The Salt House Project: Designing for Death (DfD)

by
SunMin May Hwang

B.S., Housing & Interior Design
Yonsei University, 2009

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 2014

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January 15, 2013

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The Salt House Project: Designing for Death (DfD)
Testing radically rapid turn-over of building life-cycle

by SunMin May Hwang

Submitted to the Department of Architecture on January 15, 2014
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Abstract

We as architects consider ourselves creators. We work under the false assumption that buildings will last forever. However, the fact is that every building eventually dies. This thesis rethinks the question of death. The Salt House Project is a product of this questioning. It tests radically rapid turnover of the building life cycle in the Islands of Galapagos, Ecuador. The thesis is carried out by designing a salt-cured seasonal residence, which will gradually and naturally be demolished over a designated period of time. The building life expectancy will be precisely set out from the beginning to the end—purporting each and every step of its life cycle—from occupation to demolition. It will be constructed and disappear back into the nature within a one-year life cycle. Some parts will obviously remain for a longer period of time depending on its structural integrity. However, the big picture is that the house will evolve—decay over time, varying not only in its form but also in its function. To implement this idea, all building materials will be based on natural resources including salt, soil, gravel, sand and coconut fiber. Water and heat will be the binding solution of the building structure and wind and rain will act as demolition agents. This thesis challenges the attempt to alleviate building obsolescence over time by reversely mandating a building’s life expectancy. In doing so, we achieve firstly, a sympathetic connection between geometry and material and secondly, a vitality to achieve eccentric expressions of life styles that can be highly unique and customized. In fact, the way we operate shifts dramatically when we design for death as opposed to perpetuity.

Thesis Supervisor: Brandon Clifford
Title: Belluschi Lecturer of Department of Architecture
Acknowledgment

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SunMin May Hwang
January 15, 2014
Introduction
- Unintended building obsolescence
- Rising building demolition rates over time
- DfD Matrix: Scale over time
- Building component life-span
- Deconstruction vs Demolition
- Architects’ attempts to alleviate building obsolescence over time
- Precedents
- Other industries
- Mandate of time
- Result of buildings not designed to be deconstructed

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Design Process
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- Plans
- Diagrammatic plans
- Section
- Renders

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Bibliography
Introduction
Interestingly enough, buildings in modern society are typically not designed to be demolished or deconstructed according to construction and demolition expert Bradley Guy. The way architects have been operating for years has been focused on growth and prosperity because we believe that long-lasting life is a virtue and at times economically more cost-effective. However, the result is that many buildings actually fail to fulfill their life expectancy set out by architects. In fact, up until now, the assumption was that building obsolescence is a matter of scale of time.

Unintended Building obsolescence

Derelict buildings seen at Villa 26 on the banks of the Riahuaco river in the Argentinian capital of Buenos Aires, Argentina. (2011)
Source: http://tetw.org/post/43373994938/ill-fares-the-land

Derelict building photography
Source: http://1074192222.blogspot.com/2011/02/12.html by Olivia Williams

DfD: Designing buildings to facilitate future renovations and eventual disassembly. This involves using less adhesives and materials and using more re-usable components.

C&D: Construction & Demolition materials consist of the debris generated during construction, renovation and demolition of buildings, roads and bridges.
(http://www.epa.gov/greenhomes/TopGreenHomeTerms.htm)

Derelict building in ZhongZeng, Taiwan
Source: http://fotografar.pt/predios-abandonados-ultrapassado-por-natureza/

Derelict building in Saint Louis, MO
Approx. 4,000 abandoned buildings in St. Louis City which has seen a declining population over the last 60 years

Derelict buildings in Saint Louis, MO

Rising Building Demolition Rates over time

Through these examples, we learn that building demolitions is a matter of "Scale of Time".
### DfD Matrix: Scale over time

