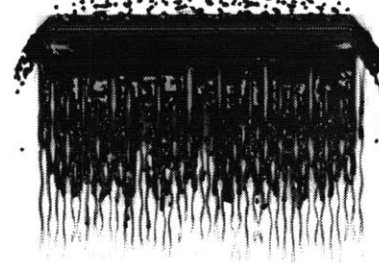
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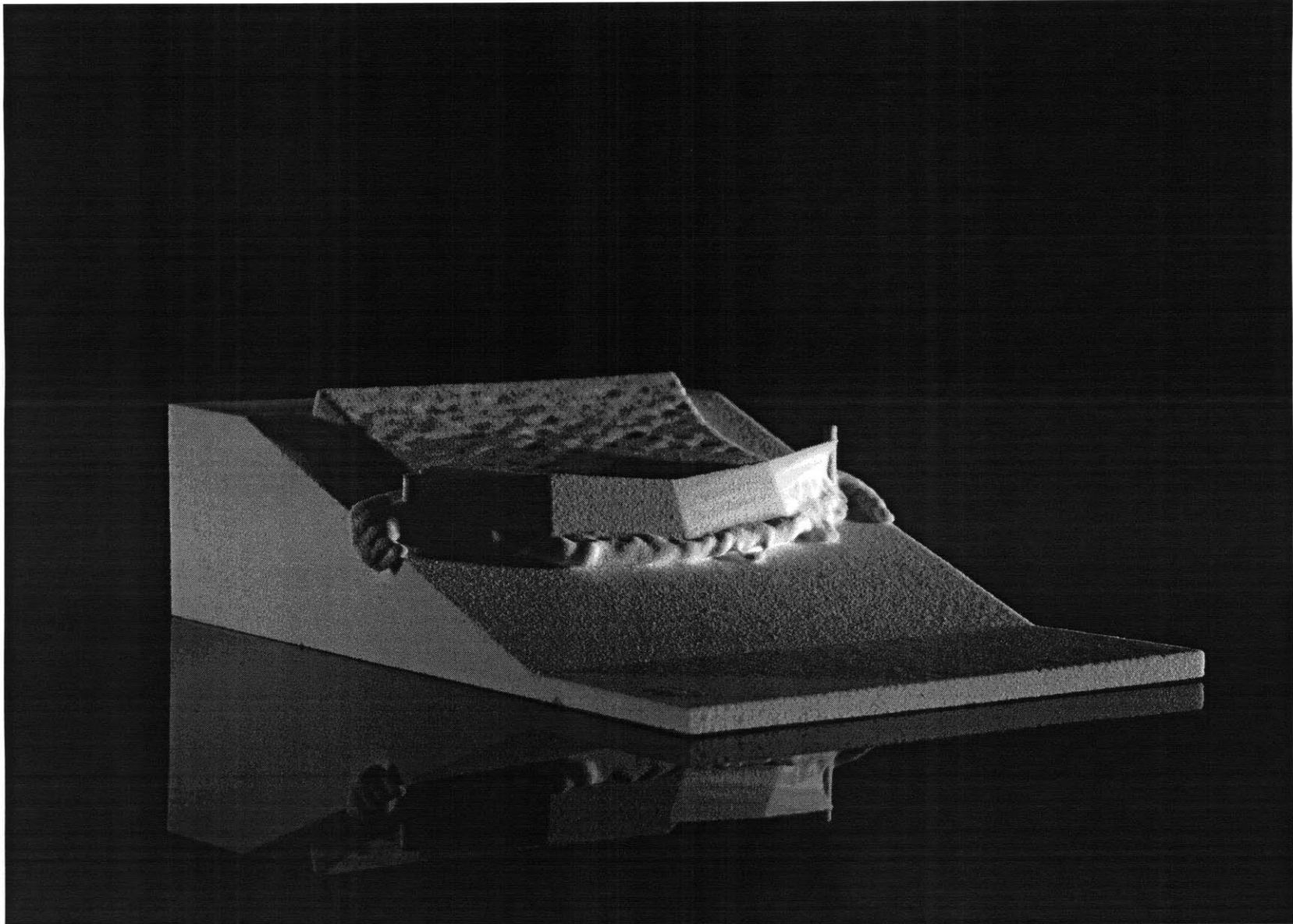


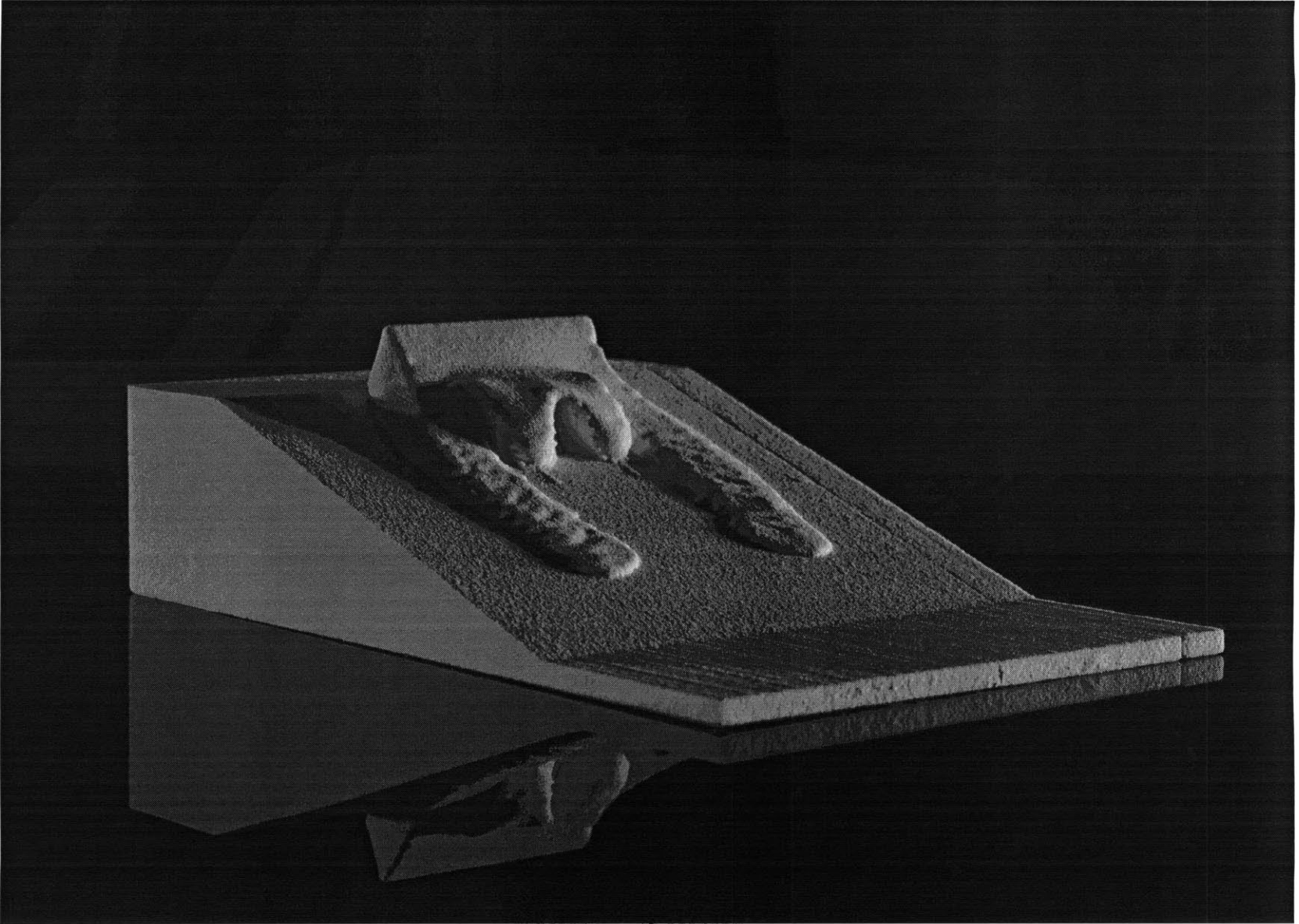
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Primitive: pyramid,
relaxed
Size: medium
Density: dense
Distribution: noise, y-scale

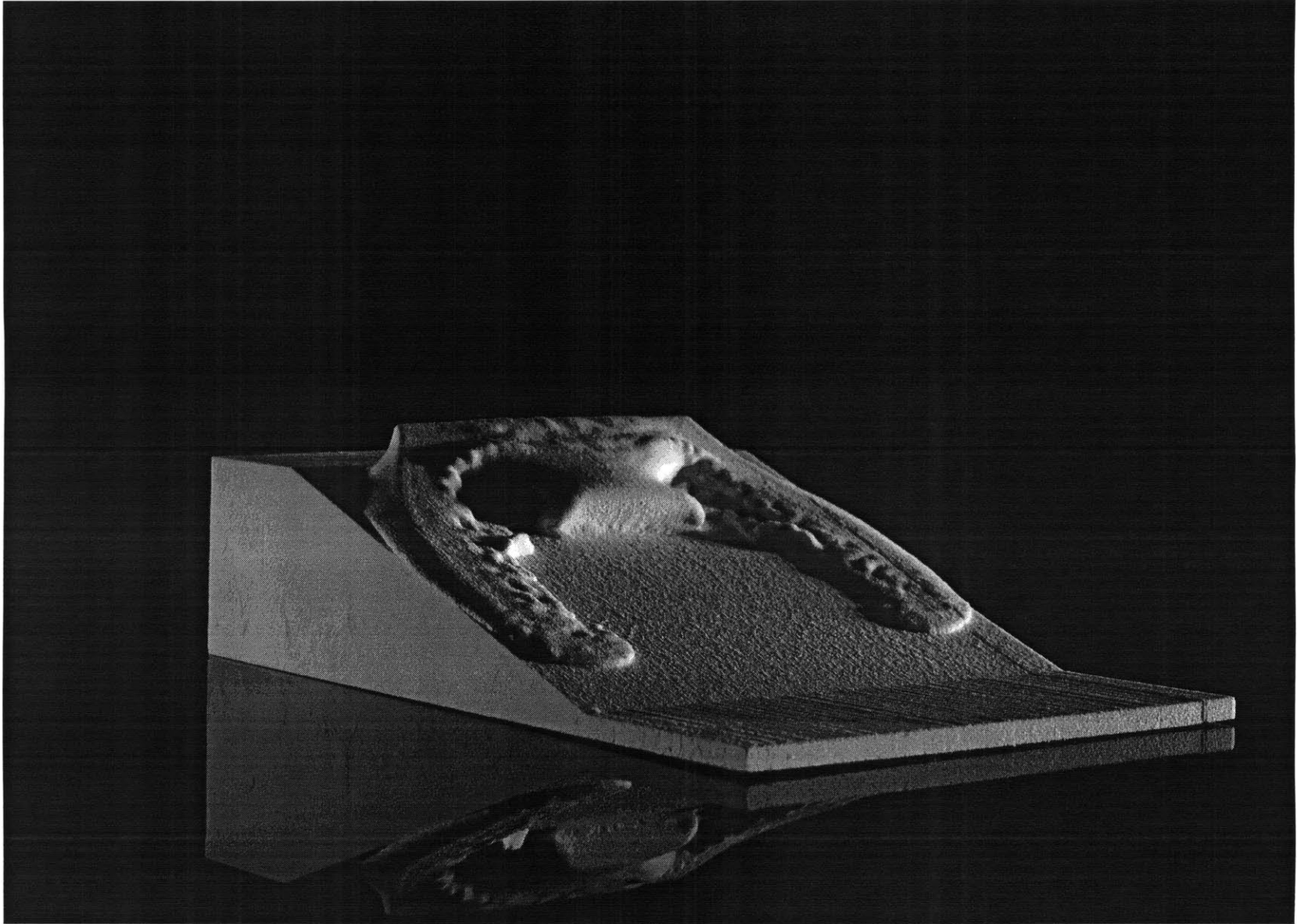


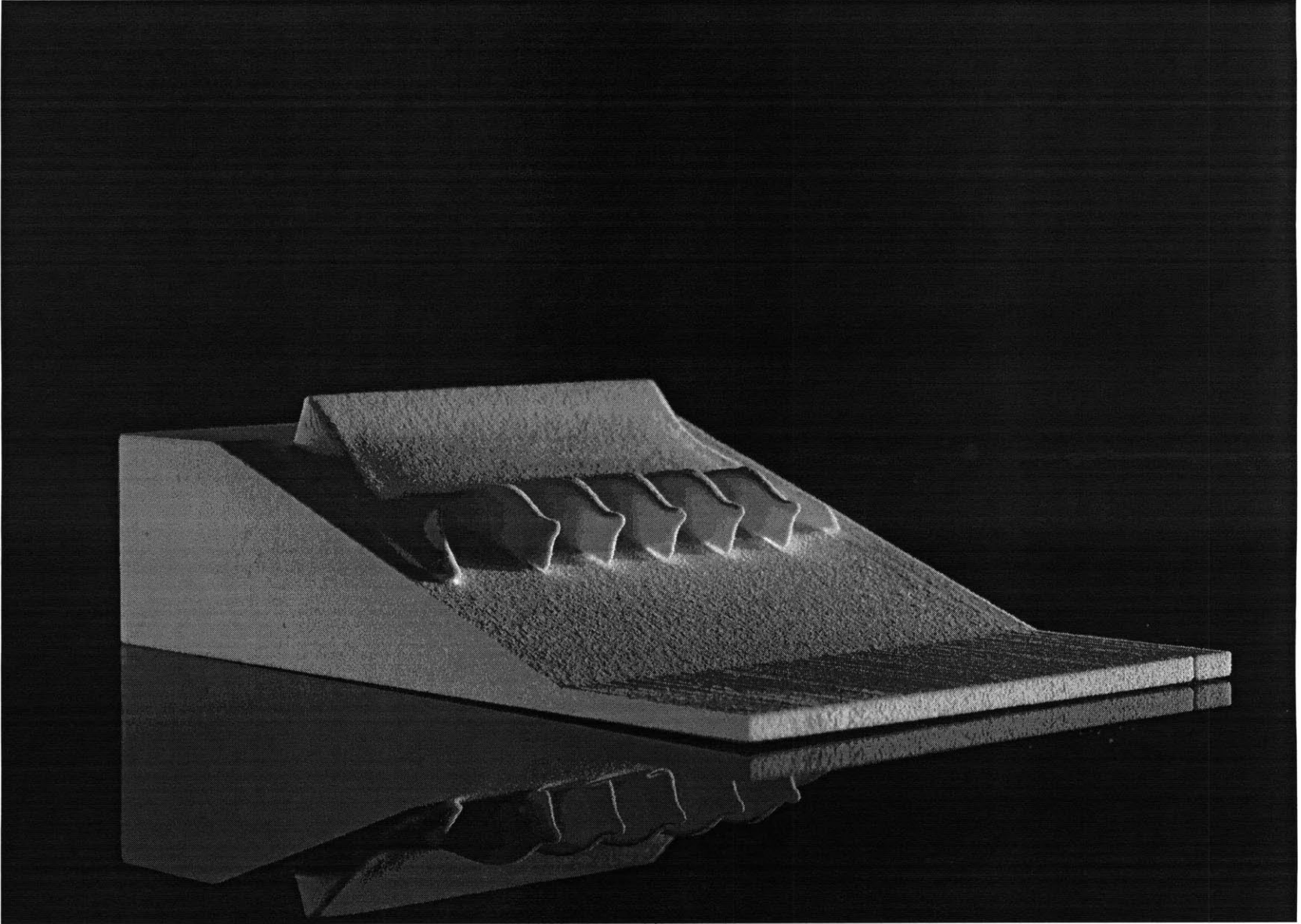
Frame: 85/200
Primitive: pyramid
Size: medium
Density: dense
Distribution: grid, shifted,
y-scale

