Permanence
Aligning Architecture, Nuclear Waste, and the Public
by John Maher

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MASTER OF ARCHITECTURE

Abstract

Permanence is intended as a provocation to question the current relationship of time and architecture. Architecture has always had a relationship with time, but historically this relationship has been troubled. In 2013 we as architects are currently operating under a false assumption that architecture should only be in a relationship with commodity. This is producing architecture with a very short shelf life, and the architecture is secondary to the commodity it houses.

Contemporary architecture only lasts for thirty to one hundred and fifty years and is constrained by budget, the building industry and material warranties. Contemporary society is fast paced and rapidly changing. This rapid change has manifested itself in our architecture and our perception of scales of time. In the modern era, when something is considered permanent it only lasts roughly one hundred years. Our perception of time in the future and the past is small in the grand scheme of history. However, this has not always been the case. We have produced architecture that spanned millennia in the past and when we did we’ve produced great architecture.

How is it that great architecture of the past was able to overcome budget, and dedicate itself to time? These great architectures all had great motivating factors that trumped budget, and were perceived as permanent. These motivating factors include; religion, body politic, or precious resources such as water. The societies that built the architecture though that their way of life, their government, etcetera, as permanent.

This thesis states that it is possible to align architecture back with time when dedicated to a motivating factor without a limit of time. The thesis project aligns itself with nuclear waste.

Nuclear energy will be necessary to serve the energy needs of a rapidly growing population, and as the technology becomes safer and more efficient it will be more prevalent in cities. The only problem with Nuclear energy is the waste. I’m proposing an architecture that aligns nuclear waste with the public through a public bath. Bathing is a tradition in most cultures that has lasted for thousands of years, and will continue in some way for thousands more.

The time is 3013 and the site is an inundated Cambridge, Massachusetts. MIT has moved it’s nuclear research facilities to an island just east of what was once Central Square, and the nuclear waste from the research is used to warm the waters of a public bath.

Thesis Supervisor: Brandon Clifford
Title: Belluschi Lecturer in Architecture

JOHN MAHER
Permanence
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Thesis Committee

Brandon Clifford
Belluschi Lecturer in Architecture
Thesis Advisor

John Ochsendorf
Professor of Building Technology and Civil and Environmental Engineering
Thesis Reader

Mark Jarzombek
Associate Dean and Professor in History and Theory of Architecture
Thesis Reader

JOHN MAHER
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*JOHN MAHER*
This first timeline illustrates our current perception of time. It shows the Great Pyramids, Jesus, MIT, and 2013. MIT is something that, in the modern era, we think of as permanent, and being around “forever”. The timeline shows that in the span of 4,553 years, MIT is just a short blip of existence, and we are currently closer to Jesus than we are to the Great Pyramids. It puts the scale of time I’m operating within in a more tangible perspective. Even this timeline is dwarfed by the length of time nuclear waste remains radioactive. Nuclear waste storage currently needs to be rated by the U.S.NRC for 10,000 years, however some waste will remain radioactive for millions of years.
Permanence
Since current trends in architecture build for budget rather than time, I’m looking at antiquities as a reference for relating architecture back to time. The research into these building is for the motivating factors behind the importance of the architecture, rather than just the form and structure. The societies that constructed this great architecture assumed their motivating factors to be permanent and built the structure that housed them for permanence.

The Colosseum was built to entertain the people of Rome. The Romans thought the gladiatorial entertainment would last forever, but even when it did not, the architecture remained and was transformed and used for something else. The importance of the original program and the architecture is what preserved the Colosseum.

I’m also interested in the grandeur of the spaces within these buildings. The scale and the massiveness of the structures add to their spectacle. The dome of the Pantheon was built
to honor Pagan gods, but is also a great architectural and engineering feat. From a design perspective, the domes, vaults, and arches have great structural performance to help these buildings last.
This diagram shows a block being demolished in China and highlights how wasteful our architecture has become. In China, buildings are being torn down before they are even completed to make room for new architecture. This new architecture will probably only last for 30 years like the architecture before it.
Nuclear
The next three diagrams highlight some facts comparing nuclear energy to natural gas, oil, and coal. Nuclear energy is cleaner, safer, and more efficient than the others. It makes sense for Nuclear energy to proliferate world wide, with population growing exponentially and energy use expected to grow with it, nuclear energy is the smartest option to fulfill energy needs and combat climate change.

