EXCRETAL ARCHITECTURE

Prototypical and Productive Urban Waste Forms

by Nancy Kim

Bachelors of Fine Arts in Architectural Design
Parsons The New School for Design, 2006

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 2013

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Author Signature

Nancy Kim
Massachusetts Institute of Technology
January 17, 2013

Certified By

Joel Lamere
Assistant Professor of Architecture
Thesis Supervisor

Accepted By

Takehiko Nagakura
Associate Professor of Design and Computation
Chair of the Department Committee on Graduate Students
Thesis Committee

Advisor: Joel Lamere
Assistant Professor of Architecture

Readers: Azra Aksamija
Assistant Professor of Art, Culture and Technology

Alan Berger
Associate Professor of Urban Design and Landscape Architecture
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Abstract

Excretal Architecture comes equipped with a set of design parameters sufficient to grow a regenerative city, while focusing on biomass accumulation as a key program. These structures are scalable and adaptable to any site, but are designed for cities that face ramifications of the industrial eras in particular - mainly toxic contamination in water and soil. The main purpose of these forms is to produce resources from waste through remediation and biodegradation process with the initial premise that soil and water are two of earth’s most valuable resources, which provide basic needs for humans. These structures have specific dry and wet program that incorporate low energy strategies by emulating natural cycles found in forests and in permacultural farming practices. Human excreta is collected, composted and used to form material for new ground. Water is collected, filtered, and deposited into its landscape as irrigation after usage using a greywater system. The city becomes regenerative through these biomass accumulation processes maintained by the architecture itself and participating inhabitants or visitors.

Thesis Supervisor: Joel Lamere
Title: Assistant Professor of Architecture
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To my parents and big sister for instilling values in me, being my firm foundation and reminding me to always be grateful and positive.

This is only the beginning!
EXCRETAL ARCHITECTURE
Prototypical and Productive Urban Waste Forms
Foreword

This thesis intends to ignite interest in integrating urban ecology into buildings and infrastructure. Specifically, urban areas that have experienced industrial contamination over several industrial periods. This is partially based on my observations of an increasing number architectural and infrastructural failure in cities, but also a look forward into the future of the ways that buildings could better respond to changing patterns of growing populations and unpredictable environmental changes.

This thesis experiments with architecture for it to be the catalyst to reducing the amount of waste produced in cities. It introduces a way of experiencing urbanity through a zero waste mentality, starting with making human waste a resource.

Waste is addressed at two scales: locally and domestically at the scale of your typical toilet and at the city-scale.

It questions the relevance of current sanitation/sewer systems. It imagines a city made up of composting toilets, recycled excreta and closed loop water filtration systems.

In Exreta (the prototypical city) a visitor or resident interfaces directly with their waste and participates in their waste becoming a resource. The very process becomes a part of the everyday.
Post Post-Industrial Conditions or The Present Moment

We manufacture products and experiences, we produce waste and forget about it. For hundreds of years, we’ve been focused on increasing economies through mass production and the export of goods. We prevailed in the economic sense for many years, but our capital hungry consciousness has brought us a plethora of toxic grounds.

The air, water and land surrounding us has been contaminated with industrial, human and domestic waste. An increasing change in extreme weather conditions is shedding light on the limits of infrastructure in our cities. Recent storm surges have made city dwellers more aware of the vulnerability of coastal habitation. They’ve also showed us how easily our sewers get overflown and spread human and industrial waste into surrounding bodies of water.

We are at a point where conventional methods of manufacturing are being challenged. Movers and shakers in city centers are developing faster and even more efficient ways of making – this time with the increasing number of fabrication labs. In turn, this is leaving old manufacturing towns abandoned – with all contaminated micro-climates in air, water and soil.

Somehow the message didn’t make its way from our precursors. Even after the devastating health concerns that resulted from the aftermath of industrial processes in the first industrial town in the world, Manchester. The conditions were harsh enough that Friedrich Engels’ two-year stay at a paper mill company in 1842 provided enough material to produce his first book: The Condition of the Working Class in England in 1844. Some of his excerpts include observations of horrid conditions.