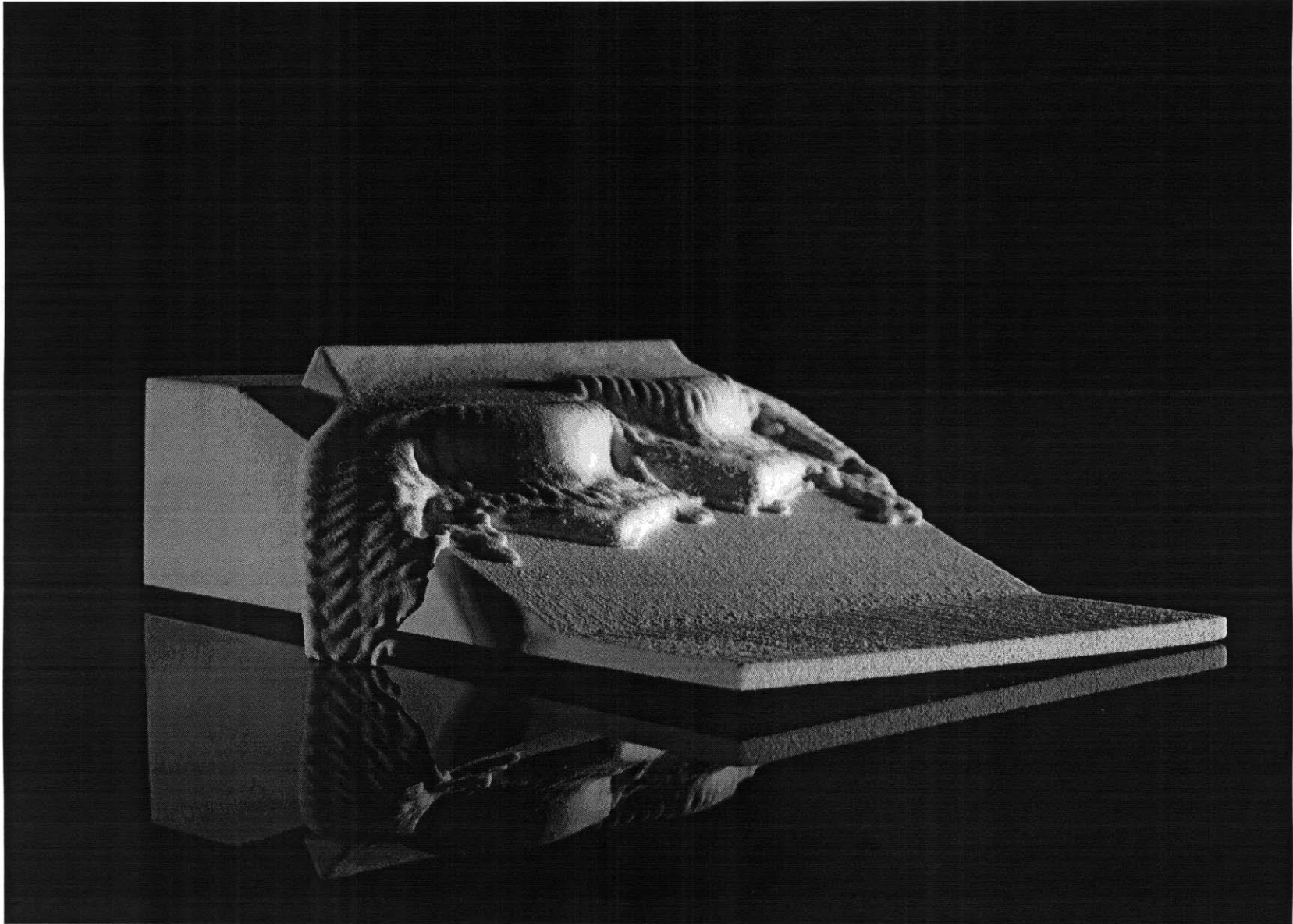


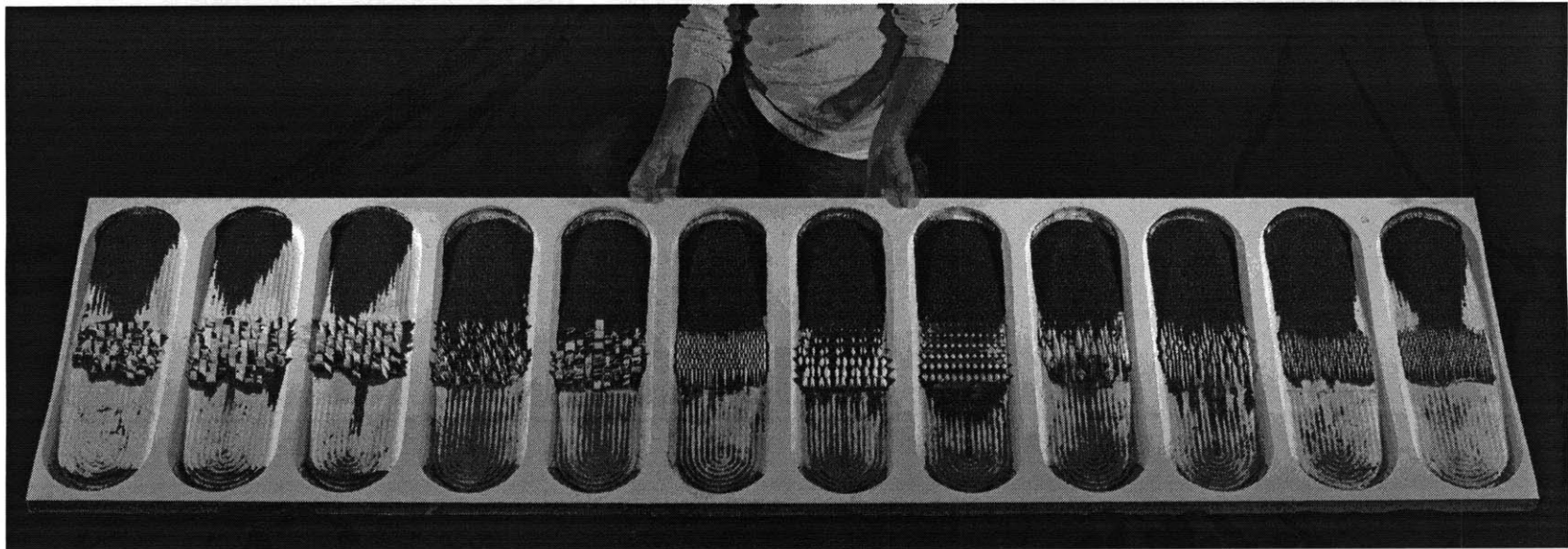
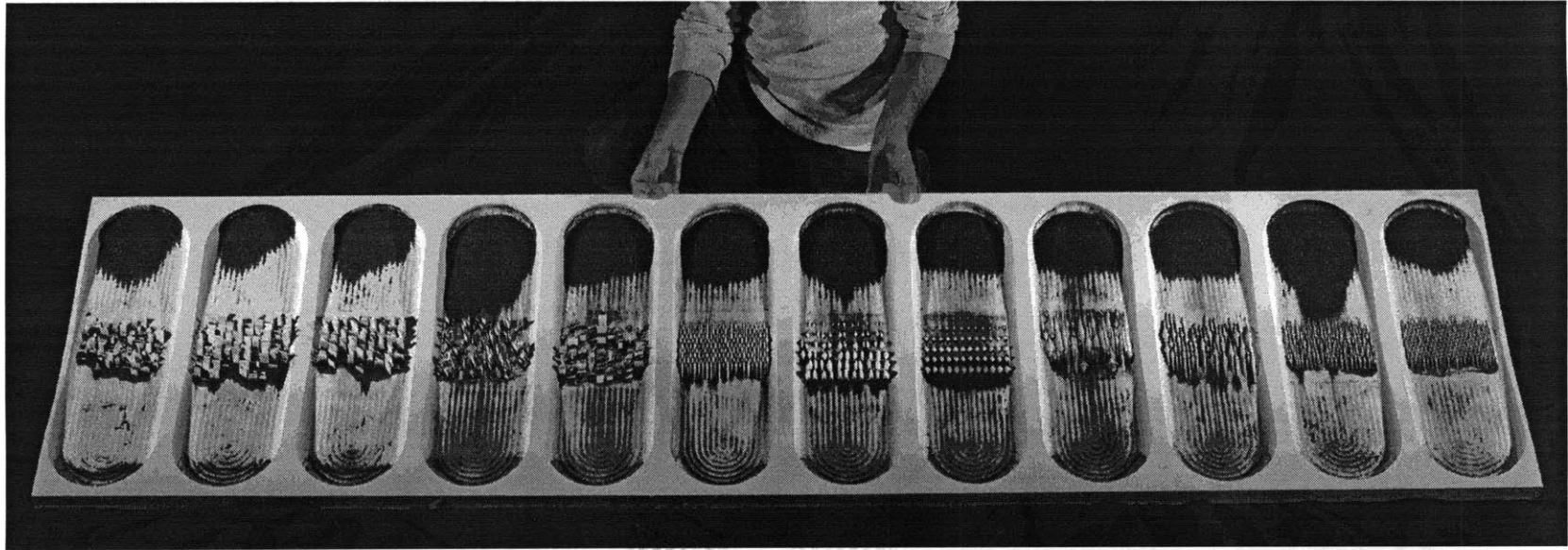




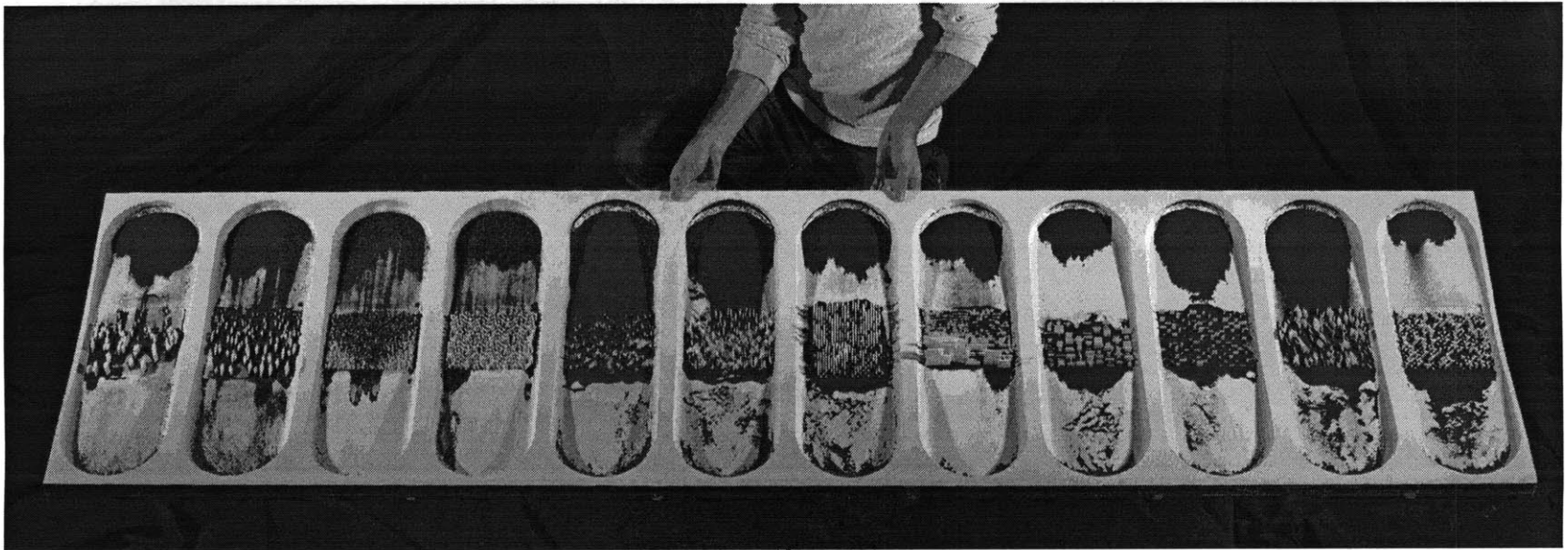


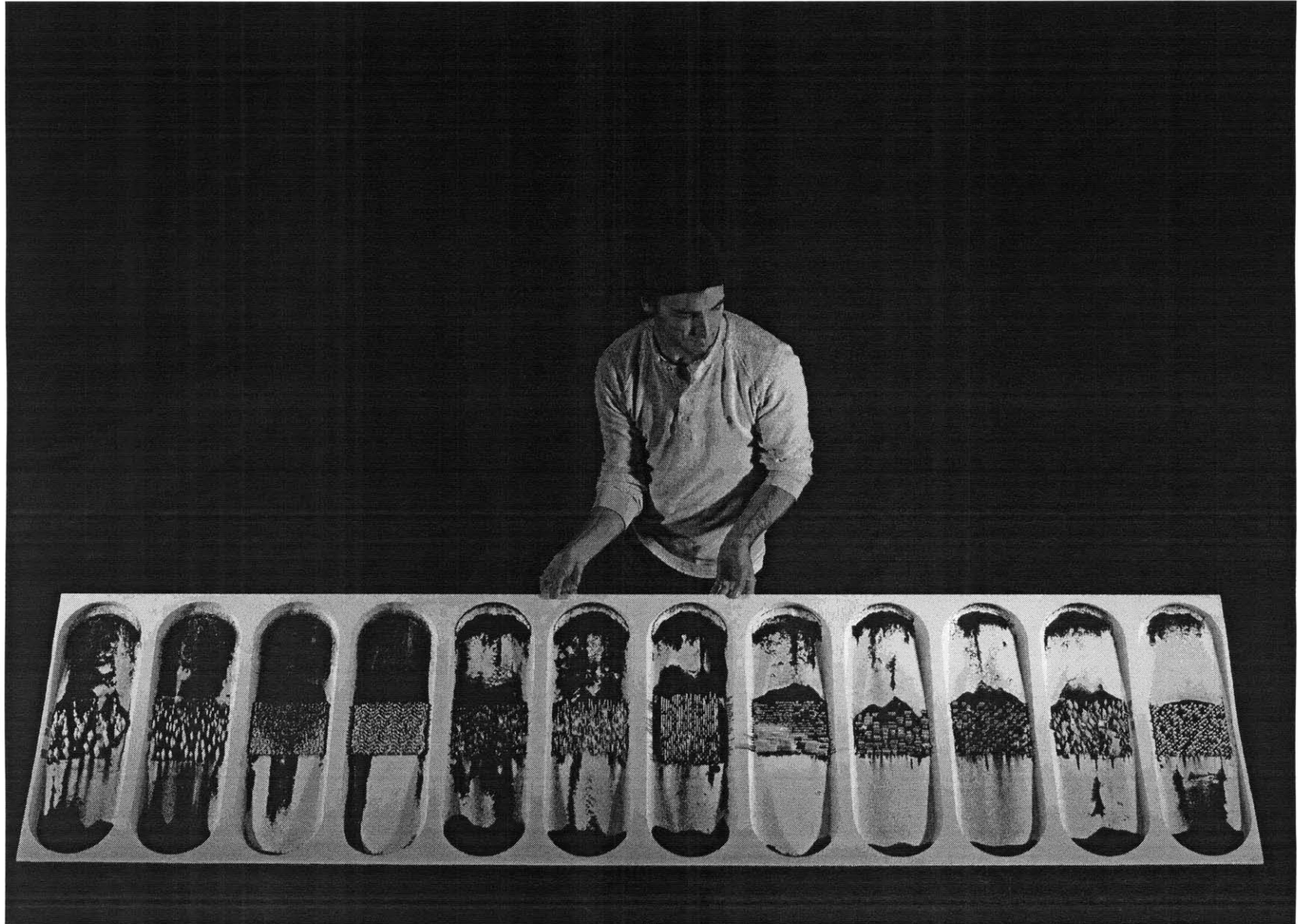


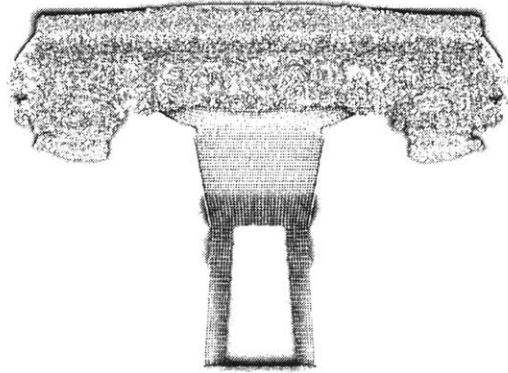












IV. Concepts

A wide variety of strategies were explored in an attempt to create a large-scale site of rapid manufacturing that could become a space for community gardens and recreation. Some were implemented in a synthesized, minimalist scheme that becomes spatial both before and after a landslide occurrence.

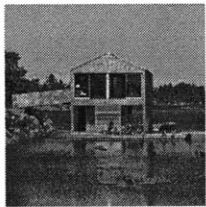
The strategies researched and considered include ideas of buoyancy, diversion, geocells, infusion, jamming, water-weight, deposition, and restraint. They are essentially driven by a process that deals with a dynamic fluid pressure. The hope is that by taking advantage of the existing flows in geology, we can capture and configure materials in a controlled manner, creating a productive scenario from large, otherwise dangerous occurrences.

The design proposed produces a barrier at the front of the unit, diverting material into the space between the double-layered skin of steel mesh. These hyperbolic, fabric-like surfaces are anchored by pilons driven deep into the ground by a portable drilling machine. This is the only 'heavy' process needed. The rest is flexible, light and transparent, yet still provides safe passage and a sense of architectural enclosure when occupied.

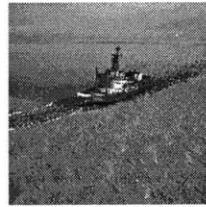
In the post-landslide phase, the unit becomes infused with debris material. This material can act as full enclosure or as an open-aired, light-filtering membrane. If needed, the top layer can then be pulled taught, restraining the material for a finalized form.

“It is not true that physical geography is not flexible....So, what I am trying to do are projects that are reversible, projects that can easily become different to what they initially were.”

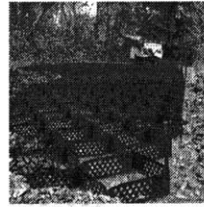
- Bernardo Secchi



Buoyancy



Diversion



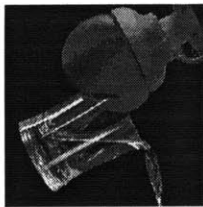
Geocells



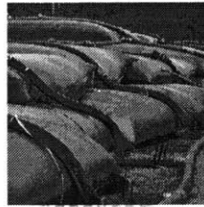
Infusion



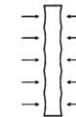
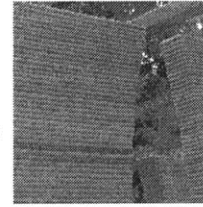
Jamming