**Short Term** (1-12 months)
- Afterparty Installation by MOS
- Pneumocell: Inflatable by Thomas Herzig

**Medium Term** (1-15 years)
- London Aquatic center by Zaha Hadid
- Philips eco enterprise center

**Long Term** (15 years - 60 years)
- Light House
- San Francisco Embarcadero Pier-Museum, Historic Preservation
- UBC C K Cho Building
- Shrinking building demolition in Japan

Building Component Life-span

Building components’ life span varies to a great extent and so some parts inevitably become obsolete earlier than other components. This distribution map (figure 1) shows how often buildings are demolished for reasons unrelated to physical obsolescence. When the building is designed for perpetuity, it falls in the pit of having to deal with area redevelopment, resale and not to mention maintenance issues.

Building Ecology Research
Building Life-cycle maps
Building Component Life-span
Building demolition reasons
Most of the reasons are unrelated to the physical obsolescence of building components

Figure 1. Source: O’Connor, Jennifer. “Survey on actual service lives for North American buildings” 2004.
Deconstruction vs Demolition

Deconstruction is a careful process that systematically disassembles a structure into its components. This process can recover items to be reused in future construction. Deconstruction process is also roughly the reverse process of construction, allowing separation of materials for reuse, recycling and disposal.

Higher cost
21% +
2.4 x man power
4 x Man-hours

Deconstruction

Demolition process usually requires detonation thereby protection of the site and surrounding buildings. Many components that can be salvaged are damaged through this process.

Salvage value
37% -
10% -
lower net deconstruction costs

Deconstruction vs Demolition

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<thead>
<tr>
<th></th>
<th>Deconstruction</th>
<th>Demolition</th>
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<tr>
<td>Cost (dollars/sq.ft)</td>
<td>$3.64</td>
<td>$1.74</td>
</tr>
<tr>
<td>Labor (people)</td>
<td>12</td>
<td>5</td>
</tr>
<tr>
<td>Time (days)</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Man-hours</td>
<td>480</td>
<td>120</td>
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</table>

Source: Deconstruction Institute, GreenHalo Systems. Note: For a typical 2000 square foot home.
Architects’ attempts to alleviate building obsolescence over time

In order to resolve the problem of partial obsolescence, architects have attempted to reuse, recycle, reprocess and relocate buildings and material components. For example, Japanese metabolism came up with plug-in unit type architecture in the 1990s. However, the initial cost of fabricating these customized unit types was too expensive that it could not supersede normal standards of building construction. It goes the same for the container box buildings, which has now become a popular architectural practice.

However, in the building industry, because of the large scale and the diverse methods of construction, despite the fact that there is a huge amount of research going on, the ramifications have been slow and minute in their impact. (Simply put, this is not to say that we lack information or knowledge, but it is rather that, it is hard for architects to have a comprehensive understanding of the technological input we can make on one’s own end.)

4 Basic scenarios for DfD: Design for Disassembly

1) Recycling Material
2) Reprocessing of Material
3) Reuse of components
4) Relocation of whole building


Source: Scenarios for Reuse in the Life Cycle of the Built Environment
Source: Philip Crowther, School of Architecture, Interior and Industrial Design, Queensland Univ. of Technology, Australia.
Precedents

Building Industry

4 Basic scenarios for DfD: Design for Disassembly

1) Recycling Material
2) Reprocessing of Material
3) Reuse of components
4) Relocation of whole building

Wang Shu, Recycling Parts
Xiangshan Campus, China Academy of Art, Phase II, 2004-2007, Hangzhou, China

PROS Historic significance, ecologically effective
CONS Time consuming, need for base resource

Ningbo History Museum, China

Historic significance, ecologically effective
Time consuming, need for base resource

Concrete Recycling Process
http://www.metalandwaste.com/Products/ferrous-metal.html

PROS Reduction in landfill space, Preservation of virgin material, Site/Storage for recovered material
CONS Lack of standards for recovered material, Devalued materials
4 Basic scenarios for DfD: Design for Disassembly