"In one of these courts there stands directly at the entrance, at the end of the covered passage, a privy without a door, so dirty that the inhabitants can pass into and out of the court only by passing through foul pools of stagnant urine and excrement...At the bottom flow or rather stagnates, the Irk, a narrow, coal-black, foul-smelling stream,"
full of debris and refuse, which deposits on the shallower right bank.

Above the bridge are tanneries, bone mills, and gasworks, from which all drains and refuse find their way into the Irk, which receives further the contents of all the neighboring sewers and privies.”

Engels’ short, but vivid descriptions of Manchester’s industrial town are not so dissimilar to the conditions that can be found in Newtown Creek, a body of water that sits between Brooklyn and Queens. This creek acts as a stagnant threshold into New York City’s largest manufacturing companies. In 1850, more than fifty refineries set up shop along this creek and for hundreds of years contaminated the air, water and soil of the site. This site is now a registered Superfund site by the state of New York and serves as an example of a site where Excretal Architecture could be implemented.
A Historical Glance Soil Degradation

Microorganisms/bacteria are adaptable organisms that regenerate organic waste into high quality soil.

Darwin observes the action of earthworms reviving soil in his backyard. Then publishes book of observations titled, "The Formation of Vegetable Mould Through the Action of Worms".

Industrial Agriculture
The identification of nitrates (nitrogen, potassium, and phosphorus) leads to the manufacturing of synthetic fertilizers (this affects spike in arable land erosion).

3.5 GIGAYEARS AGO

1750 Pre-Industrial period
Civilizations were built on passive/solar building methods. Working with natural ecological systems was intuitive.

Karl Marx
Projections of the ramifications of an industrial society constructed w/o proper ecological considerations.

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An increase in industrial manufacturing advances us technologically, but further contributes to high levels of contamination of ground and water.

**FORDIST ERA**
Mass production, efficiency, speed and mass quantities

**THE 60S**
Post-Industrial peak, leftist riots
Focus on environmental policy change and public health

---

**The Dust Bowl**
Industrial farming caused over 100 million acres of land in the High Plains to be stripped of its native buffalo grass and barren of any crop, being a particularly bad storm on May 11, 1934, over three tons of dust for every American alive at the time traveled from west to east across the country. The dust blanketed Chicago, New York, Atlanta and other urban centers. It darkened the skies and choked those who ventured in it hundreds of miles from its source. The storm spanned 1,800 miles, spreading 350 million tons of dust across the nation.

**Permaculture**
Permacultural practices take off in Australia, Austria and the United States. The damaging effects of industrial farming techniques encourage a shift to organic farming practices.

**NTC - Superfund Site**
In September, NTC gets listed as a Superfund Site after finding harsh industrial metals and contaminants in sediment samplings.

**NTC - Poor Water Quality**
New York State declared that Newtown Creek was not meeting water standards under the Clean Water Act.
First Signs of Contamination
From Contaminated Zones to Garden Cities

Many theorists and philosophers projected that economic and urban growth, without sensitive consideration of ecology would eventual lead to the depletion of the very resources that enabled productive economy.

“It is not the unity of living and active humanity with the natural, inorganic conditions of their metabolic exchange with nature, and hence their appropriation of nature, which requires explanation or is the result of a historic process, but rather the separation between these inorganic conditions of human existence and this active existence, a separation which is completely posited only in the relation of wage labor and capital.”