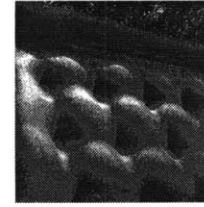
Water-Weight

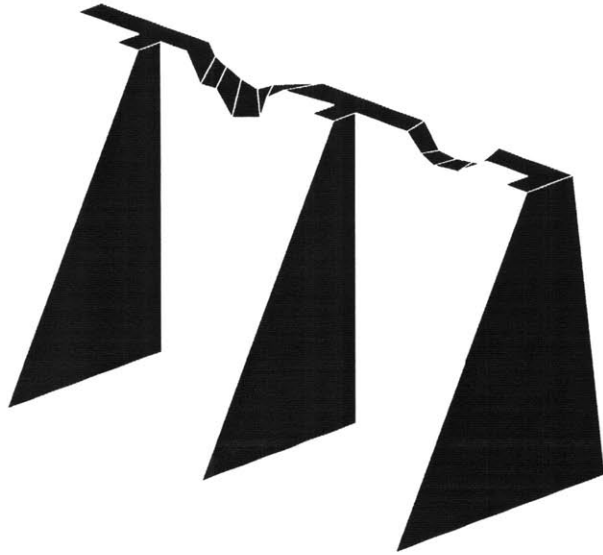


Deposition

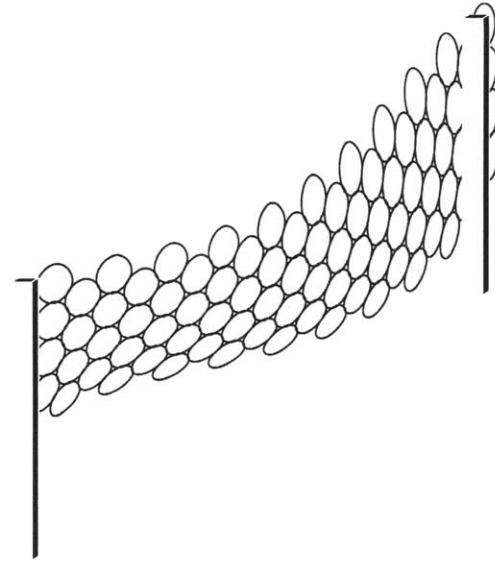


Restraint

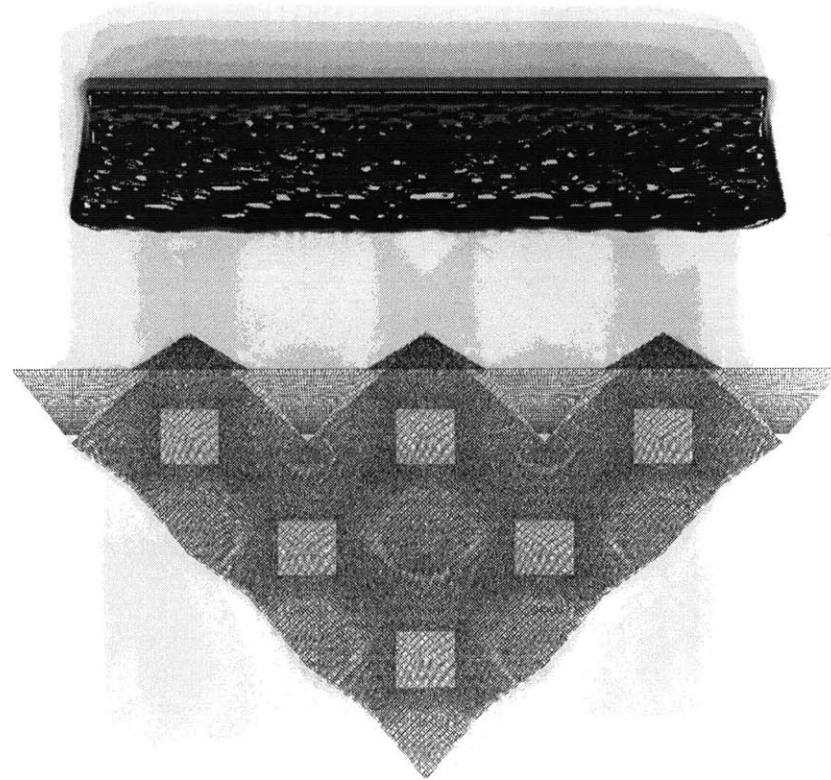


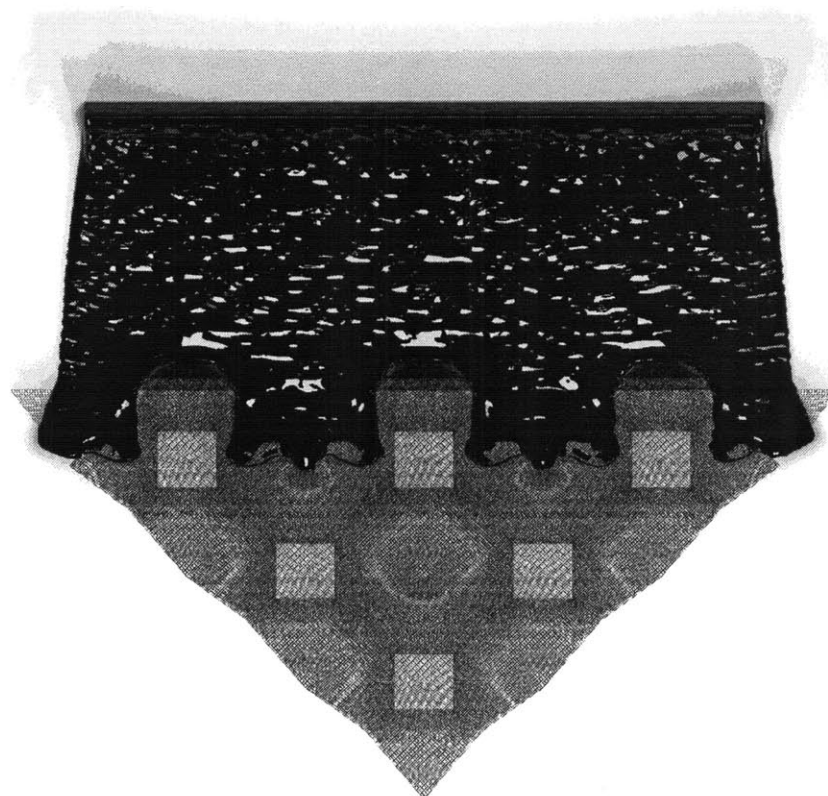


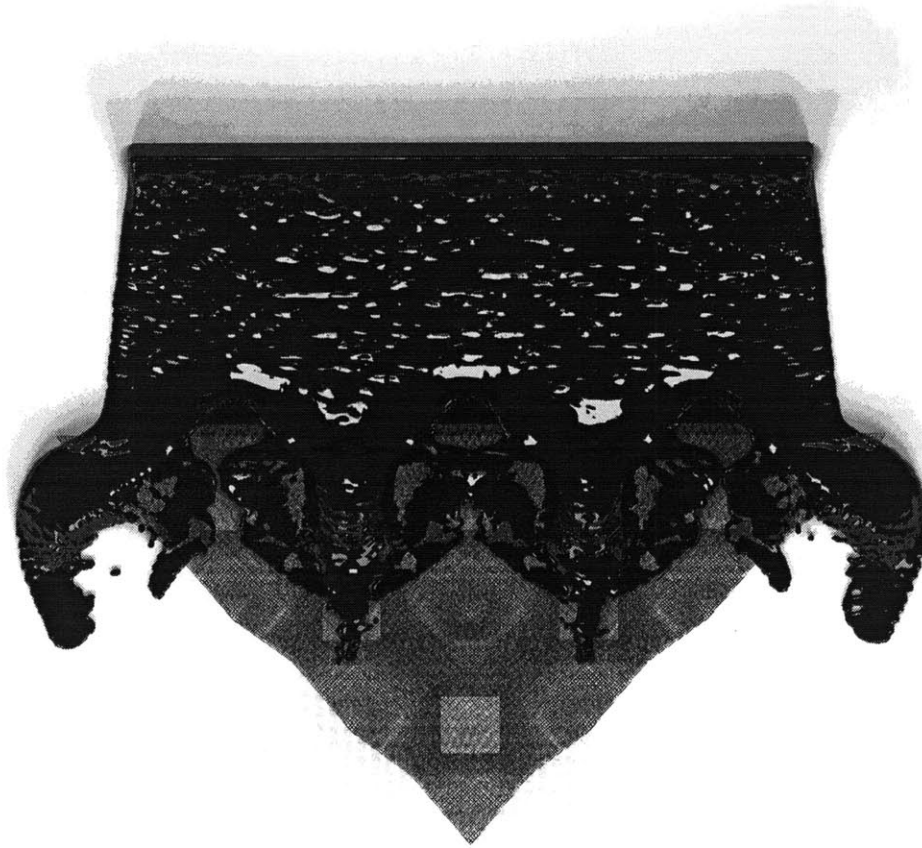
This 'hard' barrier for debris flow mitigation is difficult to deploy and breaks up over time, becoming ineffective.

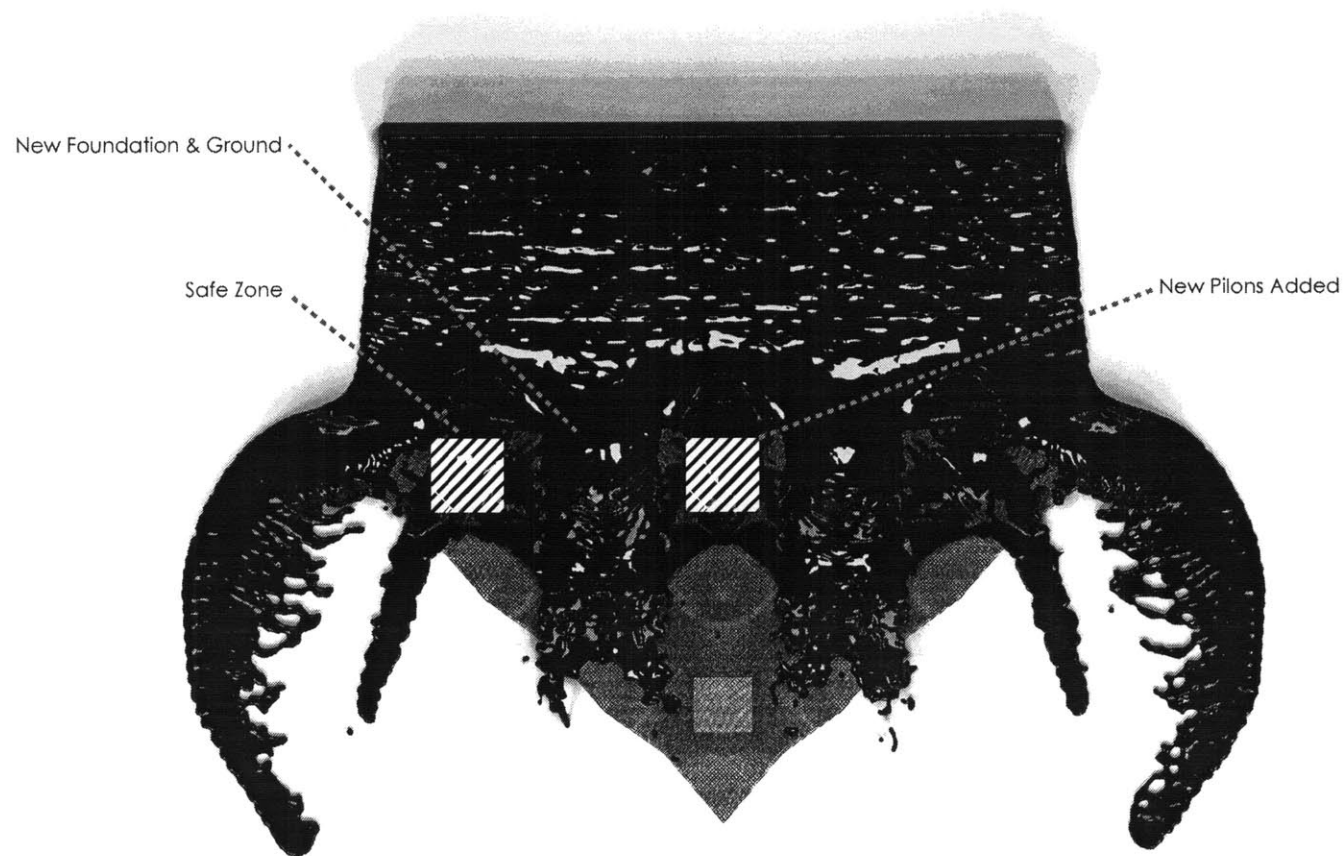


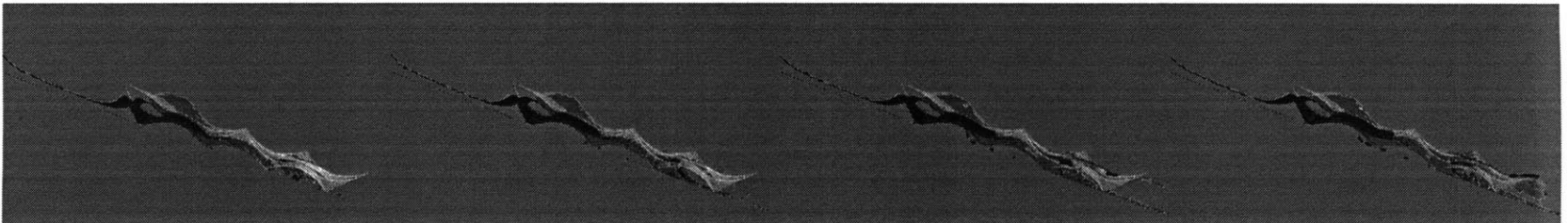
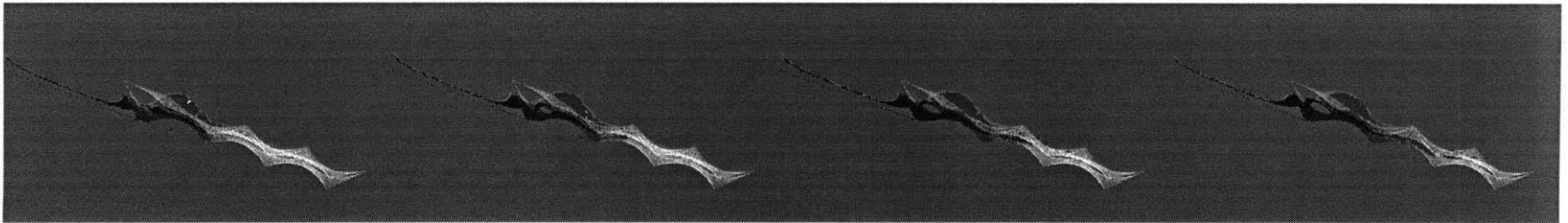
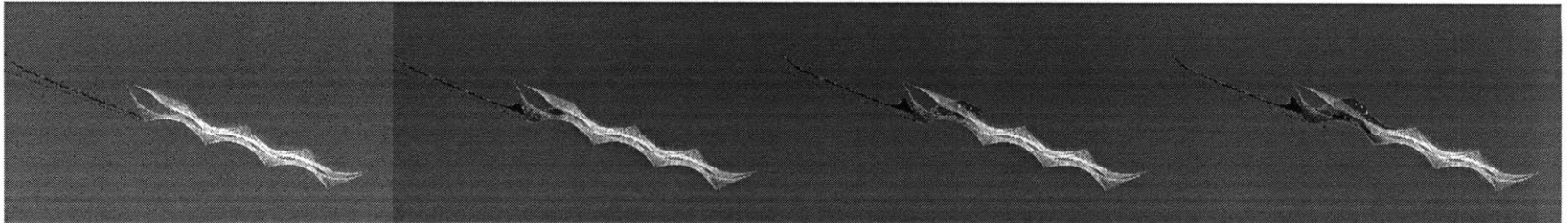
A soft strategy becomes a more viable and easily deployable solution, but is still only a geotechnical solution. An architectural use for this resilient infrastructure requires another step of design development that the proposed system provides, merging architecture, landscape, and infrastructure.



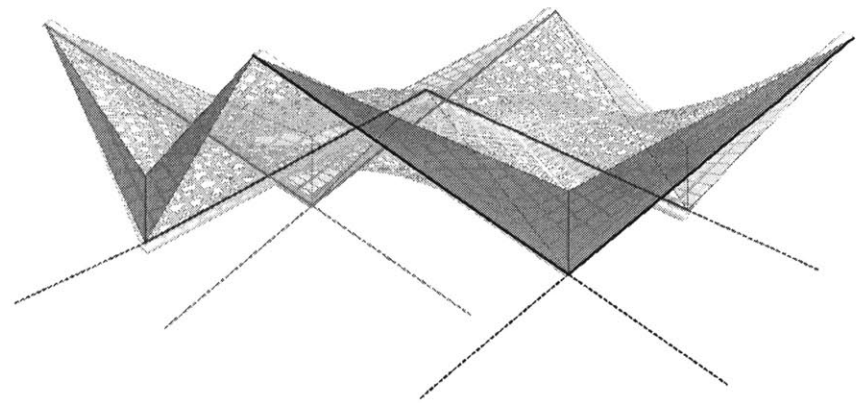
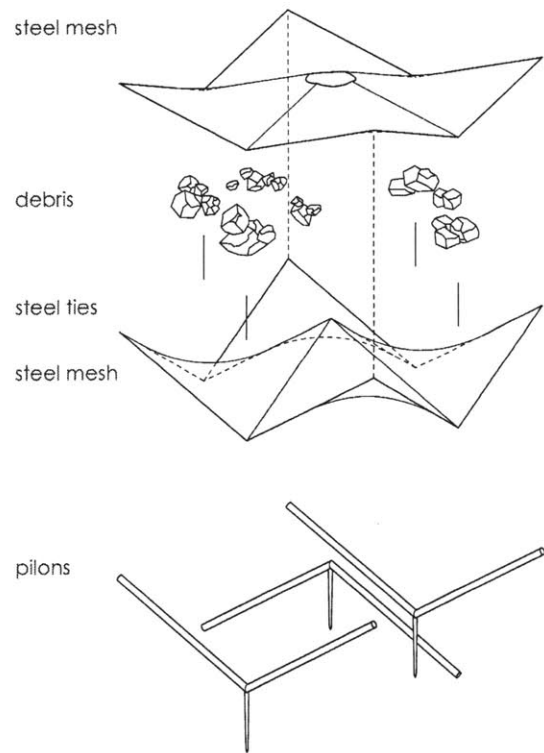




