Thick matters: De-optimizing Infrastructural Redundancies, Pt. 1

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Closed system design methodologies have produced infrastructures that anticipate only a single lifetime use. This approach has burdened many urban areas with defective infrastructures in need of perpetual modification and repair. Rather than continue to over-engineer these vital frameworks to resist the inevitable failure of individual components, the next generation of public infrastructure needs to exceed its technical specifications and seek ways to create spatial reciprocity among systems.

This thesis calls for a renewed understanding of redundancy in order to strategically infuse infrastructure with public agency and diverse utility. Such an approach has the potential to yield greater systemic outputs and a more productive lifespan, allowing future infrastructures to be positioned both as a collective good and a resilient service.

Infrastructures are inextricably linked to the development of cities and the delivery of improved living standards. These ideals are embedded within the typology of the bridge – a structure critical to the efficacy of transportation networks. Optimized to facilitate the continuous flow of people and goods, the present state of bridges forecasts a future of urban dysfunction. Over the last decade, bridges in the United States have become a significant feature in the growing crisis of public infrastructure. Built during the post-war era when the growth of transportation networks was less of an expansion and more of an explosion, many bridges have now exceeded their 50-year lifespan.

Via the prototyping and design of a new Liberty Bridge in Pittsburgh, Pennsylvania, this thesis aims to demonstrate how infrastructural thickening might enable the next generation of public works to perform as resilient systems rather than standalone structures.

Infrastructural Thickening is the term I propose to describe a strategy that aims to modify the spatial, systemic and experiential utility of infrastructure – a strategy that works towards shifting the understanding of infrastructure from line to volume. This shift is achieved by virtue of de-optimization, a design technique that seeks to augment engineered specifications into scenarios for inhabitation, participation and added value.

In pursuit of infrastructural thickening, this thesis explores relationships between structure, space and form as a means to generate redundancies that have the capacity to address issues beyond the bridge’s physical footprint. Topics such as storm water run-off, waste management, and public space are central to the design agenda. In response to these urgent issues, a system of structural cones is deployed that mediate flows of water, cars and people into a unified, heterogeneous interface.

This thesis envisions the next generation of infrastructure as thick matter – a new public territory that provides people the opportunity to engage and participate in mutually productive dialogues with issues of urban, spatial and environmental urgency.
Treats 200 million gallons of wastewater daily at the junction of Gay and Lombard Streets in Baltimore, 1908.

Lewis Mumford’s Invisible City (*note: The hidden pipes and conduits at the heart of cities*)

INFRASTRUCTURE

Industrial Typology

Pittsburgh: City of Bridges...and aging sewer systems

Engineered Redundancies

Changing Perceptions

Steel Production

Riverfront with

Founding Diagram: The invisible city of Infrastructure

INFRASTRUCTURE IN THE CONTEXT OF ENGINEERING

Social

Economic

WHAT IF INFRASTRUCTURE IN THE CONTEXT OF ARCHITECTURE

 mobility

Energy

Water Filtration

Riverfront Revitalization

Technology, Healthcare and Education

Waste Management

Mobility

National

What: Bridges are a technology both for mobility within the interior of cities and also for the modern city’s expansion, its reach deep into rural landscapes and across national borders, as an inherently controlling, imperial and colonizing power.

The strength of the bridge determines the magnitude of allowable ‘live load’.

If every bridge in the city could collect/capture the volume produced by a 1-inch storm event, how much water would they be able to keep out of the CSO?

The bridge is a repetitive assembly of structural components. Its primary purpose is to facilitate the continuous flow of vectors (people and cars) and processes (mobility) between nodes.

Due to excavation costs, tunnels are the most expensive type of infrastructure.

<table>
<thead>
<tr>
<th>System</th>
<th>Cost Per Mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bridges</td>
<td>Highest</td>
</tr>
<tr>
<td>Tunnels</td>
<td>Second</td>
</tr>
<tr>
<td>Small Overpass</td>
<td>Third</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Volume of Vehicles</th>
<th>Average Cost per Mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over 4 lanes</td>
<td>$43,000</td>
</tr>
<tr>
<td>2-4 lanes</td>
<td>$30,000</td>
</tr>
<tr>
<td>1 lane</td>
<td>$15,000</td>
</tr>
</tbody>
</table>

There is a doubling surface area of infrastructure for every doubling in volume of vehicles crossing the bridge.