-Karl Marx, Grundrisse
This diagram is an early illustration that I altered at the onset of thesis. The last scenario was added to Ebenezer Howard's original drawing. The original purpose of his drawing was to imagine improved living conditions during the first Industrial era. The "Now!" scenario that is added imagines life one step further. Could buildings and parks be more productive?
A Zero Waste Approach

This diagram illustrates the percentages of waste by category. The aim of this thesis is to address natural waste, which consists of anything that is biodegradable. (Source: US EPA)
Could we have come full circle? From an agrarian to industrialized and now back to somewhat of an agrarian state? Prior to Industrialization, humans were sensitive to the environment. This relationship was evident in two essential components of living: food and shelter. Buildings were predominantly built out of local materials that were easily transportable and in close proximity. Forms of buildings were optimal for interior comfort. The aim was to take advantage of ‘free’ resources.
Contamination and Toxicity

The diagram above was an attempt at trying to understand pH balances and levels of acidity in products. It was a way of delving into the chemistry of things.

Shown above is a brief timeline of Newtown Creek, the site that acts as a sample site for this thesis where excretal architecture could start to be implemented. (Source: US EPA)
Prior to industrialization, it was apparent that humans were much more aware of natural ecological systems in their daily life. This was apparent in architecture and food production. Architecture was designed to take full advantage of sunshine hours and wind directions for ventilation and cooling. Farming practices didn't involve toxic chemicals or harmful fertilizers.
Precedents
<table>
<thead>
<tr>
<th>CONDITION</th>
<th>EXAMPLE</th>
<th>HOW DOES IT WORK?</th>
</tr>
</thead>
</table>
| HYPERBOLIC (NEGATIVE GAUSSIAN CURVATURE) | COOLING TOWER | 1. WATER BOILS AT BASE  
2. STEAM RISES  
3. NARROWING OF TOWER ACCELERATES LAMINAR FLOW |
| MASS (THERMAL MASS) | COURTYARD HOUSES | 1. MASS STORES COOLNESS AT NIGHT AND DISSIPATES IT DURING THE DAY (WARMER HOURS) |
| DIRECTIONAL       | KASBAH (TRADITIONAL MIDDLE EASTERN HOUSE) | 1. HEAT ENTERS AT LOWER LEVEL  
THEN VENTILATES THROUGH CONVECTION  
(preceded by collective movement of molecules within) |
| DOMES             | WIND CATCHERS (TOWERS) “BAGER” (TRADITIONAL IRANIAN HOUSES OF YAZD) | HEAT LOSS BY CONVECTION ACROSS THE ROOF |
|                   | HOUSES / GENERAL BUILDINGS WHERE WIND IS UN-DIRECTIONAL | |

Above is research and analysis on natural heating and cooling methods found in varying examples of architecture.
These diagrams are samples from simple waste flow studies conducted in order to understand at which point architecture could enter to prevent waste flowing out into surrounding bodies of water.
This diagram shows a typical city wastewater treatment process in a facility. The information was sourced from NYC DEP.
This diagram shows the performance of a typical city sewer system or a publicly-owned treatment works (POTW) during dry and wet weather.
Abstracted Porosity Studies

Shown above are varying porosity levels. They are abstracted renditions of the porosity levels of soil, oyster gills and biosand filtration system.
Composting During Thesis Semester
(Duration: 3 months)
I obtained some worms from a local organization and tried to compost my daily foodscraps in order to produce fresh compost for my final model. Unfortunately, it didn't make enough clean compost in time.
At the onset of the semester, I studied the formal geometries of buildings and infrastructure in order to get better acquainted with how much the forms affected the performance of the structure. I looked at various vernacular buildings that were commonly known to be successful at naturally heating and cooling interior spaces.
FIELD CONDITION STUDIES (AIR FLOW)
(CHEEDED, PACKED, TRANSFORMED, SCALED)
Field Condition Studies
(3D Printed Physical Models)
3D printed studies of applying and adapting forms in a field condition.
Transformation Study

Shown here are transformational studies from a square to hexagon across a sectionally varied field. The field imagined here was a sloped landscape.
Transformation Study