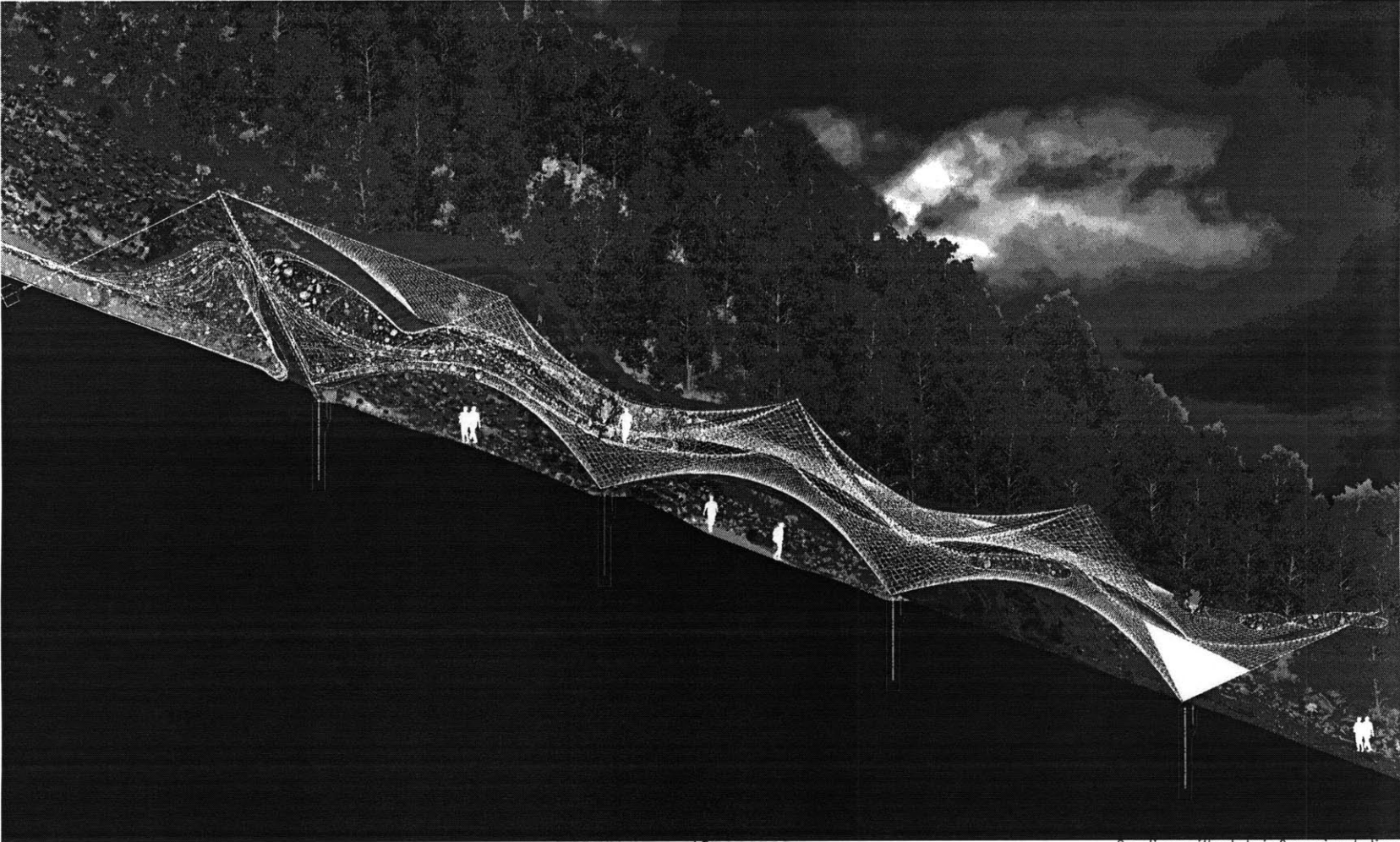


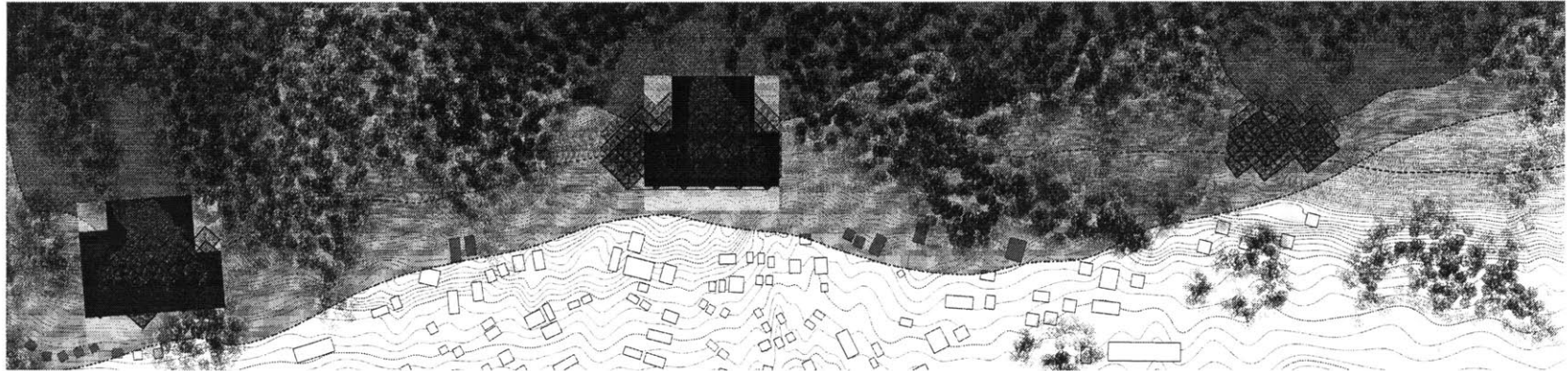


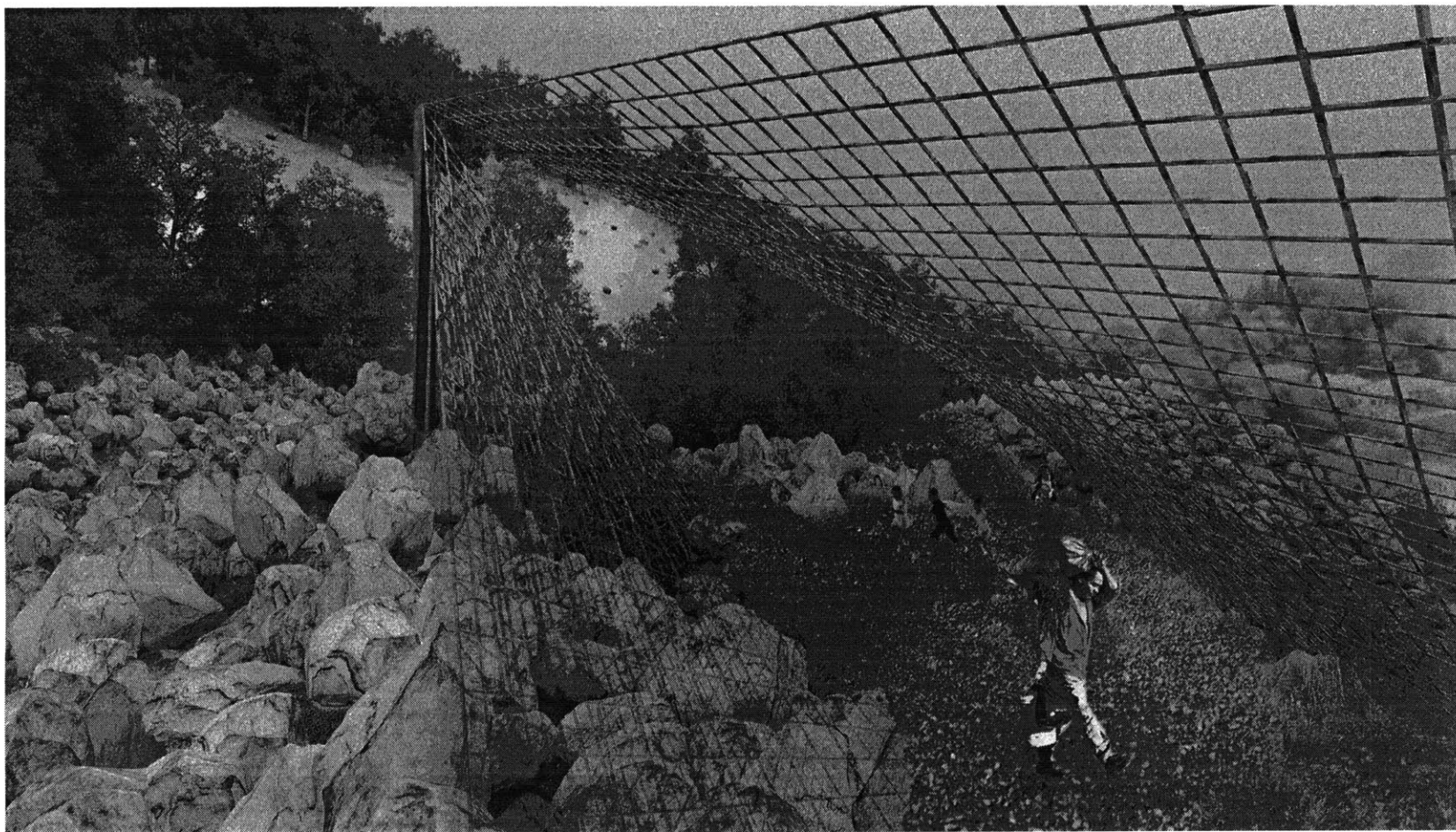


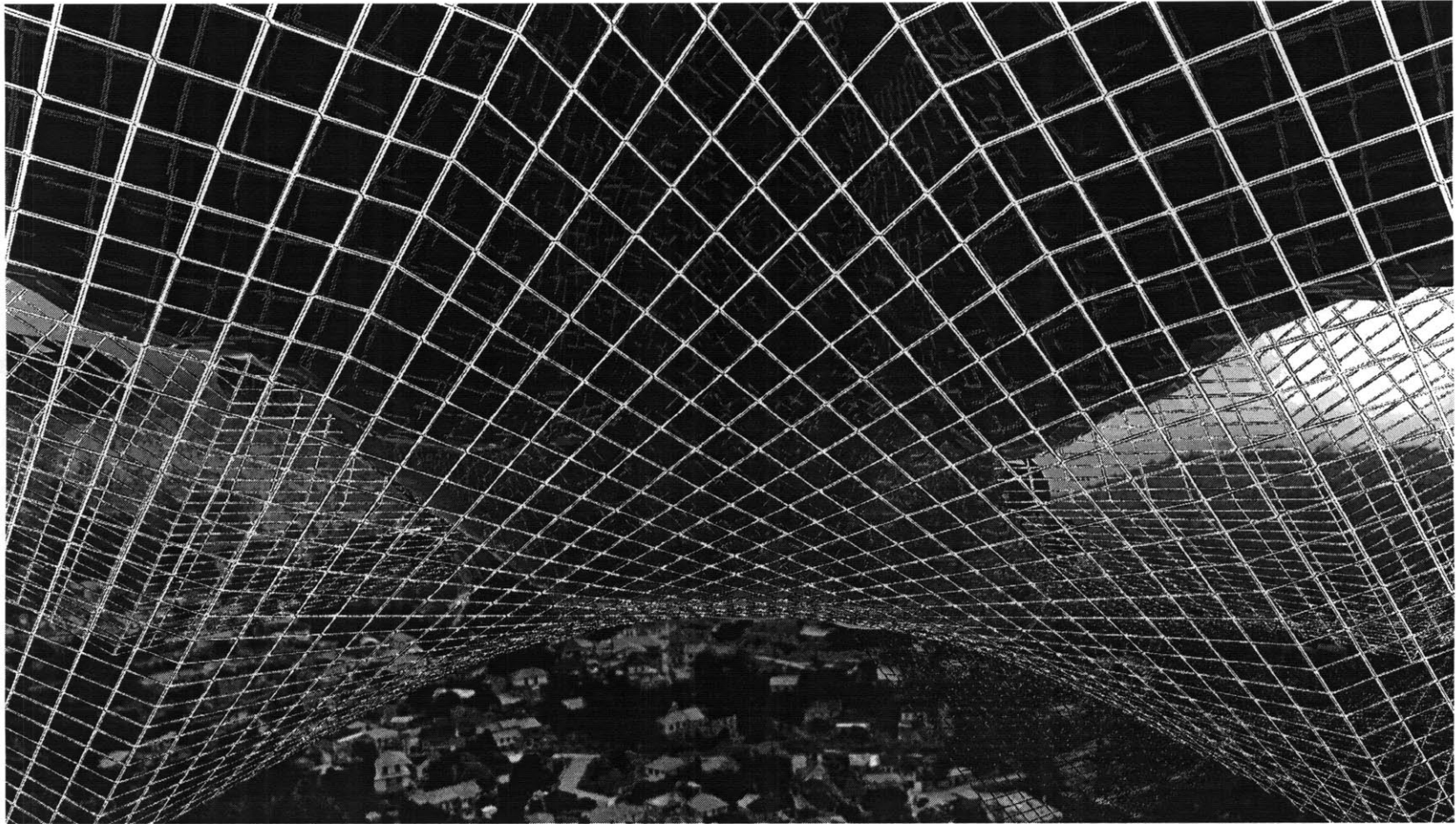


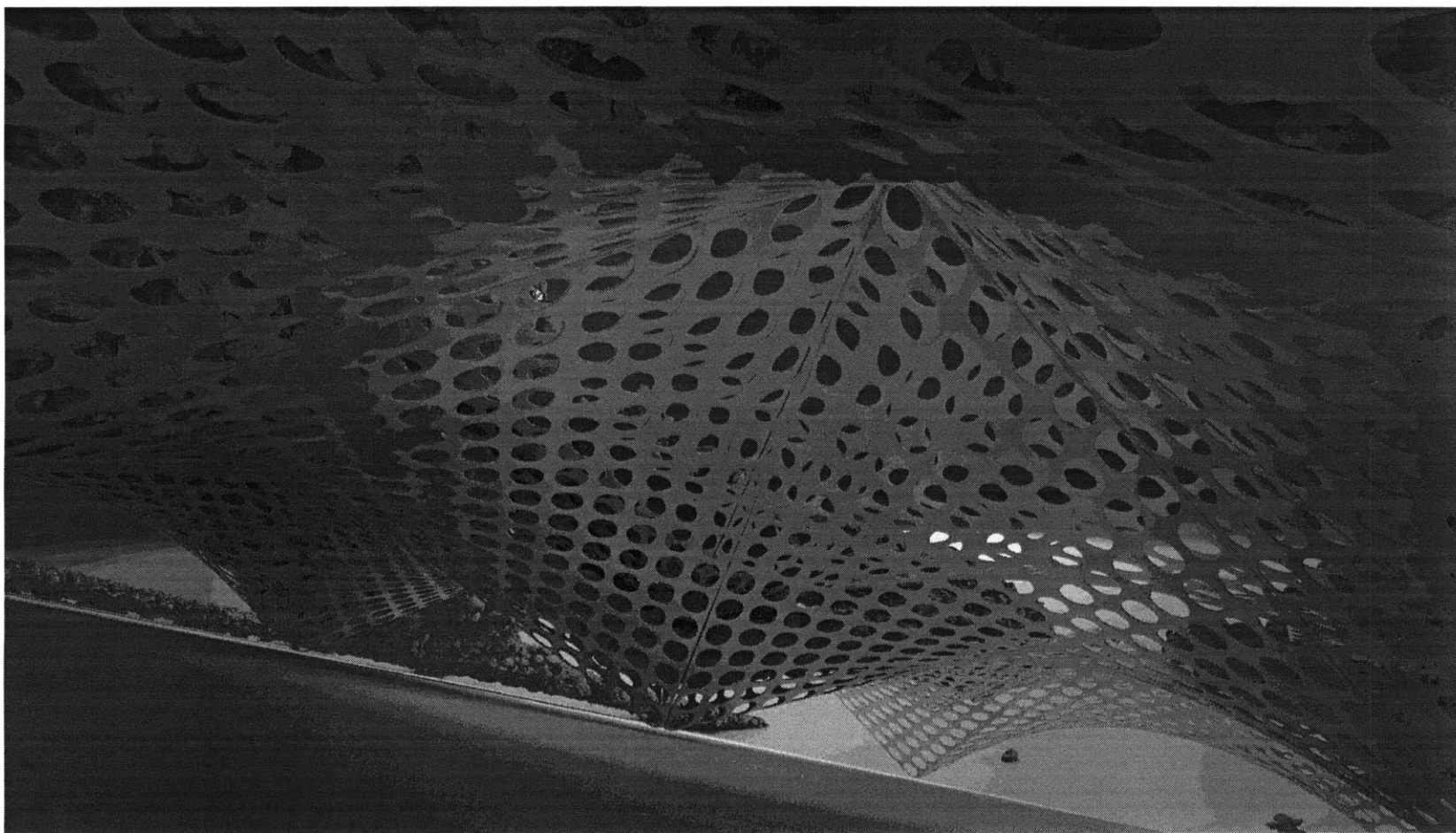
V. Design



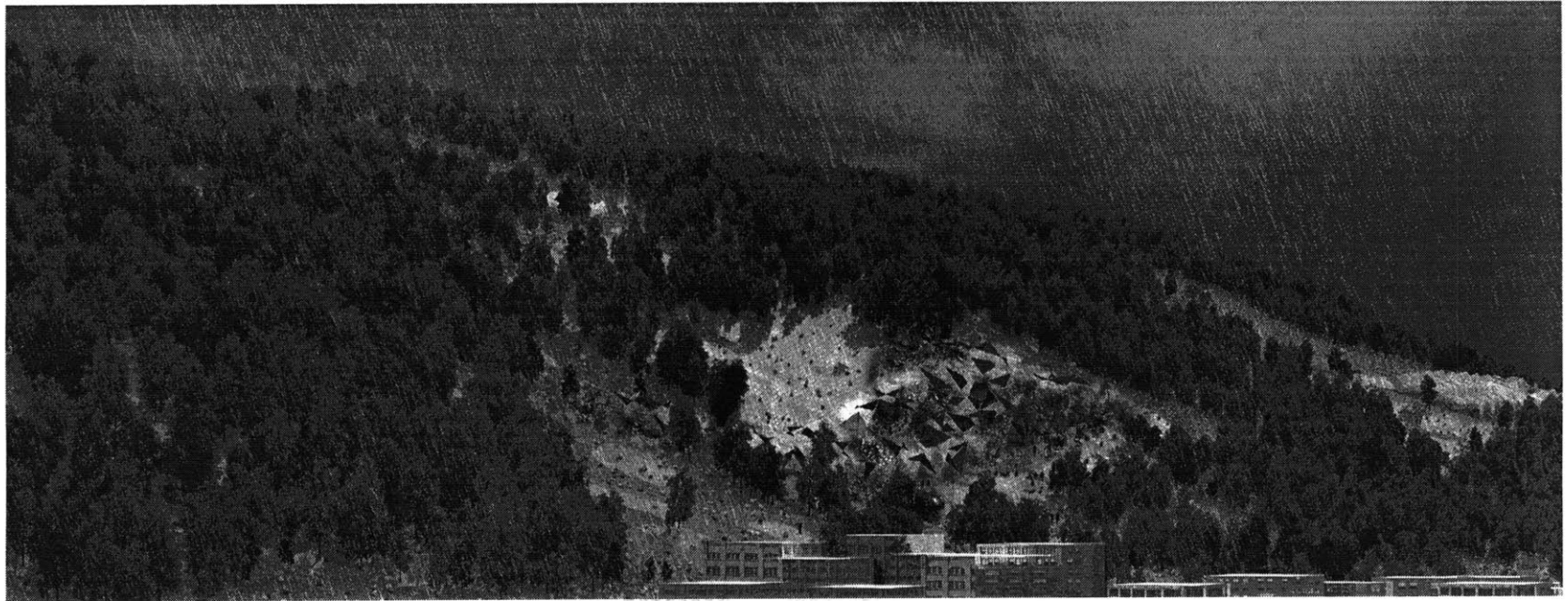


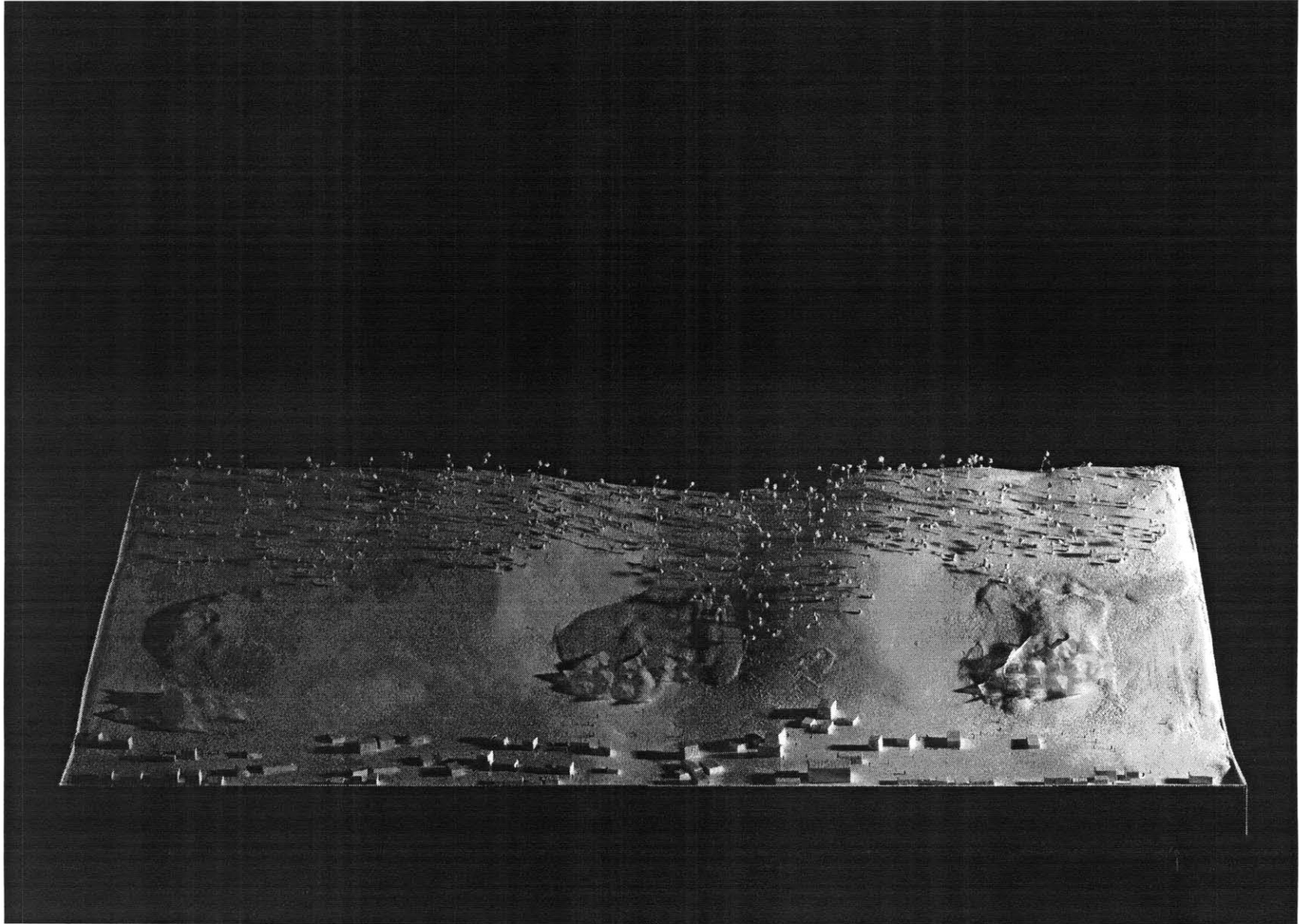


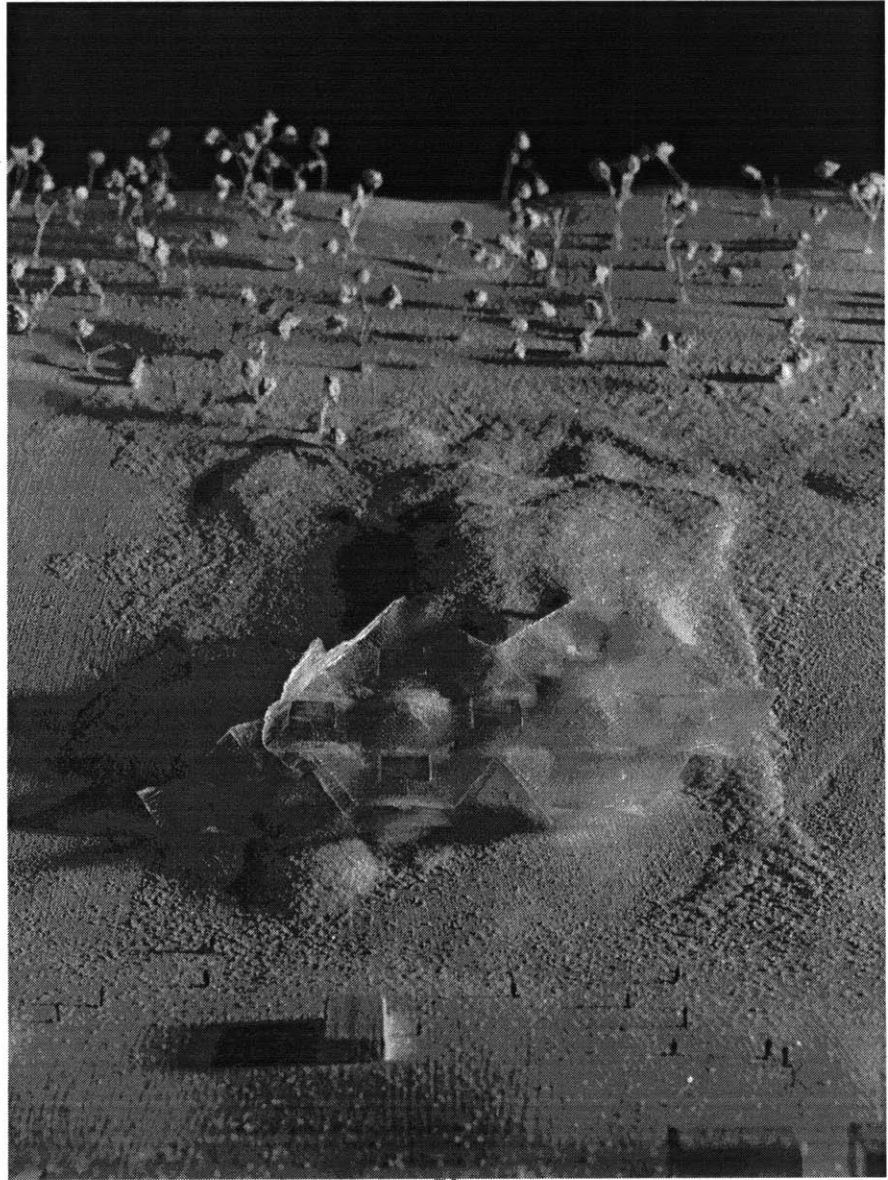


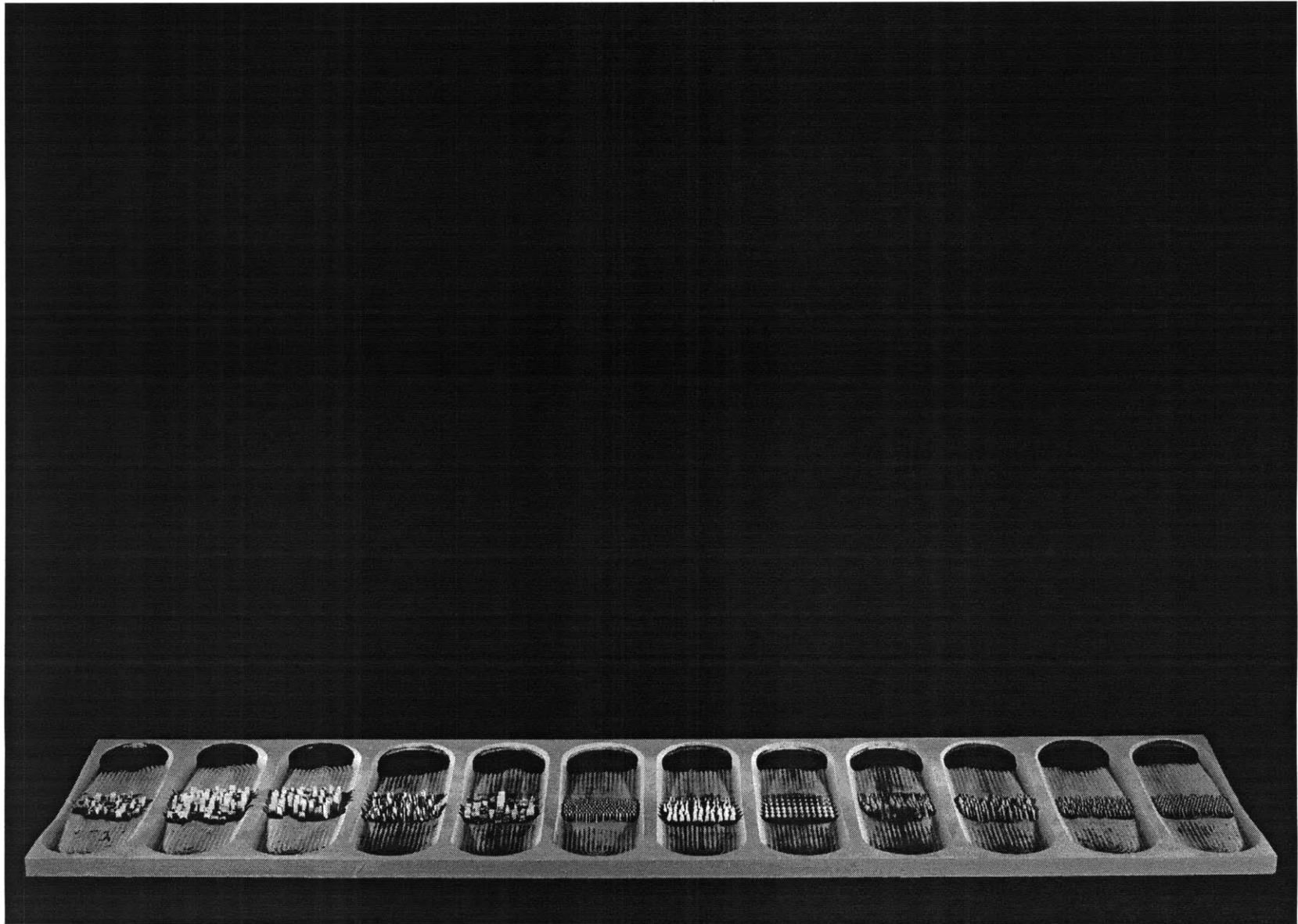












VI. Final Review

December 18, 2014

E14 - MIT Media Lab

ADVISOR:

Skylar Tibbits - Research Scientist - MIT SA+P, Director - Self-Assembly Lab

READERS:

Geoff Manaugh - Writer - BLDGBLOG, Lecturer - Columbia University GSAPP

Matthew Bunza - Lecturer - MIT SA+P, Principal Architect - Metaamo

CRITICS:

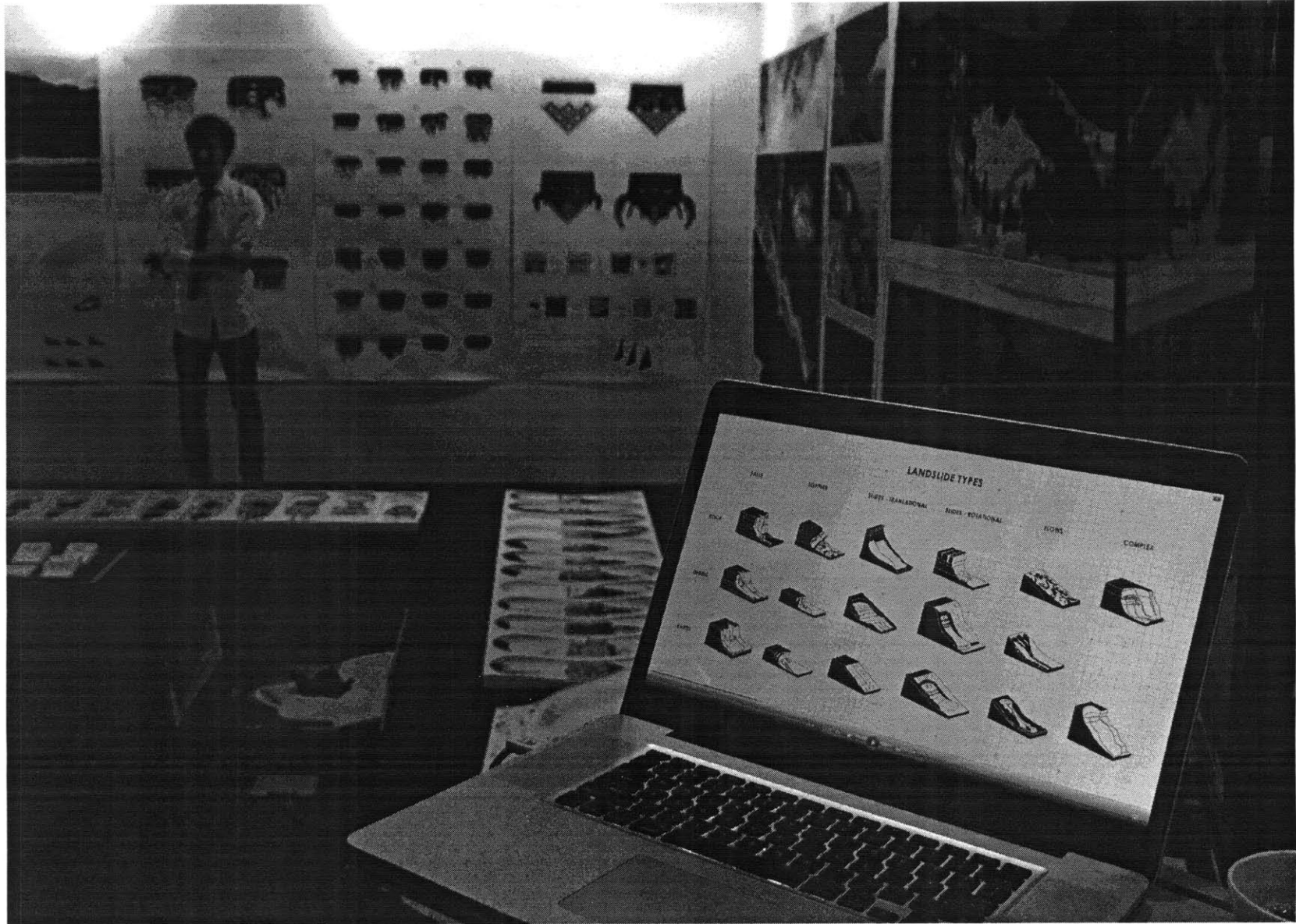
Hashim Sarkis - Dean of MIT SA+P

Igor Marjanovic - Professor - Associate Professor of Architecture - Washington University in St. Louis

John McMorrough - Associate Professor of Architecture - University of Michigan

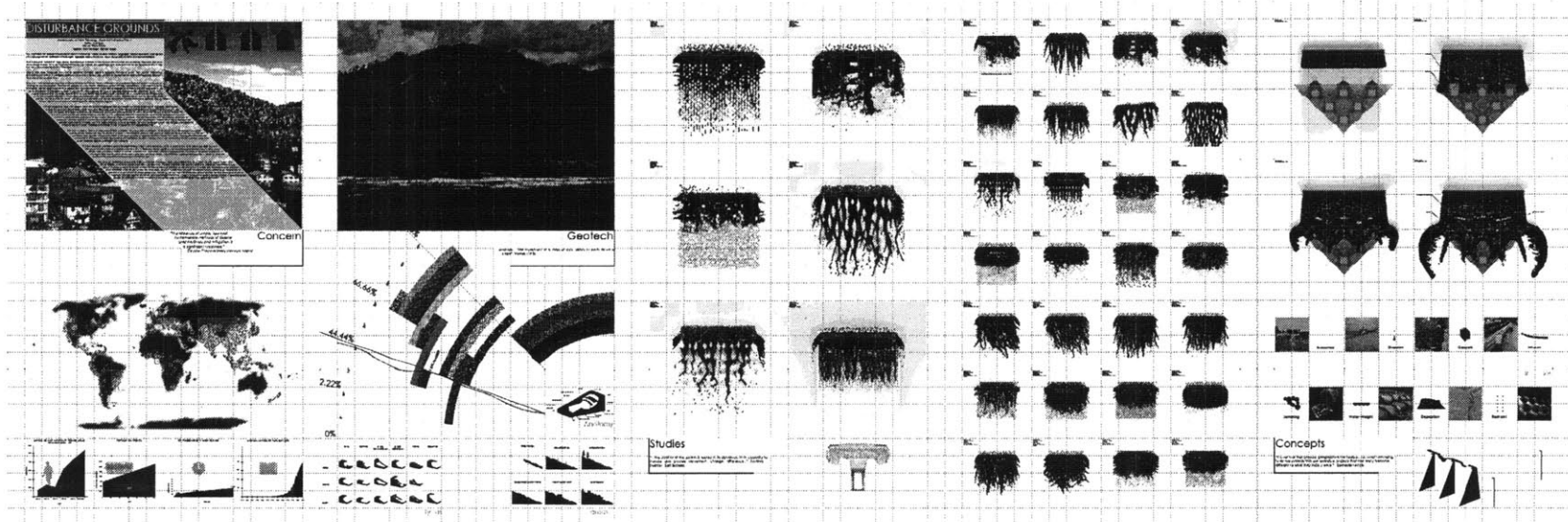
Pierre Belanger - Associate Professor of Landscape Architecture - Harvard University



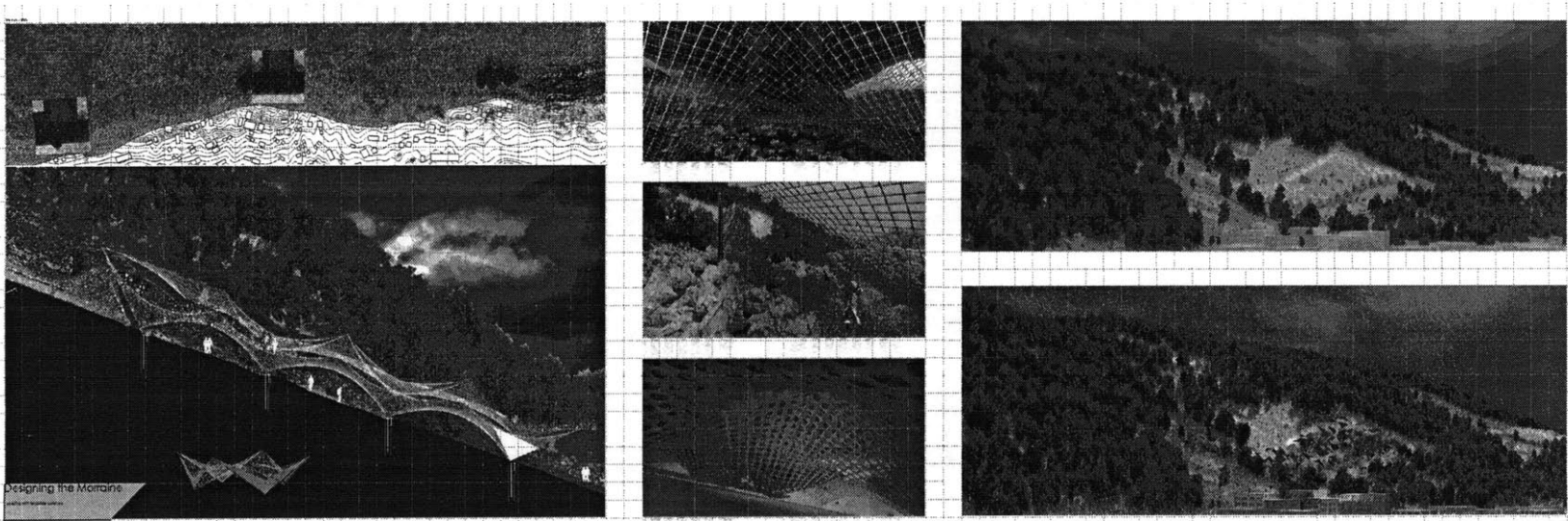




Final Boards



Final Boards



VII. Bibliography

- Amend, John R. Jr. and Hod Lipson. "Shape-Shifting Materials for Programmable Structures." *UbiComp* (2009).
- Andrea J. Liu and Heinrich Jaeger. "Far-From-Equilibrium Physics: An Overview." *Condensed-Matter and Materials Physics: The Science of the World Around Us*, (2007).
- Amend, John R. Jr., Hod Lipson, and Heinrich M. Jaeger. "Soft Matter: Particle Shape Effects on the Stress Response of Granular Packings." *Royal Society of Chemistry* (2013).
- Athanasios G. Athanassiadis, Marc Z. Miskin, etc. "Particle Shape Effects on the Stress Response of Granular Packings." (July, 2013).