The diagram below shows CO² emissions per kWh of energy. Nuclear energy emits no CO² during the actual energy conversion process. This diagram does not include embodied energy such as mining the ore.
The diagram below shows the number of deaths per kWh. Nuclear energy leads with .04 deaths per kWh historically, this includes the disasters at Chernobyl, Fukushima, and 3 mile Island.
The diagram below shows the volume of fuel per mWh, and nuclear energy needs a very small amount of fuel to produce a very large amount of energy.
These photographs show current storage options for low-level nuclear waste. All of them involve a geological burial of the waste to prevent human contact. All of these places are in remote locations away from the public. What if we could harness the waste as a resource and use it for a public function?
This map shows the locations of all the current Nuclear facilities in the United States, and the proposed shipping routes of the waste, via truck, train or barge, to two remote locations in Nevada and New Mexico. As Nuclear energy becomes more widely used in cities the US it will no longer be feasible to ship the waste from all of the country to these two place. I'm proposing to store the waste on site and use the heat to power a public amenity.
The Yucca Mountain nuclear waste repository in southwestern Nevada, is the official nuclear waste repository in the U.S. The waste is placed on rail carts and taken deep into the ground. When the repository is filled with waste it will be capped with many feet of concrete and left. Warning signs for future civilizations have been designed to keep future curious populations from disturbing the site. This facility is for waste only, no research is to be done at Yucca Mountain.
The Waste Isolation Pilot Plant (WIPP) is a deep geological repository and research center for nuclear waste. It is located in southeast New Mexico. The repository is located within a 3,000 foot thick, stable salt formation. The salt is important because, if it cracks due to geological instability or water groundwater begins to penetrate the waste zone, it self heals, filling the cracks with more salt. WIPP is for both storage, and research.
My project in Cambridge, MA is a combination of a repository, research center, and public bath. The nuclear research conducted produces the nuclear waste, the nuclear waste is placed in waste pools to cool, and the steam generated from the long cooling process is used to warm the bath house.
This diagram shows the material thickness needed to reduce radiation produced to a safe level when placed between a person and the source of the radiation.
Historic and “Projected” Energy Consumption in the USA

(qtr trillion BTU)

USA LEADER IN ENERGY CONSUMPTION

19% NUCLEAR POWER

100 NUCLEAR POWER PLANTS

800 BIL kWh/yr

87,000 kWh/capita

PERMANENCE
My Necessary Projections

NUCLEAR

RENEWABLES

HYDRO WOOD

2000

2050 COAL

2100 OIL

FRANCE
LEADER IN NUCLEAR ENERGY

59
NUCLEAR POWER PLANTS

420 BIL
kWh/yr

40,000
kWh/capita

80%
NUCLEAR POWER

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The chart below shows radiation exposure for the average person, and compares it to other high risk jobs, disasters, and medical procedures. Radiation exposure can be dangerous at extremely high levels, but with properly designed facilities exposure to radiation can be prevented. The bathhouse uses design parameters that prevent radiation exposure between the research labs and the bathhouse.

**Radiation Exposure**

*measured in millisieverts (mSv)*

- **2.4 mSv/yr** -- AVERAGE PERSON
  - 230 mSv dose -- FUKUSHIMA EMERGENCY WORKERS
  - 4.5 mSv/yr -- URANIUM ORE MINER
  - 350 mSv/lifetime -- CHERNOBYL DISASTER RELOCATION

- **10 mSv** -- CT SCAN
  - 800 mSv/yr -- HIGHEST LEVEL OF BACKGROUND RADIATION ON A BRAZILIAN BEACH
  - 100 mSv dose -- CANCER RISK
  - 1000 mSv dose -- CAUSES RADIATION SICKNESS