Shown here are transformational studies from a square to hexagon across a sectionally varied field. This differed from the previous study because I was studying a dipped field - one that could retain water.
This was a study aggregating a form that was ideal for sinusoidal airflow. Serendipitously, an interesting relationship between interior to roof access was discovered.
Sinusoidal Scale Change

This was a similar study of the same form, but changing its scale to see how that could allow flexibility in airflow and temperature change across a field.
Sinoidal Geometry Study

Airflow study models shown above on a flat site. The bottom level was kept open to allow actual testing.
Sinosoidal Geometry Study

Airflow study models shown above on a sectionally-varied site. The aggregation of the form was kept the same in order to be able to compare the advantages and disadvantages of what the field conditions could offer.
Thermal Mass Study

This model was a study of thermal performance. The performances were varied to try to understand how different needs of occupants could be accommodated across a site.
Dome structure studies. The varying was an attempt at creating the potential for interior spaces with differing temperatures.
Hyperbolic Geometry Study

This form was taken from a cooling tower, which has a hyperbolic geometry. It was packed across a field to see the spatial potential.
Site Adaptability and Scalability

The site of Newtown Creek will be approached through a tabular rasa fashion. Due to the presumed conclusion that more than one hundred fifty years of industrial activity on the site probably contaminated the majority of the land cover and water that make of the site.
Newtown Creek, NYC
(Information on the maps were sourced from data from the Newtown Creek Alliance)
Adaptability and Scalability

The excretal forms are organized through a propagation of circles organized by a grid, tangencies and gradations across the site. Shown here, is a preliminary urban program. The program consists of:

- Innovation District
- Experimental Farm
- Residential Areas
- Natural Burial Forest
- Urban Remedial and Recreational Beaches and Pools
- Compost Park
Organization and Aggregation
The excretal forms are organized and constructed through their tangencies sectionally and through their apertures in plan.

Natural Lighting
Natural light enters the structures through central light shafts.

Water
Water is collected, filtered and dispersed through the collection containments at the roof. These do not have to occur at every instance.

Sanitation
All toilets are dry composting toilets so that they do not enter the larger systems. It is seen as a closed loop system in this Excretal City.

Circulation
Circulation is organized centrally in the elevator cores. These are used by both residents and visitors. They are educational platforms as well because you can visit the underground composting facilities.

Material
Cast-in-place reinforced concrete is the proposed material. The structures are constructed as they are needed.
ZONING STRATEGIES

PROGRAM ZONING

UNDERGROUND NODES

WASTE SYSTEMS UNDER/ABOVEGROUND

ORGANIZATIONAL STUDIES

TANGENCIES

SPINAL

CLUSTERING AROUND HINGEPOINTS

INFRASTRUCTURAL POTENTIAL

STREETS/PATHS

SECTIONAL OVERLAP

HINGEPOINTS
Formal Potential of Cone Geometry
(Landscape, Median, Architecture)
These conical structures are a type that allowed me to explore the performative qualities of a living building, which could blur the line between landscape, urban space and architecture.
Program Taxonomy

PHASES OF NATURAL BURIAL FOREST

PLANTERS

WATER COLLECTION/FILTRATION

WATER SOURCE/FITTINGS

CUSTOMIZABLE APERTURE ORIENTATION
EXPERIMENTAL FARMING

FLEXIBLE ROOF SYSTEMS
ABILITY TO ATTACH EXTERNAL MEMBRANES

CIRCULATION BETWEEN UNITS

STRUCTURAL FOUNDATION
RECREATIONAL/REMEDIAL POOL
CONTAINMENT

SLOPED FIELDS/NEW GROUND

SHADED AREAS FOR
MUSHROOM/BROCCOLI FARMS
Rules to Building an Excretal City

FOUNDATION ALIGNMENT

CENTRAL ATRIUM FOR NATURAL LIGHTING

STRUCTURAL CORE

STACKING
- MUST ADD 8’ INTERVENING LEVEL FOR PROGRAMMATIC ACCESSIBILITY FROM CIRCULATION CORE
NESTING
- Angle of slope must align w/ nesting partner

FORMING NEW GROUND
- Edge tangencies
- Flexible cores
STEEP SLOPE
-If slope of cone is inaccessible due to steepness, make that portion an exit/entry point.