- Bloszies, Charles. *Old Buildings, New Designs*. New York: Princeton Architectural Press, 2012.
- Berger, Alan. *Drosscape: Wasting Land in Urban America*. (Princeton: Princeton Architectural Press, 2006).
- Claudio Margottini, Paolo Canuti, and Kyoji Sassa. "Landslide Science and Practice" (2013).
- Dierichs, Karola and Achime Menges. "Material Computation in Architectural Aggregate Systems." *ACADIA*, (2010).
- Geobruugg. "Geobruugg News." Last Modified October 23, 2014. <http://www.geobruugg.com/en/news/?category=Debris%20flow%20and%20landslide%20protection>.
- Gissen, David. *Subnature: Architecture's Other Environments*. New York: Princeton Architectural Press, 2009.
- Huijben, Frank. "Vacuumatics: 3D Formwork Systems." (PhD diss., University of Eindhoven, 2014).
- Steltz, Mozeika, Rembisz, Corson, Jaeger. "Jamming as an Enabling Technology for Soft Robotics". (The University of Chicago, Chicago).
- Jenkins, Bruce. *Gordon Matta-Clark Conical Intersect*. New York: Afterall Books, 2011.
- Josephson, Anna M. *Demolition in American City Planning*. Master in City Planning Thesis, MIT, (2010).
- Kahle, Matthew. "Sparse Locally-Jammed Disk Packings." *Mathematics Subject Classification* (2010).
- Keith Forbes and Jeremy Broadhead. "Forests and Landslides: The role of trees and forests in the prevention of landslides and rehabilitation of landslide-affected areas in Asia." *Food and Agriculture Organization of the United Nations: Regional Office for Asia and the Pacific* (2011).
- Kenzari, Bechir, ed., *Architecture and Violence*. Barcelona – New York: Actar, 2011.
- Kipnis, Jeffrey. "Moonmark." *Assemblage* (1991) 6-13.
- Kwinter, Sanford. "Soft Systems". In *Culture Lab*, Princeton Architectural Press, (1993).
- Manaugh, Geoff, ed., *Landscape Futures*. New York – Barcelona: Actar, 2013.