- **20 mSv/yr** -- LIMIT FOR NUCLEAR WORKERS
  - 1000 mSv dose -- CAUSES CANCER IN 5/100 PEOPLE SEVERAL YEARS LATER

- **9 mSv/yr** -- AIRLINE CREW TOKYO - NYC
  - 700 mSv/yr -- THRESHOLD FOR MAINTAINING EVACUATION ZONE

- **5 mSv/yr** -- AVG AIRLINE CREW
  - **250 mSv/yr** -- NATURAL BACKGROUND LEVEL IN RAMSAR, IRAN

- **0.3 mSv/yr** -- NUCLEAR SUBMARINE WORKER
10,000 mSv dose -- FATAL WITHIN WEEKS

5000 mSv dose -- KILLS 1/2 PEOPLE WITHIN A MONTH

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The timeline is showing eras of time since the invention of writing in 4,200 B.C. The images on the timeline show important moments in civilization, nuclear discoveries, and architectural accomplishments. The graphs in the background juxtapose population growth and types of energy use. Everything past 2013 is future speculation. Showing the length of time nuclear waste will still be radioactive for, and speculates the fate of the human race.
TIMELINE

10000 YEARS

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Nuclear waste is still bubbling and will continue to bubble long past the end of this timeline. The timeline is meant to put the length of radioactivity in perspective. The waste will last longer than current human history.
Bathing
Bathing is a tradition in many cultures, and has been so for thousands of years. People have always bathed and will continue to do so for thousands of years into the future. The bath house program for the project makes sense because of its long history and use of heat. The baths are at different temperatures. The frigidarium is the cold bath, and the water can be cycled to cool the nuclear waste. The caldarium is the hot bath, and the steam from the waste pools can be used to heat the pool water. The sudatorium is the sauna and the steam can be used directly in this room. Bath houses also had a natatorium, a large pool for swimming which is located at the top of the bathhouse and the very bottom. The heat from the nuclear waste can be transferred to heat the baths, and the steam can also be used to turn turbines and power the rest of the bath house.
This image is showing the structure below the baths and saunas. The steam or hot air warmed the voids below the pools and transferred the heat to the water or air in the room above. The project uses this same traditional strategy to heat the bath house.
The apodyterium is the traditional changing room of the Roman bath. The modern bath has showers and lockers.

The tepidarium is the warm room between the baths and saunas. The tepidarium in the thesis is conceptualized as the circulation and ramps through the bath house.

The frigidarium is the cold bath, usually bathers transfer between the caldarium and the frigidarium. The cold water is transferred from the frigidarium to the waste pools.

The caldarium is the hot bath, where bathers spend the most time. The steam from the waste pools heats the water indirectly.
The sudatorium is the sauna. The steam enters the sudatorium directly.

The laconicum is the dry sauna. The steam warms the surfaces but never enters the room, leaving it warm and dry.

The natatorium is the largest pool and is meant for swimming, the temperature is moderate.
Site
The next few pages show historical, current, and future maps of the Boston area. It shows the huge changes in the landscape, and the massive amount of man-made land used to construct the city. The infill above the old marshland, and harbor is currently sinking and is becoming more prone to flooding. I'm proposing that the maps of the future, due to sea level rise and storm surges, will return the Boston area to a map similar to the one drawn in 1806.
This is a current map of Boston and Cambridge with at the current sea level. Over the next few pages sea levels will rise, and the city will begin to transform.
Cambridge in 3013 after sea level has risen 15ft. The site for the project is what will become an island just outside of where Central Square is in 2013. MIT has been inundated, and my project proposes moving all of MIT’s nuclear research facilities to the small island. This isolates the research center, and creates the bath house as a destination within the new harbor.
This site drawing shows New Cambridge, with former Cambridge submerged under water. It shows ferry routes to the bath house and to Boston.
This image shows the height of the water in 3013, Cambridge has been returned to marshland and MIT has moved to higher ground, leaving the great dome in the new harbor.
Design
Gray, Samuel M. Section of Paris Sewers, Circa 1884.