1) Recycling Material
2) Reprocessing of Material
3) Reuse of components
4) Relocation of whole building

Cargo Container Architecture

PROS: Strength, Durability, availability and cost (as cheap as $900 sometimes)
CONS: Toxic coatings used to facilitate ocean transport, Hazardous chemical flooring, Cumbersome process of making the box habitable, Energy consumed to transport container into place where needed, Awkward dimensions for human living space

Japanese Metabolism

PROS: Interchangeability, Replaceability
CONS: Costly fabrication of customized pieces
Low feasibility for mass production
### Basic scenarios for DfD:
Design for Disassembly

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<th>1) Recycling Material</th>
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<td>2) Reprocessing of Material</td>
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<tr>
<td>3) Reuse of components</td>
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<tr>
<td>4) Relocation of whole building</td>
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</tbody>
</table>

### PROS
- Interchangeability, Replaceability
- Costly fabrication of customized pieces
- Low feasibility for mass production

### CONS
- Interchangeability, Replaceability
- Costly fabrication of customized pieces
- Low feasibility for mass production

### Buckminster Fuller's Dymaxion

Using Tecorep system, building components are disassembled in the closed space. Two floors are removed each time. The roof of the top floor is supported by temporary columns, which are placed on large beams two floors below. While building components get dismantled, jacks incorporated into columns are lowered, creating a shrinking building effect from the outside.

The Carnegie Library of Patchogue was relocated as the 334 ton three-story brick building was moved to a storage location. The moving will be done in several phases.

### Building Mobility

http://www.wolfehousebuildingmovers.com/showcase/project-list/gallery/new-york/patchogue-ny

### Precedents

#### Building Mobility

The Carnegie Library of Patchogue, NY


### PROS
- Quiet demolition, Potential for reuse of materials

### CONS
- Specificity and high technology required

### Heavy machinery moving process
Other industries

Automobile Industry

General Motors, Chrysler and Ford formed the "Vehicle Recycling Partnership 1994" to develop means to recover materials from automobiles for reuse and recycling (Billatos and Basaly, 1997).

Furniture Industry

Do-it-yourself (DIY) furniture allows components to come apart easily as it is to assemble them, allowing easier access to reuse, recycle and reprocessing of materials.
**Mandate of time**

**Successful Example: LEED Point System**

LEED, in fact, mandates the use of dead buildings as much as possible.
After a thorough examination of current and past attempts to reduce building construction waste, the realization was that the major problem lies in the fact that buildings in modern society are typically not designed to be deconstructed\(^*\). That is why so many building materials end up in trash.

\(^*\)Source: Guy, Bradley; Shell, Scott; Esherick, Homsey. “Design for Deconstruction and Materials Reuse,” Designing for Built-in-Obsolescence

The consequences are as follows... ...

**Result of buildings not designed to be deconstructed**

- 60% of the materials are never recovered and end up in landfills.
- 80% of the materials are never re-used to make durable goods for long-term reuse after immediate reuse.

**Designing for Built-in-Obsolescence**

Perhaps we can reverse the common notion and design with built-in obsolescence and make a building last for only for a certain period of time.

What would it mean for architects to break away from creation?

What does it mean to design for death instead of birth?
Site Specifics

Galapagos, Ecuador

The SALT HOUSE will be sited in Santiago Island of Galapagos, Ecuador. Santiago Galapagos is a volcanic island in the northern part of Galapagos that consists mostly of arid and dry zones. There is also a history of salt mining in the northwestern part of the island, which now sits as a scar of human invasion. The project will utilize salt from this mine as an essential part of the project.

Most importantly, this is a site where awareness for human encroachment on its natural habitat cannot be more ecologically sensitive. The rising level of awareness in reducing disruptive and wasteful practice of human invasion makes it a perfect testing ground for this thesis.