Managh, Geoff. "Soft Serve Space." Bracket-Goes Soft, 2012.

Muskopt, Christopher Jon Dalton. The Generative Powers of Demolition. M.Arch Thesis, MIT, 2005.

Nadia G. Cheng, Maxim B. Lobovsky, and Steven J. Keating. "Design and Analysis of a Robust, Low-cost, Highly Articulated Manipulator Enabled by Jamming of Granular Media." 2011.

NOAA-USGS Debris-Flow Task Force. "Warning System--Final Report" (2005).

Winchester, Jared. "Grounding: Landslide Mitigation Housing." Bracket-Goes Soft, 2012.

Yang Hong, Robert Adler, and George Huffman. "Evaluation of the Potential of NASA Multi-Satellite Precipitation Analysis in Global Landslide Hazard Assessment." Geophysical Research Letters, Vol. 33, (November, 2006).

Images

Figure 009.01 - Baguio City, Philippines - Edwin Verin/Shutterstock.com

Figure 010.01 - Forest Fire, Siberia - zebra0209/Shutterstock.com

Figure 012.01 - Ifugao rice terraces - Klara Vlasakova/Shutterstock.com

Figure 020.01 - Landslide scars, Southern Thailand after heavy rains (1988), Source: Masakazy Kashio

Figure 025.02 - Photograph by Andy Ryan (soft flow test digital model, 3d print)

Figure 026-40 - Renderings by author

Figure 041.01 - Photograph by Andy Ryan (soft flow test digital model, 3d print)

Figure 042.01 - Photograph by Andy Ryan (soft flow test digital model, 3d print)

Figure 043.01 - Photograph by Andy Ryan (soft flow test digital model, 3d print)

Figure 044.01 - Photograph by Andy Ryan (soft flow test digital model, 3d print)

Figure 045.01 - Photograph by Andy Ryan (soft flow test digital model, 3d print)

Figure 046.01 - Photograph by Andy Ryan (abstract physical pour

tests 01-12, black sand, 3d prints, mdf)

Figure 046.02 - Photograph by Andy Ryan (abstract physical pour tests 01-12, black sand, 3d prints, mdf)

Figure 047.01 - Photograph by Andy Ryan (abstract physical pour tests 01-12, black sand, 3d prints, mdf)

Figure 048.01 - Photograph by Andy Ryan (abstract physical pour tests 01-12, black sand, 3d prints, mdf)

Figure 048.02 - Photograph by Andy Ryan (abstract physical pour tests 01-12, black sand, 3d prints, mdf)

Figure 049.01 - Photograph by Andy Ryan (abstract physical pour tests 01-12, black sand, 3d prints, mdf)

Figure 051 - Renderings by author

Figure 054-60 - Renderings by author

Figure 062 - Section Rendering by author

Figure 063 - Site Plan Rendering by author

Figure 064-68 - Perspective Renderings by author

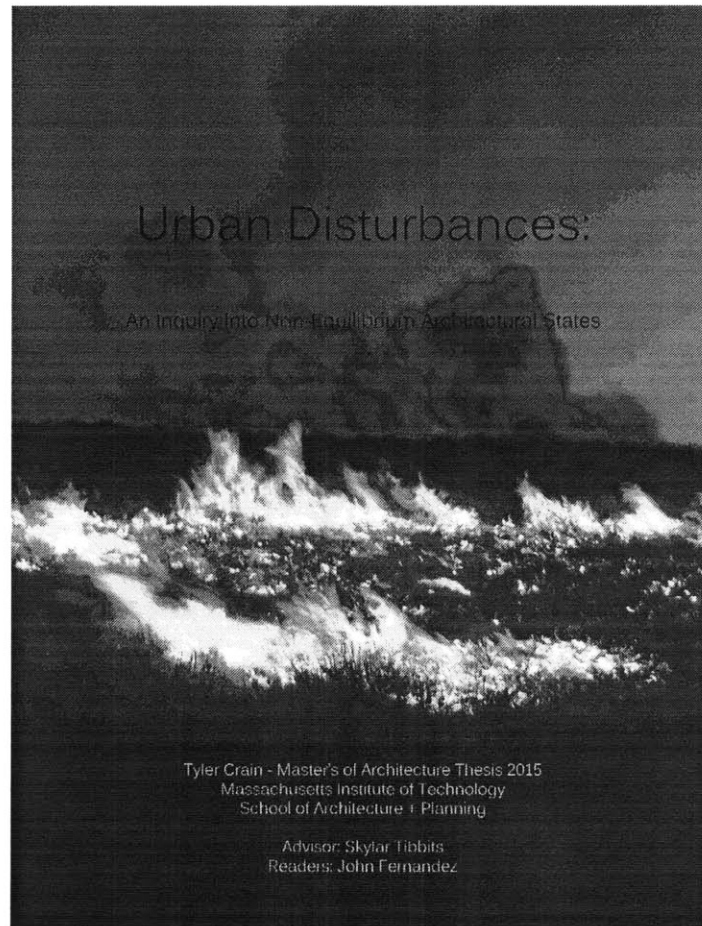
Figure 069-70 - Photograph by Andy Ryan (styrofoam, plaster, photopolymer 3d print, foilage, wood, paper, styrene)

Figure 071 - Photograph by Andy Ryan (abstract physical pour tests, black sand, 3d prints, mdf)

Figure 074-76 - Photographs by Barry Beagen (final review at MIT Media Lab)

Figure 077-78 - Drawings by author

VIII. Initial Thesis Preparation Draft



Contents


natural disturbances, ecological succession, moonscape, anthropocene, synthetic biology, human rights, Viollet-Le-Duc, Eyal Weizman, UAVs, LiDAR, ScanLabs, Jeffrey Kipnis, Forensic Architecture, Geographical Imaginations, Geoff Manaugh, Drone Archaeology, Matta-Clark, The Everywhere War, jamming, intelligent geotextiles, breakwater, dilatant materials, gablons, mattresses, traplons, bastions, riprap, self-organized criticality, photogrammetry, shrinking cities, revitalization, additive manufacturing, Gissen, biogeomimicry, soft-serve robotics, self-assembly, meshworm, granular physics, rock mechanics, programmable matter, artificial muscles

part I Introduction natural disturbances, ecological succession, moonscape, anthropocene, synthetic biology, human rights

part II Demolition, Destruction, & Dilapidation Viollet-Le-Duc, Eyal Weizman, UAVs, LiDAR, ScanLabs, Jeffrey Kipnis, Forensic Architecture, Geographical Imaginations, Geoff Manaugh, Drone Archaeology, Matta-Clark, The Everywhere War

part III Aggregation & Accretion jamming, intelligent geotextiles, breakwater, dilatant materials, gablons, mattresses, traplons, bastions, riprap, self-organized criticality, photogrammetry, additive manufacturing, David Gissen


part IV Implementation shrinking cities, revitalization, redevelopment authorities, blight removal task forces, Pruitt-Igoe Demolition, St. Louis (1972)



Tyler Crain
M.Arch Thesis Prep

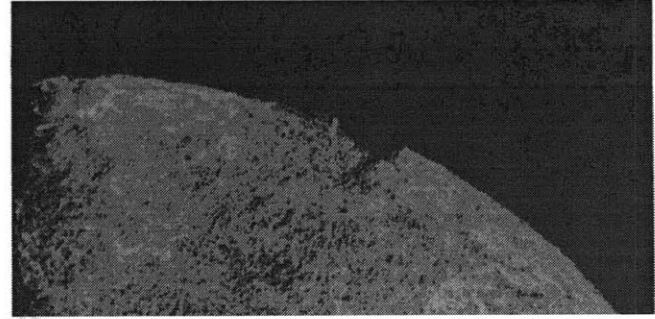
Part I

part I Introduction



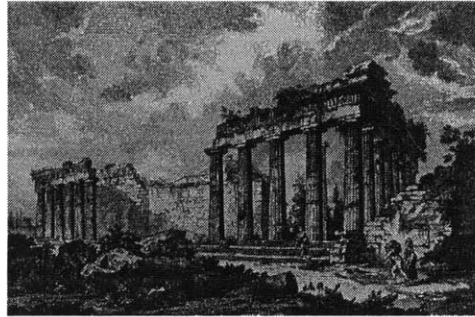
The goal of this proposal is to use traditionally destructive processes as a form of architectural creation by exploring phase-changing latencies in construction ecologies. It will make a case for undervalued or irregular materials in combination with intelligent, labor-reducing processes for reprogramming and redeployment, thereby expanding the repertoire of material properties and applications for architects. New material methods will be proposed to make use of existing, undervalued material. The end of a building's life and the redistribution of its components is not typically a well understood scenario from an architect's perspective; therefore, it will provide a bridge between the beginning and the end of a construction's life where there currently is none.

The proposal's title borrows the ecological concept of a 'natural disturbance', referring to a temporary destructive change in an environment that has the ability to play a role in the balance of an ecosystem. The project's setup takes



Urban Disturbances

Drawing of the
Parthenon
Eugene Emmanuel
Viollet-le-Duc



Moonmark
1991
Assemblage
Jeffrey Kipnis

the stance that this concept can be applied to an urban ecosystem as well, accepting the act of destruction and redeployment of building material as a regulatory act of rebirth. It is an event that architects could play a larger role in rather than leaving it to planners and engineers. Prototypical examples in nature might include forest fires, flooding, windstorms, insect outbreaks and trampling. Major disturbances may also exist in the form of natural or anthropogenic processes, for instance, forest clearing or the introduction of invasive species. The disturbances that take place in our society take the form of environmental factors, natural disasters, social decline, war, or cultural events. As architects, we attempt to take control over and work against the grain of these events rather than exploit the energies embedded within them. Much effort is made to rule out certain scenarios and promote others. However, architecture has recently started to take on a cyclical meaning to people again, a 'cradle to cradle' type philosophy. This thinking placed in an urban context is an architectural tool that can be deployed by those in construction, planning or development as a potential act of 'everyday urbanism.'

The 'disturbance' approach is not unlike a concept conceived by physicists Heinrich Jaeger and Andrea Liu's entitled "Far-From-Equilibrium Physics". These researchers push the idea of materials at a non-equilibrium state in pursuit of more extreme material phenomena and properties. Some examples may include fluid flows becoming turbulent and the point at which solids give way and fracture¹. Rapid cooling, for instance, is key to some manufacturing processes in order to create strong alloys and plastics. While we are still working to gain scientific understandings of these phenomena, we are also gaining new understandings through artistic and design speculation. These two non-typical states in natural systems suggest a

biogeomimicry approach to transitioning architectural scenarios and offer credibility to the idea of looking to things like geological processes outside typical equilibrium states for ideas on architectural manufacturing and assembly.

The idea of re-phasing or re-programming materiality has been around for some time, but research is often only carried out at a very small scale. There are, however, concepts that can be translated from disciplines such as robotics and geotechnical engineering into architectural applications. In addition to the obvious structural assembly arguments, part of the concept implies an adaptability and redeployment of a simple, irregular material. Here a link is made to theory in recent years on destruction and demolition in architecture. An exploded building transitioning from a solid to a liquefied state is perhaps one of the closest things we have to a rapid reprogrammable architecture. Materials have advanced enough to begin to design structures that have the ability to be rapidly deployed and potentially make use of existing material such as rubble that would have little purpose for examination outside of architectural culture.

One of the problems faced is the fact that building processes are relatively slow and require massive amounts of coordination. They take advantage of cheap labor with traditional processes while other industries take off with efficiency and inventiveness. People are still suffering to construct projects in an era which has

ample technology to provide humane measures. The larger hope is to prod at the existing paradigms of material, process, and their larger impact on society. It is well documented that material production and distribution by way of the industrial revolution has depleted resources and charred landscapes. Shifting interest into options such as bio-materials and semiotic aggregations of found material seems more relevant as an approach.

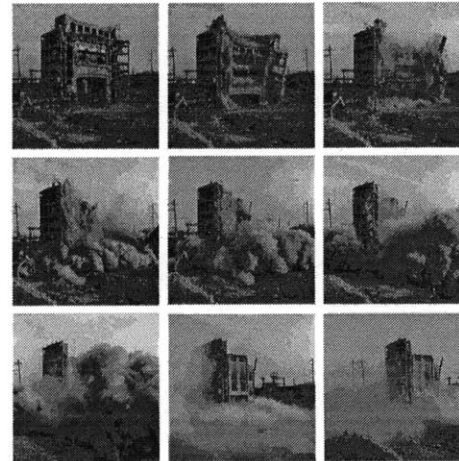
The study searches for new material methods and a nuanced sensitivity to areas that are at the end of their life and in need of reconstruction. The intervention focuses on a process rather than specific programmatic intent. However, in addition to materials and processes, there is always a tertiary, parasitic result ready to latch onto our architectural systems. The proposal seeks to take advantage of, imitate, and learn to deploy systems that work with, or adapt to inefficiencies and inconsistencies inherent in architectural materials. The disturbances that take place in our society take the form of environmental factors, natural disasters, social

decline, war, or cultural events. As architects, we attempt to take control over these factors. Much effort is made to rule out certain scenarios and promote others. The hypothesis' argues for a less deterministic strategy, going beyond typical methods of adaptive reuse or demolition.

While a large body of architectural and urbanism theory draws thoughts on destructive acts' effects in architecture, the engineering and construction industry might focus on demolition and material flows, and yet another group's political efforts revolve around eliminating urban blight, crime, and redevelopment efforts; there is little work that merges the efforts into a meaningful scenario from every facet. That is the realm of overlap this thesis will hope to situate itself in and add new knowledge to.



Tyler Crain
M Arch Thesis Prep





Frederico Diaz's
Geometric Death
Frequency - 141

Frederico Diaz's robotically constructed sculptures build a materiality that implies granular flows and a blurring of solid and liquid material phases

part II

Demolition, Destruction, & Dilapidation



The link to demolished material comes from both the desire to embed semiotics into the architecture, and to bring into light theoretical issues that may come from working with demolished aggregate as material. Relatively recent events such as terrorism, the widespread use of unmanned aircraft systems, and the increased sophistication of satellite imagery, geographical, and spatial analysis systems have incited a new wave of methodologies and thought in numerous disciplines. Many architects, having the ability to take the role of a specialist in spatial analysis and composition, have initiated new discussions on these topics as they combine technological, cultural, and political realms. Architects are in a unique position to theorize and contemplate the ways that these networks intersect and contribute to our built environment and way of life. Whether it be a war zone, crumbling ruin, or a dilapidated neighborhood, these are all potential avenues for architects to inquire through design speculation.

UAV Bombing Spatial
Analysis
30 March 2012
Miranshah, Pakistan
Forensic Architecture
Group



There are several key things that come from along with the process of dilapidation and reconstruction. Formulating the goals of the modernist movement, Eugene Viollet-le-Duc offers insight into the process before it was what we recognize as steam-powered machinery and writings. In things that he wrote in the book *Substantif*, Viollet-le-Duc was also interested in the process of reconstruction. On a site of war, he created it (or destroyed it) and theorist Eyal Weizman. In the following architectural theory, there is always an incident. There is a driver for the materiality that represents violence. At some point in time, a piece of architecture must meet a condition that makes it incapable



Urban Disturbance



"Walking Through
Walls"
Eyal Weizman

of housing inhabitants or even being recognizable as a structure. Traditionally, architects expect this scenario to be beyond their control, power, or even interest. In the thesis proposed, the incident does not necessarily need to be violent in nature, but rather, controlled and actuation-based. As Gissen describes: "in one flash of a moment, the distinction between social creation and nature are atomized." The harboring of debris, aggregate, and granular materials is an almost geologic approach to construction and deconstruction. This thesis will deal with methods of deposition and control of chaotic systems that embody the aesthetic of decay, destruction, debris, and fragment. Ideas of accumulation re-composition of material will drive the project.

Materiality was key in Le Duc's thinking, drawing influence from medieval gothic buildings. In more recent history, materials have become more hybridized and are being developed to further take advantage of natural

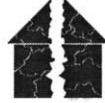


Conical Intersect
1975
Paris
Gordon Matta-Clark

systems of performance. Designers have drifted into the a zone of developing new compositing processes as well as growing their own biomaterials or becoming part of the development process of the tools they use. This interest in becoming more a part of the processes and materials that inherently shape architectural projects is still a relevant concern. The taxonomy of heavy machinery depicted later in this book references many tools that are commonly used in construction, yet never make it to the drawing board. The largest machinery is applied to destructive processes such as cutting or crushing. If part of the artistic process calls for a subversive use of tools, then perhaps there are more creative uses for the tools already on construction sites. As shown later, studies of these 'destruction machines' are underway for their potential use within a new material logic.