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These primitive geometries are found in the historical precedents I've researched, and have all been adapted for use in the bath house and nuclear research facility. Vaulting, domes, columns, and buttresses all provide spatial and structural qualities to the architecture. The modern permanent architecture relates to the precedents by re-purposing these spatial strategies.
These three diagrams show flows of systems, people, heat, and the relationship between the public and the researchers. The building cools as the steam gets further away from the heat source of the waste pools.
To bring the architecture into the realm of reality the construction sequence is shown on the previous two pages. First a masonry arch is built, then a form work is placed inside the structural arch to achieve the necessary geometry. Concrete is poured between the arch and the form work. The interior or the space is surface in stone, and boulders and construction rubble from the razed zones of Cambridge are used as fill above the arch. The mass is needed to prevent the transmission of radiation through the walls. This process is then repeated to construct the building.

The drawing on the right shows more detailed flows of the steam through the spaces and out of the large vent pipe. It shows the turbines within the pipe that provide electricity to the building. It shows the material composition and the amount of steam used to heat each space.
This is section shows the variety of spaces within the architecture. The buried spaces at the bottom of the section are for the nuclear research and the waste pools. The large shaft that runs through the center of the section is for ventilation of steam from the waste pools. The shaft also delivers the steam to the bath house, and powers the turbines along the shaft. The top of the building is a water reserve. The water reserve has a warm side, for the caldarium and natatorium, and a cold side for the frigidarium and the waste pools. The dock on the right side of the section is the entrance for the research facility. It’s used to transport fuel and scientists to the lab. The public entrance is from the hillside to the left of the section, that is for access to the bath house only.

The bathers first proceed to the apodyterium where they change for their pool experience. The entire bath house is accessed by a ramp that winds through the pools and saunas. The outdoor pool is located below the water reserve, and has views to Boston, Cambridge, and the new harbor.

The experience of the bath house would be dark, damp, and steamy with shafts of light from the vents being the only natural light.

The walls are incredibly thick and heavy, to both prevent radiation exposure, and also so the building will last thousands of years. The use of compression only forms is also helpful in that it removes steel from the construction and so the steel will not decompose and crack the concrete.
SECTION

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This exterior rendering shows the building in a cold winter. The steam pouring out of it shows it’s warm and is meant to be a source of warmth during the long Boston winters. Since the heat source is infinite the steam will continue to flow for thousands of years.

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This rendering shows the view from the exterior natatorium. There are views of Boston and the surrounding marshy harbor. The water is warm enough for year round use. The steam pouring out of the building forms a winter oasis.
WASTE POOL
This is a view of the waste pools at the bottom of the building. The bright blue glow is from the radiation escaping the waste but the depth of the water prevents any danger.
This is the tepidarium. The tepidarium was conceptualized as the ramp through the bath house. The vents open into the tepidarium to keep it warm.
The pool on the right is the frigidarium, and the pool on the left is the caldarium. This shows how bathers could transfer between pools.
The caldarium is the hot pool. The rooms are filled with hot water and steam.
The sudatorium is the humid sauna. It is filled with steam from the waste pools.
NATATORIUM
The natatorium at the lowest depth of the bath house is dark and has a diving platform. The room is filled with steam and has access to saunas.
FINAL
PERMANENCE

ALIGNING ARCHITECTURE, NUCLEAR WASTE, AND THE PUBLIC

COMPARING ARCHITECTURAL AND NUCLEAR WASTE SAFEGUARDING STRATEGIES
SITE SCENARIO
Cambridge, MA - 3013 - 15/R

DESIGN STRATEGY
ROMAN BATH

SITE PLAN

FLOWS/PROGRAM/CONSTRUCTION

PERMANENCE


Gray, Samuel M. Section of Paris Sewers, Circa 1884. Digital image. The History of Sanitary Sewers.

David Rumsey Map Collection. David Rumsey Historical Map Collection | The Collection.


THANK YOU