PLANNING FOR GROWTH
-When stacking new structures, add walkways to the perimeter so that streets could form from adjacencies.
Typical Plan and Section
(of an Excretal City)
Typical Plan
Shown above is a typical plan layout with the main elevator and stair circulation core in the center and residential units radially organized in a flexible fashion. The idea is that the infrastructure is set up for the dwellers to decide how these forms get divided depending on unique needs.
Shown in this plan are a guide of holes in the floorplate, which are to be used for your individual portable toilet pod. Every unit has an "underyard" composting facility underneath where the excreta can deposit to.
Above is a rendering of an imagined typical day meandering through the city. One would interface with familiar urban conditions as well as experience new program, such as seeing finished compost fall from the undersides of buildings.
Typical Open Air Lobby to Residence

Typical open air lobby or entry area into a rentable space. The spaces could be residences or offices.
Typical Interior
(Lofted space, skylight)

Shown above is a typical interior lofted unit. Each unit is a wedge that is approximately 15' high. The skylight and elevator shaft are the main sources of natural light, which is the encouraged before using artificial lighting.
Tending to One's Underyard

Shown above is a typical interior lofted unit. Each unit is a wedge that is approximately 15' high. The skylight and elevator shaft are the main sources of natural light, which is encouraged before using artificial lighting.
The above renderings show a typical "underyard" of a residence. Each dwelling unit comes equipped with a personal humanure composting facility. In the background is the main elevator core that serves as a space for visitors to view the actions taking place as well as circulation for actual occupants.
The section shows the ability for the city to transform and perform differently between dry and wet weather. Before a storm, interior waterfront spaces have flexible programs such as market stalls, art gallery spaces and performance halls. After or during a storm, these forms become storage facilities for boats, and market set up materials. They also retain water and act as flood mitigators. The inhabitants can ascend up the tower as the
Typical City Scape

This rendering shows a moment where passersby could be educated on how rainwater is collected on the roofs of buildings.
After a storm, the city might be submerged, but in an a city constructed of excretal architecture, buildings and streets are made to be aqueous. Submergence is expected.
Section Showing Stackable Qualities and Waterfront Program
City Details - Recreation
Having an adaptable form allows for a multiplicity of recreational activities to emerge. Who needs a mountain, when you have an excretal wall to climb? Outdoor sports are made more accessible through the formal transformations across the city.
City Details - Compost Toilet Program
The proposed humanure sanitation system is designed to use a thermophilic composting process of human waste. This process is an aerobic decomposition of organic matter. It includes a high temperature stage where most of the work is done by microorganisms.

(Source: http://humanurehandbook.com)
Water is collected, filtered and then dispersed for use. Afterwards, through a greywater system, used water is filtered and recycled for use within the city landscape.
Flexible buildings could house performances that could be enjoyed by passersby. The flexibility of section through the city creates new datums. In turn, this creates a dynamic experience of the city.
Excretal City Sampling
(Physical Model)
The purpose of the forms presented are to provide the infrastructure for programmatic use. At one point, I thought it would be interesting to design wall/insulation systems from waste material such as jeans or felt. These could be easily clipped onto the forms and stowed away when not used.
Final Model (Portion of a City)
The physical model delineates the performance of the buildings. The white portions show how the water filtration systems work.
Final Model (Portion of a City)
Shown above is a typical view to productive parks, where the soil making up the grounds comes directly from the composting facilities, which hold and process human excreta from the composting toilets within.
Appendix
Initial Concept Sketch


King, F. H. Farmers of Forty Centuries; Or, Permanent Agriculture in China, Korea and Japan,. Madison, WI: Mrs. F.H. King, 1911.