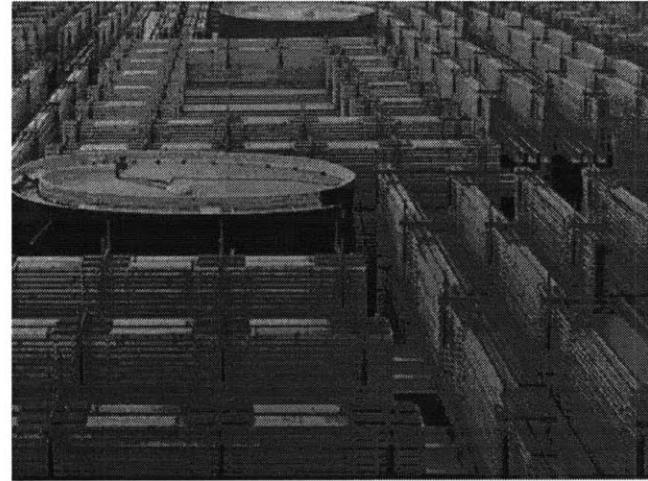
part III

Aggregation & Accretion



This line of research parallels many engineers and architects already working with large-scale additive manufacturing, several of whom have actually stepped deep into the domain of reconstituting material in efficient and provocative ways. As the demolition process essentially changes a material's properties, a method of reprogramming or adjusting material phases is a useful area of inquiry. Transitioning from solid to aggregate material and perhaps back again will require both technical and experiential analysis of irregular, macro-scale granular parts. The current and future solutions for redeploying these parts will look at existing systems for building 'heavy composites'. The potential sought takes the form of lightweight composites mixed with heavy materials such as broken concrete or stone.

The fields of geotechnical engineering and physics have several concepts that may be common within some specific contexts and applications, but have not been fully explored in the conditions of architectural space. According to a paper by the Jaeger Lab at University of Chicago, there have been no systematic studies of the mechanical responses of widely varying convex and non-convex geometries due to that fact that only recently have 3D printers become accessible to the point of making this type of study feasible. In other words, the complexities inherent in irregular granular aggregates are still relatively unstudied. The architectural implications for such a study are incredibly significant, as they imply a new methodology to 3D collage and structural challenges, conjuring images of works by de-constructivist architects and collage artists such as Kurt Schwitters. Such an exploration would have resonance across a technical, aesthetic, and a political standpoint. It could offer new relationships with the surrounding community and built context, producing a relief of experimental architecture in an otherwise neglected space. Perhaps a repositioning of materials that lack strength in some regards will be able to regain strength upon redeployment.

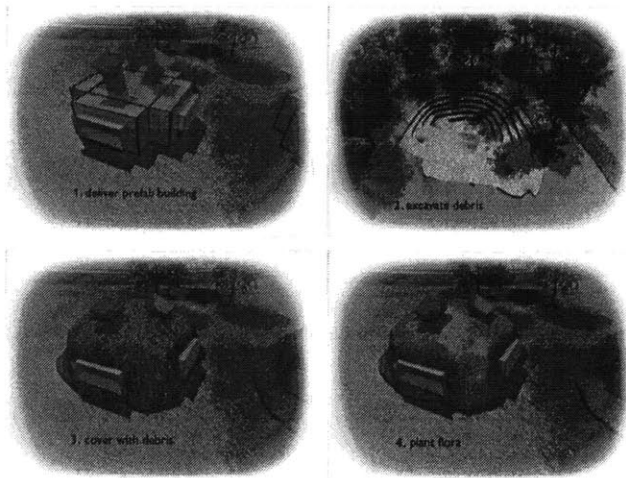


Swiss Sound Box
2000
Hanover Exhibition
Photo by Thomas
Flechner
Peter Zumthor

Zumthor's Swiss Sound Pavilion employs principles of basic architectural forces, organization, and reuse

"Tent Pole"
Formless Finder
Miami Pavilion

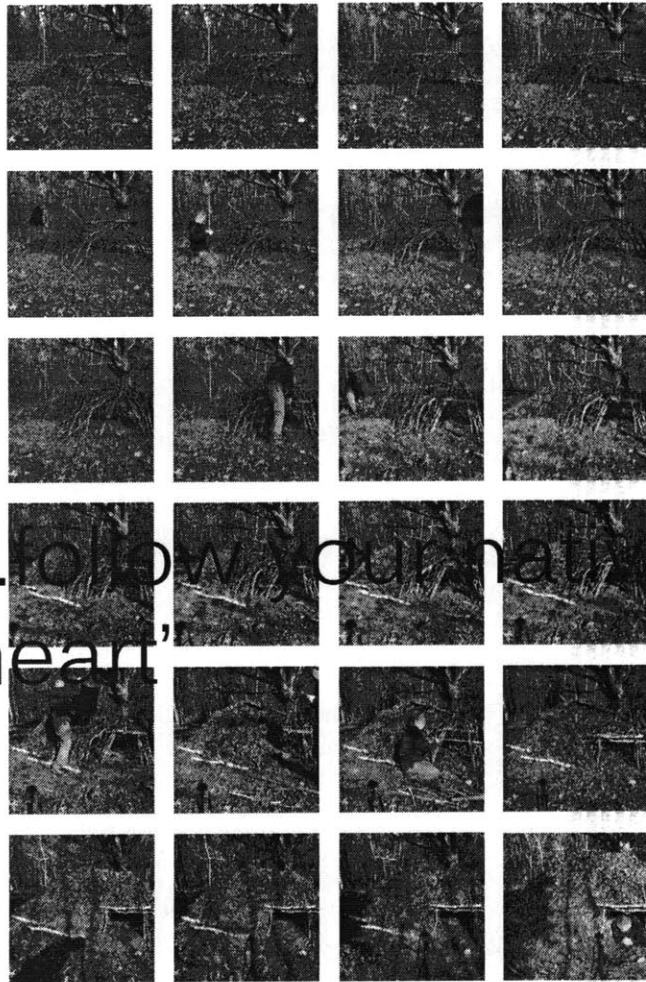
Open-Air Parkcafe,
2003
Cologne, Germany
Manuel Herz and Eyal
Weizman



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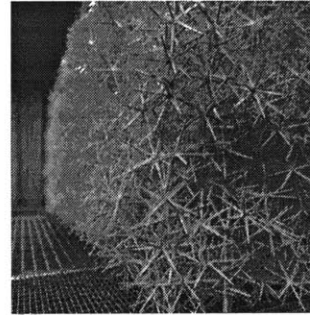


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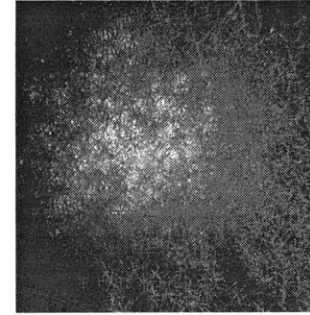


... follow your nature
heart’ e

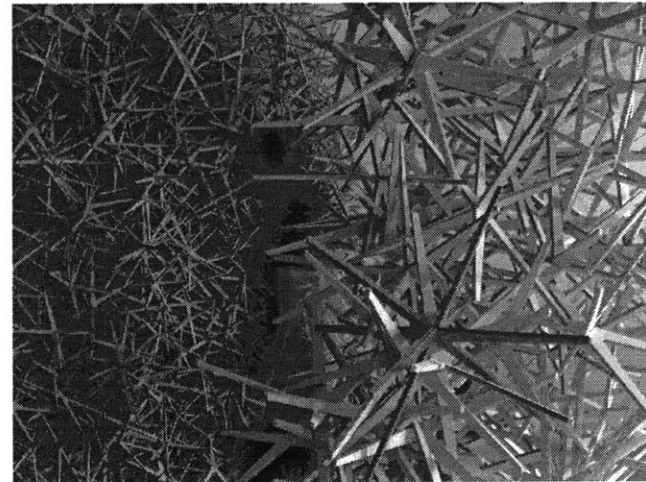
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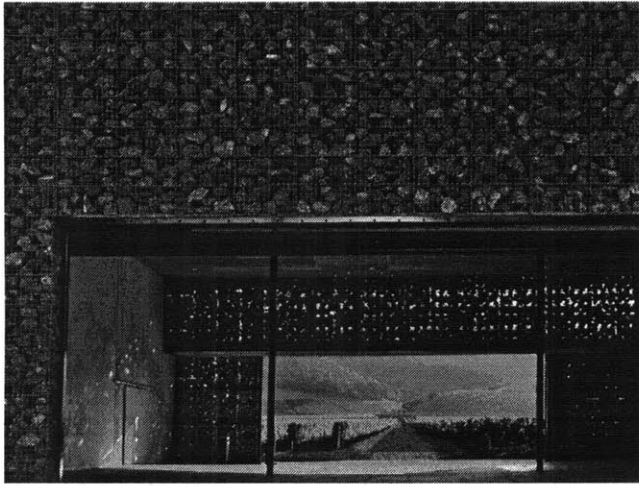


Karola Diedrichs
Aggregate Structures
2011



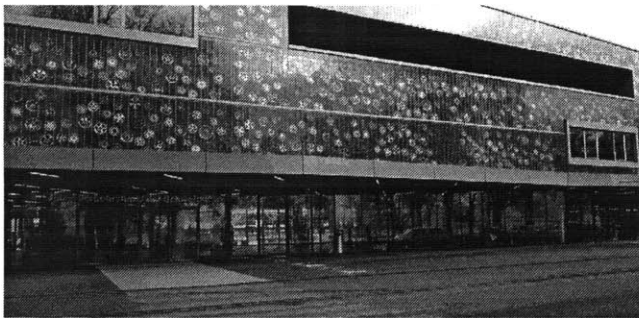
Karola Diedrichs
Aggregate Structures
2011





Dominus Winery
1997
California
Herzog & DeMeuron

Auto Museum
Switzerland
Guyot & Gligon



Tyler Grain
M Arch Thesis Prep

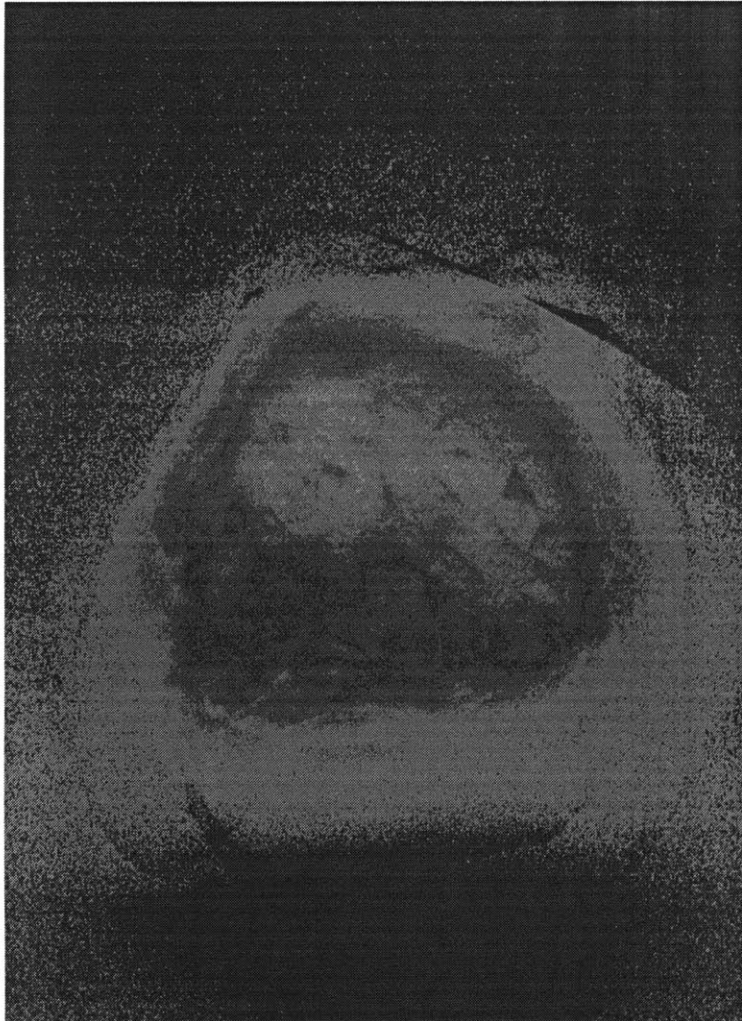
part IV

Implementation

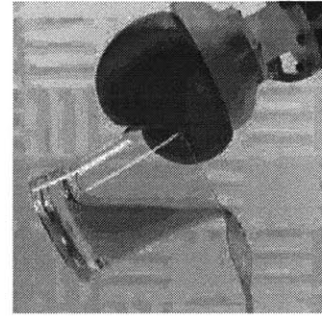
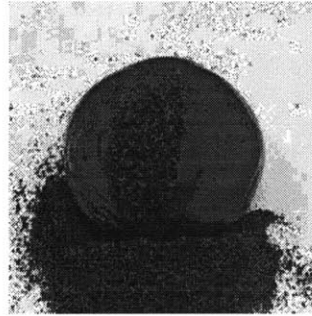


There are a few trajectories that are being explored. A variety of scales will need to be assessed with empirical testing. If testing is not feasible in scenarios, a prediction or simulation of events will be projected based on known data. The key concepts to be explored will be various methods extracted from geotechnical composites and granular physics phenomena such as jamming. Research into robotic locomotion and adaptable gripping devices have yielded phase-changing material observations that could prove feasible in a wide variety of applications, most of which are likely unexplored. The jamming-activated truss demonstrated by Cornell's Creative Machines Lab hints at architectural implications (see images) in addition to gripping devices and soft-robotic locomotion. This technique exploits a locking of material in granular material flows. The re-programmability of the surface topology allows a robot to pick up complex objects easily without the typical prerequisite of extensive haptic processing and programming. The idea remains relatively unexplored in architecture and building technologies. All of these examples utilize a soft outer membrane that has some tensile integrity. The method of inquiry in this proposed exploration will look at the strengths and drawbacks of introducing an outer membrane.

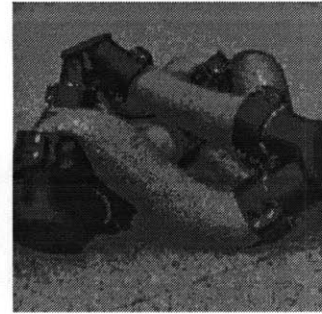
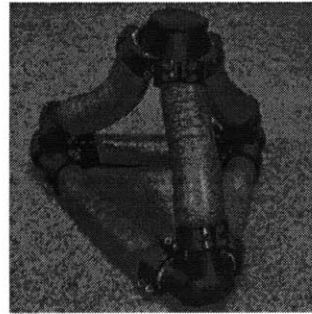
Granular materials are a unique phenomenon as they are able to transition from a fluid-like to a solid-like without a change in temperature. Our typical approach to building is still one of restrained stress and design precision even though nothing in its actual production suggests a scenario of perfection, orderliness, or precision. Thus, the concept of granular materiality from the approach of material computation warrants study. Loosely combined grains yield under shear stress while jammed grains lock in position and resist applied stress. It inherently embraces process rather than end product. It embraces the forces inherent in architectural production and the imprecision of architectural construction. One of the fundamental issues in architectural praxis which will be explored extensively is the act of binding materials together. From a practical approach, binding, adhering, attaching, welding and securing things together is the only way for us to construct. New technologies will continue to evolve to achieve these goals as more efficient solutions are uncovered. From a cultural perspective, the way things are pushed together is a combinatorial method, adhering, attaching, and securing material to material imbue a variety of different cultural meanings. Influence from geotechnical engineering can provide a starting point for experiments in compositing large-scale, variable matter aggregations. Geocells, gabions,



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Jamming at Cornell
Creative Machines Lab
(2010) "Universal robotic
gripper based on the
jamming of granular
material," Proceedings of
the National Academy of
Sciences (PNAS), Vol. 107,
no. 44, pp.18809-18814

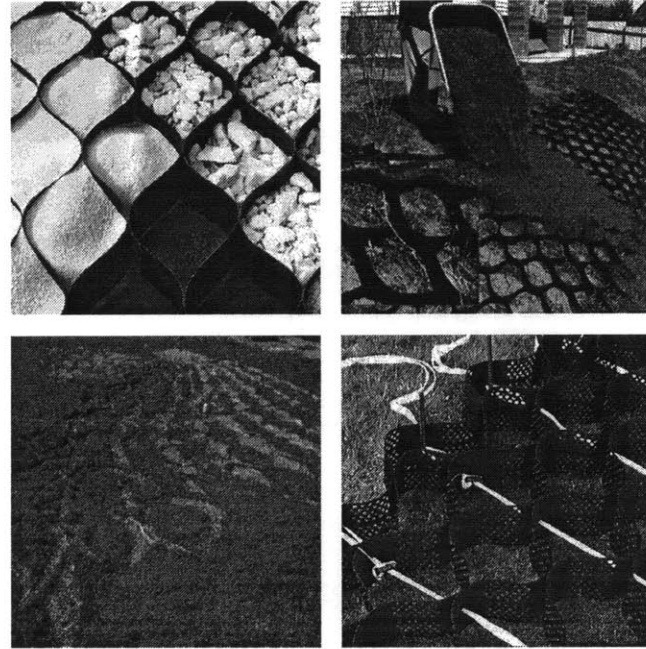
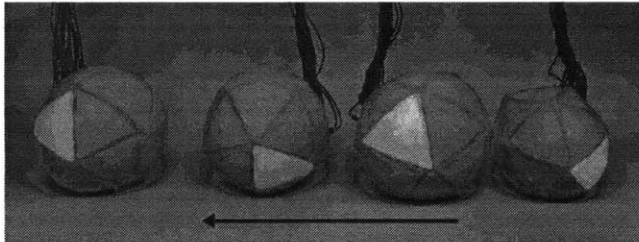


Jamming-activated truss

and ripraps all have ample design exploration potential that are already proven in geological contexts.

Working with geotextile-inspired solutions designed for earth stabilization could provide a system of tensile control to a system of pure compressive modes at a large scale. Composites in geotechnical engineering are getting to be quite advanced, utilizing fiber optics sensing systems and high strength, flexible materials. Furthermore, exploration into the qualities of jamming could yield a method of repurposing existing, irregular materials into structurally-performing configurations. The site in this proposal inherently has holds less bearing in the initial stages of the research. However, shrinking cities with highly frequent demolition such as Detroit or Philadelphia are being explored as a mode of artistic endeavors seeking to give back value to these communities. essentially a rebirth of the architectural object, therefore, it should situate itself in a place that seems

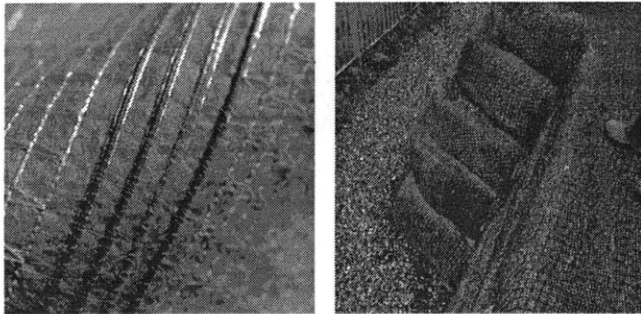
Jamming Skin Enabled
Robot
Jaeger Lab
James Franck Institute
The University of Chicago



common geotextile
deployment

to be on the last strand of life. The site will be in a shrinking, blighted neighborhood in either Philadelphia or Detroit as they are some of the primary examples of dilapidation and rapidly shrinking populations in the country. The fact that they have been in decline for some time is a good thing by the definition of this project. They can make way for a new beginning, ready for a 'disturbance'. Not only is population in decline, the buildings have been in decline. Philadelphia's Neighborhood Transformation Initiative (NTI) for example removed almost six thousand vacant buildings in six years with no redevelopment strategy for the newly empty lots. The same has occurred in other cities such as St. Louis and Detroit. There have been some interventions by artworks, city gardens, and other initiatives. Artist Tyree Guyton's Heidelberg Project in Detroit ornaments houses, lawns, and streets with optimistic, playful symbols.