Galapagos, Ecuador

WARM SEASON
Weak southwest trade wind (<1 knots)

COLD SEASON
Strong northwest trade wind 11-15 knots

UNDESIRED ZONE
Safe for development, Dry land

1 knot: 1.151 miles per hour

Seasonal Architecture at the intersection of Biodiversity and Encroachment in the coasts above Galapagos MIT Galapagos Studies Spring 2011

Area: 585 km²

Maximum Altitude: 907 meters

History: 1960's Salt mine excursion by Mr. Hector Edgas, the first settler

Santiago Island
During 1920s and 1960s, companies extracted salt from the Salt Mine Crater. The mine is a small volcanic cone whose crater has a seasonal, salt-water lagoon, where flamingos and other birds can be seen. Galapagos hawks are often observed in the area.
Resources & Rise in Tourism in Galapagos

Galapagos holds very little capacity for fresh water.

**STONE EXTRACTION TIMELINE**

<table>
<thead>
<tr>
<th>Year</th>
<th>Action</th>
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<tbody>
<tr>
<td>1999</td>
<td>Granule used for pavement of the Puerto Ayora Canal de Itabaca Road</td>
</tr>
<tr>
<td>2000</td>
<td>Complete rebuilding of the road to Baltra</td>
</tr>
<tr>
<td>2001</td>
<td>Increase in salaries for civil servants sparks wave of construction</td>
</tr>
<tr>
<td>2004</td>
<td>“La Cascade” neighborhood is built and new streets are created</td>
</tr>
<tr>
<td>2007</td>
<td></td>
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</tbody>
</table>
Hence, the thesis is carried out by designing a salt-cured seasonal residence, which will gradually and naturally be demolished over a designated period of time. The building life expectancy will be precisely set out from the beginning to the end-purporting each and every step of its life cycle - from occupation to demolition. It will be constructed and disappear back into nature within a one-year life cycle. Some parts will obviously remain for a longer period of time depending on its structural integrity. However, the big picture is that the house will evolve over time, varying not only in its form but also in its function.

**Life Cycle**

_Salt House Construction & Habitation Cycle_

<table>
<thead>
<tr>
<th>Season</th>
<th>Actions</th>
<th>Duration</th>
<th>Temperature</th>
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<tbody>
<tr>
<td>WARM SEASON</td>
<td>Passive Occupation</td>
<td>5 hr</td>
<td>29°C</td>
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<tr>
<td></td>
<td>Contemplation Shelter</td>
<td></td>
<td>27°C</td>
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<tr>
<td></td>
<td>End of Life-cycle</td>
<td></td>
<td>24°C</td>
</tr>
<tr>
<td>DRY SEASON</td>
<td>Beginning of Construction</td>
<td></td>
<td>29°C</td>
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<tr>
<td></td>
<td>Interior Excavation &amp; Build-up</td>
<td></td>
<td>24°C</td>
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<tr>
<td></td>
<td>Family Vacation House</td>
<td></td>
<td>21°C</td>
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**PLOTS:** 7/9, 9/9 done moving, still need to plot 5/9, need to cut 8/9 - 5 ft side (v) & 5 ft side.

---

**Notes:**
- CLEAR SKY (hrs)
- AIR TEMPERATURE
- WATER TEMPERATURE
- AVERAGE RAINFALL (in)
Main Material Stream

The main material of the building will be salt, water, soil, sand, gravel and coconut fiber. The reposed mounds built out of earth, will be the form works (or mold) for the house and coconut fiber will be layered on top of each mound to become the building façade. Salt crystallization over this layer will add rigidity and controlled opacity to the house.

Using angle of repose as form work allows the space inside to get as big as the mound gets. The important factor in this method is that it leaves no harmful impact on the ecology. Forms will vary in diameters, heights and angles depending on the mixture of earthen elements—which will add uniqueness and variability to each and every time a house with this method.
Comparison among different building types

Life Cycle Assessment

Variant 1.
Variant 2.
Variant 3.
Variant 4.

Construction & Demolition Process

Life-cycle Diagram

The diagram shows the construction process.