Number of lanes constricts the number of vehicles crossing the bridge.

Bridge Crisis in the U.S.

Due to excavation costs, tunnels are the most expensive type of infrastructure.
COLLECTING STORMWATER

CLARIFYING

TREATMENT PLANT

REPROCESSING

REUSE

URBAN SPECTACLE

WATER PLAZA

VISITOR’S CENTER

RELEASE / ABSORPTION
Since a bridge is fundamentally an aggregate of structural modules, how can we utilize structure to maximize surface porosity and also facilitate rainwater flow?

**WHAT RAINWATER IS FORCED TO DO...**

**HIDDEN**

- Percolate vertically and re-enter the hydrological system in order to recharge the aquifer.

**WHAT RAINWATER WANTS TO DO...**

**VISIBLE**

- Permeabilize vertically and infiltrate into the superstructure to capture, convey, store, filter, and release rainwater run-off.

**PROPOSED**

- Minimize existing trabeated pier spacing.
- Increases surface porosity but forces structural footprint to increase.
- Maintain some horizontality for vehicular and pedestrian traffic.

**Approach:** Utilize existing spacing of vertical superstructure to capture, convey, store, filter, and release rainwater run-off.

**OPTION 1**

- Maximizes surface porosity, minimizes structural footprint.
- Horizontal aggregation of vertical elements.

**OPTION 2**

- Minimizes structural footprint, maximizes surface porosity.
- However, it dissolves horizontality, halts flow of people and cars.
INFRASTRUCTURAL THICKENING
Shifting from Line to Volume

The structure is no longer distinguished by its basic subdivisions. Instead, through the process of infrastructrural thickening, the bridge begins to express a whole-to-whole relationship; a fine grained structural lattice that enables people, water and cars to participate in the issue of volume.

Structure, Water and Porosity
If water is the space for water, where do cars and people emerge?

Linear Volume
Vertical aggregation of horizontal planes allows for infrastructure to shift from a line to a volume.

Unified Interface
Multiplicity of horizontal planes allows for various flows to weave and traverse both in plan and in section.

Composite Structure
Merging cones with horizontal structure

Structural Gradation (x, y, z)
Add structure where needed, remove where not needed

The structure is no longer distinguished by its basic subdivisions. Instead, through the process of infrastructural thickening, the bridge begins to express a whole-to-whole relationship; a fine grained structural lattice that enables people, water and cars to participate in the issue of volume.
STRUCTURE, POROSITY and FLOW

The Pier: Grid Manipulations

Filter / Absorption Coupling Processes
(Water tank + Bio filtration swale)

Circulation Core + Water Cistern

Water Tank

Pier Types

Water Generator

Circulation Core + Water Cistern

Program

Filter / Bioclipper

Coupling Processes
(Water tank + Bio filtration swale)
Generating Porosity

Primary Structure (Truss)

Secondary Structure (Steel Frame)

Light Frame Structure (Filigree)

Pier Grid Water 'Heat' Map

Pier Zoning

Flexible Circulation

High Basic Grid Low
URBAN STRATEGY: Expanding the bridge’s physical + virtual footprint

LESSONS LEARNED FROM WATER TOWERS

Virtual

Physical

Current

FOOTPRINT

Existing

Proposed

STORE

RELEASE/ RE-USE

BRIDGE AS WATER NEXUS

Process

+485

+100

-180

+180

The site of old 28-acre Mellon area has been proposed to be transformed into a mixed-use development. Utilizing the elevation of the site, rainwater run-off could be channeled to the bridge for collection and processing.

This convergence of highway ramps is bounded between Duquesne University and the Downtown area. Further accumulation of rainwater can be guided to the bridge structure for storing and processing.

This underutilized and crucial public space nested between the Municipal Courthouse and the county Jail has the potential to assume part of the systemic logic of the bridge. Water-based activities and habitats can be reintroduced in order to create a more productive space for public engagement.

The 14-acre "East Parcel" of Station Square is proposed to be transformed into a mixed-use residential and office development. Utilizing the elevation of the Mt. Washington neighborhood

Housing the headquarters for Friends of the River and Just Harvest, the Terminal Warehouse next to the bridge sets the tone for the kinds of activities that could complement these public interest organizations (i.e., urban agriculture, water plaza, a visitors center etc)

Utilizing the 485' elevation of Mt. Washington, rainwater run-off can converge on the bridge where it can be stored, processed, re-used and/or released.