At the real scale of construction, an exploration into heavy machinery was conducted in order to draw out potential instruments for use and misuse by an operator, planning for rapid synthesizing with existing building processes. Many categories of equipment are listed and depicted in order to get an overview of the equipment typically used in construction. Three different speculations were pulled out as to suggest potential utilization in a large-scale deployment of the jamming concept. The act of construction becomes an act of spectacle and performance.



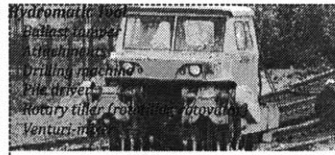
Tencate Geosynthetic Systems

Heavy Machinery Taxonomy:

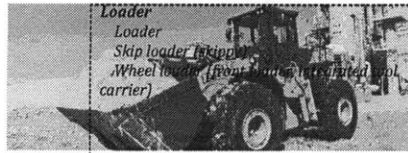




Articulated
 Articulated hauler
 Articulated truck
 Wheel loader



Hydraulic loader
 Backhoe loader
 Articulated
 Drilling machine
 Pile driver
 Rotary tiller (rotary hoe)
 Venturi mixer



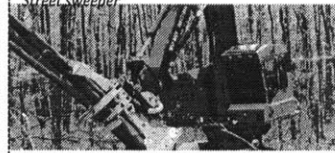
Loader
 Loader
 Skip loader (kipper)
 Wheel loader (front loader integrated wheel carrier)



Dump truck
 Dump truck
 Highway roller (compactor) (tuff-pac) (hollow tire roller)
 Highway roller (dual-drum roller)
 Highway roller (single-drum roller)
 Lowboy (trailer)
 Street sweeper



Track Loader
 Track loader



Material Handler
 Aerial work platform / Lift table
 Boom truck
 Cherry picker
 Crane
 Forklift
 Grapple loader (trailer mount)
 Reach stacker
 Telescopic handlers



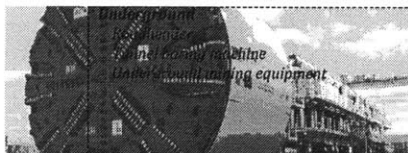
Paving
 Asphalt paver
 Asphalt plant
 Cold planer
 Concrete mixer
 Concrete mixer truck
 Paver
 Pneumatic tire compactor
 Roller (road roller or roller compactor)



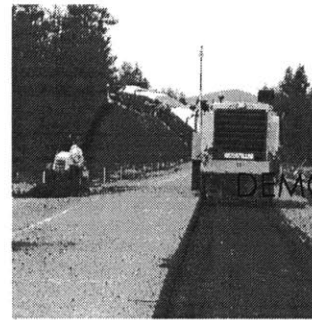
Underdrain
 Backhoe loader
 Wheel loader
 Underdrain paving equipment



Supreme paver
 Vibratory road roller
 Stomper
 Vibratory drum roller



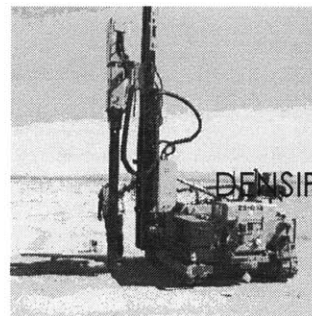
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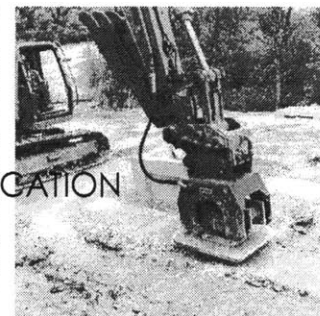
DEMOLITION



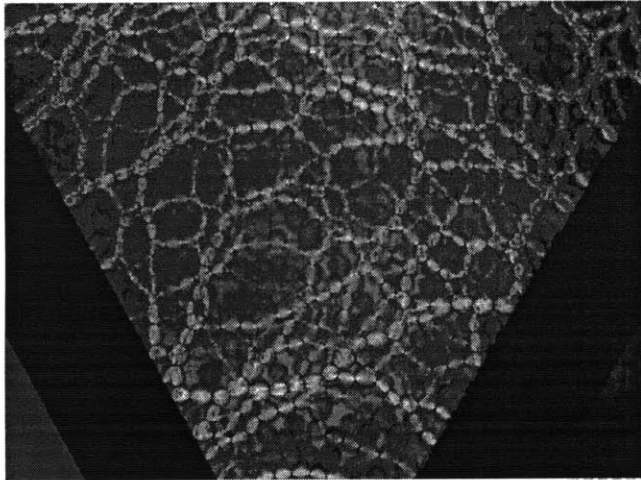
DEPOSITION



DENSIFICATION



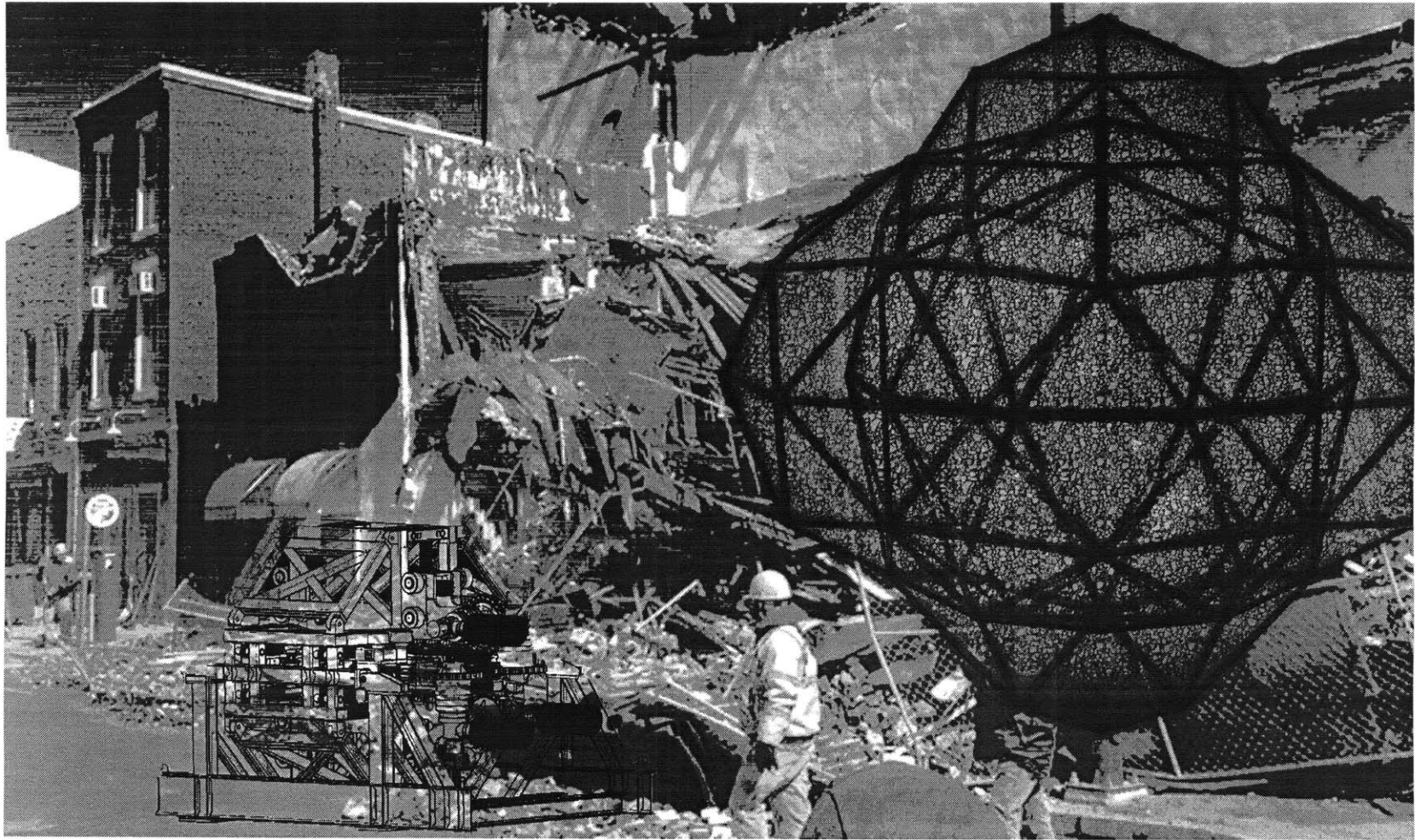
Programmable matter is a concept that is well established within many disciplines. It is driven by the fundamental idea of a material that has the potential for infinite reusability, being controlled and adapted to form different shapes for different purposes. The project proposed here is along a similar line of research, but it is calling for a smart process of 're-programming' material with new processes and designed materials rather than producing initially smart, programmable parts. This creates a project that is inherently multi-contextual and reproducible within similar contexts, yet retains the ability to easily produce different results for different contexts. The project extends the discussion of rapid architectural deployment into a place that ultimately deals with less-engineered objects and materials.



research on jamming
at The O'Hern Group
Yale University



Heidelberg Project
Detroit, Michigan
Tyree Guyton



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Bibliography

Amend, John R. Jr. and Hod Lipson. "Shape-Shifting Materials for Programmable Structures." *UbiComp* (2009).

Andrea J. Liu and Heinrich Jaeger. *Far-From-Equilibrium Physics: An Overview*

Amend, John R. Jr., Hod Lipson, and Heinrich M. Jaeger. "Soft Matter: Particle Shape Effects on the Stress Response of Granular Packings." *Royal Society of Chemistry* (2013).

Berger, Alan. *Drosscape: Wasting Land in Urban America*. (Princeton: Princeton Architectural Press, 2006).

Josephson, Anna M. *Demolition in American City Planning*. Master in City Planning Thesis, MIT, (2010).

Kahle, Matthew. "Sparse Locally-Jammed Disk Packings." *Mathematics Subject Classification* (2010).

Kipnis, Jeffrey. "Moonmark." *Assemblage* (1991) 6-13.

Nadia G. Cheng, Maxim B. Lobovsky, and Steven J. Keating. "Design and Analysis of a Robust, Low-cost, Highly Articulated Manipulator Enabled by Jamming of Granular Media." 2011.

Ben-Joseph, Eran. *Rethinking A Lot: The Design and Culture of Parking*. London: MIT Press, 2012.

Bloszies, Charles. *Old Buildings, New Designs*. New York: Princeton Architectural Press, 2012.

Gissen, David. *Subnature: Architecture's Other Environments*. New York: Princeton Architectural Press, 2009.

Jenkins, Bruce. *Gordon Matta-Clark Conical Intersect*. New York: Afterall Books, 2011.

Kenzari, Bechir, ed., *Architecture and Violence*. Barcelona - New York: Actar, 2011.

Manaugh, Geoff, ed., *Landscape Futures*. New York - Barcelona: Actar, 2013.

Muskopt, Christopher Jon Dalton. *The Generative Powers of Demolition*. M.Arch Thesis, MIT, 2005.

Ryan, Brent. *Design After Decline: How America Rebuilds Shrinking Cities*. Philadelphia: University of Pennsylvania Press, 2012.

Bibliography

Salvadori, Mario. *Why Buildings Stand Up*. New York: Norton, 1980.

Steltz, Mozeika, Rembisz, Corson, Jaeger. "Jamming as an Enabling Technology for Soft Robotics". (The University of Chicago, Chicago).

Web References

<http://matthewkahle.org/about>
<http://www.phy.duke.edu/~j41/research.html>
http://www.goldsworthy.cc.gla.ac.uk/image/?tid=1982_136
<http://www.lichtblicknet.com/ausstellungen/index.php?id=63>
<http://v-e-n-u-https://jamming.research.yale.edu/e.com/>
http://en.wikipedia.org/wiki/Cellular_confinement
<http://www.loc.gov/pictures/>
<http://www.3ders.org/articles/20140414-new-photos-of-10-green-3d-printed-houses-in-shanghai-built-in-24-hours.html>
<http://scanlabprojects.co.uk/projects/barn-2b>
<http://bldgblog.blogspot.com/2012/03/demolition-composites.html>
<http://digitalnomad.nationalgeographic.com/author/digitalnomad/>
<http://bldgblog.blogspot.com/>
<http://3dprinting.com/news/winsun-uses-waste-3d-print-houses-4800-dollars/>
http://en.wikipedia.org/wiki/Marco_Breuer
<http://www.archdaily.com/459841/formlessfinder-s-tent-pile-a-hit-at-design-miami/>
<http://www.bbc.com/news/science-environment-27113732>
<http://www.gizmodo.com.au/2014/04/how-you-can-make-graphene-at-home-in-your-blender/>
http://www.huffingtonpost.co.uk/2013/05/01/white-graphene-miracle-pa_n_3191081.html
<http://www.formlessfinder.com/statement>
<http://web.physics.ucsb.edu/~complex/research/granular.html>
<http://lcd.uni-stuttgart.de/?p=10339>
http://www.amazon.com/gp/product/0520257553/ref=as_li_ss
<https://www.youtube.com/watch?v=10EjU7ZMcw>
<https://www.youtube.com/watch?v=IdlFEZILJSA>
<http://www.businessweek.com/news/2014-04-10/parking-lots-demolished-in-cities-revenue-bid-as-driving-wanes>
<http://bldgblog.blogspot.com/2013/04/ingham-landslide.html>
http://www.davidmaisel.com/works/picture_2009.asp?cat=min_bla&tl=The%20Mining%20Project:%20Black%20Maps
<http://www.compositesworld.com/articles/albany-engineered-composites-weaving-the-future-in-3-dw.ksl.com/index.php?page=1&sid=24748916>
<http://mass-removal.com/Construct>
<http://bldgblog.blogspot.com/2008/04/gamespace-interview-with-daniel-doctul.html>
<http://www.youtube.com/watch?v=ODE1OeTwCfI>
<http://pruned.blogspot.com/search/label/disasters/>
<http://www.youtube.com/watch?v=qs3xDPjCj8>
<http://fi.uchicago.edu/~jaeger/group/JaegerLab/Projects/Projects.html>
https://www.youtube.com/watch?v=bT8km_wDTo8
<https://www.youtube.com/watch?v=dpLOY2LBSI>
<http://web.mit.edu/prets/www/research.html>
<http://www.ocfealty.com/naked-philly/graduate-hospital/updates-some-19th-street-projects-graduate-hos>
<http://www.phillymag.com/property/2014/04/08/philadelphia-blight-li/pital>
<http://pubs.rsc.org/en/journals/journalissues/SM#recentarticles&all>
[http://en.wikipedia.org/wiki/Breakwater_\(structure\)](http://en.wikipedia.org/wiki/Breakwater_(structure))
<http://www.craigslist.com/article/20140409/NEWS/140409833/detroit-blight-authority-steps-aside-in-demolition-efforts>
<http://www.mos-office.net/>
<http://www.sepretechnology.com/?p=4460>

Web References

<http://www.directindustry.com/prod/tesmec/cable-tensioners-40327-588724.html>
<https://vimeo.com/channels/freedomofcreation>
<https://vimeo.com/75869311>
<http://abandonedphiladelphia.com/>
http://www.phila.gov/philacode/html/_DATA/TITLE16/CHAPTER_16_400_VACANT_AND_SURP/16_404_The_Vacant_Property_Rev.html
<http://thecreatorsproject.vice.com/blog/it-the-thread-wrapping-machine-creates-furniture-by-wrapping-its-parts-in-a-cocoon-of-string>
<http://fabricarchitecturemag.com/design/newmaterialsandapplications>
<http://en.sergeferrari.com/bioclimate-facade/>
<http://agbeat.com/housing-news/inspirational-project-turns-dilapidated-homes-into-symbols-of-hope/>
<http://agbeat.com/tech-news/>
<http://www.davidgissen.org/>
<https://www.youtube.com/watch?v=cer3WKT0cy8>
<https://www.youtube.com/watch?v=UNYFicV9R1w>
<https://www.youtube.com/watch?v=I9LInmNjE>
<https://www.youtube.com/watch?v=v5CRISJ46M8>
<http://www.dhsciecast.com/>
<http://store.steampowered.com/app/65270/>
<http://demolition-uk.blogspot.com/>
<http://demolition-nfd.com/news/index.html>
<http://www.sctx.com/index.php?id=164>
<http://www.crushersmill.com/knowledge/concrete-pulverizer.html>
<http://michaelfrolo.wordpress.com/2012/06/21/a-perspective-on-photography-and-preservation/>
<http://www.machinerytrader.com/1st/1st.aspx?ETID=2&catid=1003>
http://en.wikipedia.org/wiki/Heavy_equipment
<http://instrumentalism.wordpress.com/tag/technological-sublime/>
<http://www.itsartmag.com/features/demolition-master-1-5/#IH4WBz>
http://books.google.com/books?id=Qn11m8-Mku4C&pg=PA130&pg=PA130&dq=Millegomme+tire+desi&source=bl&ots=s26Wxu_Oze&sig=EaEKDHHp9C56lyXach2iP4SttaY&hl=en&sa=X&ei=S91U7GZDe_sQZwICYBA&ved=0CFYQ6AEwBg#v=onepage&q=Millegomme%20tire%20design&f=false
<http://nextstl.com/2014/05/st-louis-houses-vacant-decades-turning-300000-homes/>
<http://bldgblog.blogspot.com/2014/05/demolition-ground.html>
<http://gizmodo.com/no-one-knows-why-deep-dangerous-holes-are-appearing-in-1568942542>
<http://www.wired.com/2011/02/pondering-landscapes-a-chat-with-bldgblog-author-geoff-manaugh/>
<http://www.iflscience.com/plants-and-animals/molten-aluminum-makes-casts-ant-nest>
<http://www.tencate.com/emea/geodetect/default.asp>
<https://www.youtube.com/watch?v=rjWeAvs06E>
<https://cee.mit.edu/research/projects#geotech>
<http://www.hizook.com/blog/2011/11/28/jambots-soft-robots-based-particle-jamming-hexapod-robot>
<http://meche.mit.edu/people/?id=374>
http://fi.uchicago.edu/~jaeger/group/Granular_Dynamics/Granular_Dynamics.html
<http://newsoffice.mit.edu/2012/autonomous-earthworm-robot-0810>
<http://www.theguardian.com/global-development/2014/may/20/nepal-migrant-deaths-treated-murder>
http://geosyntheticsmagazine.com/articles/1009_f1_applications.html