1) Earth will be dug out, pile of sand that was excavated will be reposed to create a mold for the space. The next couple weeks will be spent on salt crystallization over the coconut fiber layer. Then, earth will be excavated back into the underlying earth. In this stage, there will be a negative space created in the ground alternatively so as to have service space and interior build-up using the leftover earth.
Program Variability

2) Over time, the form will deform and some parts will fade away. Some parts can be made structurally more rigid in the layering process so that the durability is intentionally increased.

Differentiating MATERIALITY of mounds
DIFFERENTIATES THE FUNCTION, LIFE-CYCLE VARIABILITY

Soft-Bright → Coarse-Dark

Change over TIME
CHANGES THE FUNCTION OF ROOMS

Private Dwelling → Public Hut

Feasible method of Maintenance & Operation

Rain Water Harvesting Potential

ROOF PROJECTED AREA: Approx. 20m²
Calculation: Area in m² x Rainfall in mm x 0.001 x 0.9 [efficiency rate]
1ton = 1,000 liter
Water needed per person per day: 2-3 liters / day | 730 liters / year

90 % RAINWATER COLLECTING EFFICIENCY
=7.31 ton/year

50 % EFFICIENCY
=4.06 ton/year

Note: Despite the huge potential in the rainwater collection system, this idea will not be incorporated into the Salt House. The rainwater harvesting goes against the natural demolition concept of the house. Although ideally feasible, it is unanimously agreed among the critiques to not include rainwater harvesting in the project as it counteracts the thesis.
"Obsolescence over time" as a desirable factor

Key element in Construction and Demolition

In the conventional practice of architecture, "OBsolescence OVER TIME" was undesirable. In this project, obsolescence over time is actually one of the key elements of construction and demolition. Over time, the form will mutate through natural weathering agencies such as wind, water and rain. This deformation will provide subtle changes at different times of the day and year, which will then cause to serve different functions at different stages of life.
Material & Building Process Experiments
1. Salt Crystallization

Experiment & Observation of 8 selected materials

Coconut Fiber | Wiremesh | Basswood | Rice Paper | Corrugated cardboard | Casting Gauze | Burlap | Cotton | Nylon Fiber

Original state of materials
1. Salt Crystallization

Daily Spraying Action

Coconut Fiber | Wiremesh | Basswood | Rice Paper | Corrugated cardboard | Casting Gauze | Burlap | Cotton | Nylon Fiber

Solution: Water, Epsom Salt and regular Table Salt
1. Salt Crystallization

**Daily Spraying Action**


1. Casting Gauze
2. Coconut Fiber

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1. Salt Crystallization

**Daily Spraying Action**


1. Salt Crystallization
2. Daily Spraying Action
3. Rice Paper
4. Cotton Fabric

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1. Salt Crystallization

5. Wire Mesh
6. Burlap

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### 1. Salt Crystallization

- **Daily Spraying Action**
- 7. Corrugated Cardboard
- 8. Basswood

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**1. Salt Crystallization**

Soaking-Natural Evaporation, Oven Baking

Coconut Fiber | Wiremesh | Basswood | Rice Paper | Corrugated cardboard | Casting Gauze | Burlap | Cotton | Nylon Fiber

Solution: Water, Epsom Salt and regular Table Salt

---

Oven Baking
1. Salt Crystallization

Soaking-Natural Evaporation, Oven Baking
1. Coconut Fiber | Basswood | Corrugated Cardboard | Cotton Fabric
2. Rice Paper | Wiremesh | Burlap | Casting Gauze

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2. Salt Solidity Test

Mound Test
10.20.2013

Oven Baking | Boiling | Microwave | Natural Evaporation
2. Salt Solidity Test

Mound Test
10.20.2013

Oven Baking | Boiling | Microwave | Natural Evaporation
2. Salt Solidity Test

**Brick Test**

10.22.2013

Oven Baking | Boiling | Microwave | Natural Evaporation
2. Salt Solidity Test

Brick Test Result
2. Salt Solidity Test

**Brick Test**
10.24.2013

Oven Baking | Boiling | Microwave | Natural Evaporation
2. Salt Solidity Test

Brick Test Results

WATER: SALT [RATIO]  1:4 | 100pwr | MICROWAVE 60sec.  1:3 | 100pwr | MICROWAVE 60sec.

1:1 | 77 °F | BOIL  1:4 | 100pwr | MICROWAVE 60sec.  1:2 | 100pwr | MICROWAVE 60sec.
3. Salt Texture, Composite Test

Sand, Salt Aggregate

11.03.2013

Sand→Plaster: Sand → Sun dried Salt → Epsom Salt → Steam → Plaster → Excavation
3. Salt Texture, Composite Test

Sand+Salt Aggregate

11.03.2013

Sand+Plaster; Sand+Sun dried Salt + Epsom Salt -> Steam -> Plaster -> Excavation
3. Salt Texture, Composite Test

Sand, Salt Aggregate Test Result
4. Earth Repose Test

Sand Build-up, Texture Wrap-up
12.05.2013
4. Earth Repose Test

Sand Build-up
12.05.2013
Sand Build-up demonstrating angle of repose
4. Earth Repose Test

Sand Build-up, Texture Wrap-up
12.05.2013
Texture Wrap-up to cast sand mound
5. Salt Layer Test (Saltification 1.)

Salt Water Spray + Drier + Light Torch
12.07.2013

Salt Water Spray + Drier + Light Torch
5. Salt Layer Test (Saltification 1.)

Salt Water Spray + Drier + Light Torch
12.07.2013
Salt Water Spray + Drier + Light Torch

First day

Few days after
5. Salt Layer Test (Saltification 2.)

Salt Water Paste application
12.10.2013
Solution: Epsom Salt + Table Salt + Boiling Water
6. Excavation Mock-up

Sand Excavation & Interior Build-up
12.11.2013
7. Demolition Test (Partial)

Syringe: Rain Simulation
12.13.2013
7. Demolition Test (Partial)

Syringe: Rain Simulation
12.13.2013
7. Demolition Test (Partial)

Syringe: Rain Simulation Result
7. Demolition Test (Full Scale Model)

Main Simulation Result
12.15.2013

[Images of demolition test setup and simulation results]
7. Demolition Test (Full Scale Model)

Main Simulation Result
12.15.2013
7. Demolition Test (Full Scale Model)

Rain Simulation Result
Experiment Settings

Salt, Rain, Demolition Test set-up room
11.20.2013-12.15.2013
**Phase Sections**

**Drawings + Material: Time**

**Section Details & Deformation over time**

Phase Sections 1/6" = 1'-0"

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3rd MONTH OF BUILDING LIFE-CYCLE
Immediately after Earth Excavation

3rd-4.5 MONTH OF LIFE-CYCLE
Beginning of Occupancy Stage

4.5-6th MONTH OF LIFE-CYCLE
Active Occupancy Stage

6th-12th (or More) OF LIFE-CYCLE
Natural Demolition Stage
**Plans**

**Drawings + Material: Time**

Occupancy Phase: Deformation and transition over time

Phase Plans 1/6” = 1’-0”
Diagrammatic Plan

Unique formations
Diagrammatic Plan Variations
Section

Occupancy Phase

Phase Plans 1/6" = 1'-0"
Lighting & Gaze

Material Function
Final Presentation

Model & Test Samples

12.19.2013, Media Lab
Final Presentation

Model & Test Samples

12.19.2013, Media Lab
Final Presentation

Model & Test Samples

12.19.2013, Media Lab
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etc.

Credit Black background photography by Andy Ryan

For video, visit link: http://youtu.be/-5GcSURhwY (Title: The Salt House Project: Designing for death, MIT M.Arch thesis’13_SunMin May Hwang )