Earth Hotel in Scheveningen

Student: LAURIS BIRZNIEKS (4120450)
Supervisers: Ir. J.F. Engels, Ir. S.C. Groenewold, Dr. A. Van Timmeren
Course: Architectural Engineering Graduation Studio
Date: 16/04/2013 (P5 presentation)

CONTENTS

THEORETICAL STUDY

technical drivers

thermal study

structural study

BUILDING IN GENERAL

context

functional zoning

DESIGN CONCEPT

function

location

volumetric study

BUILDING IN DETAIL

horizontal volume

vertical volume

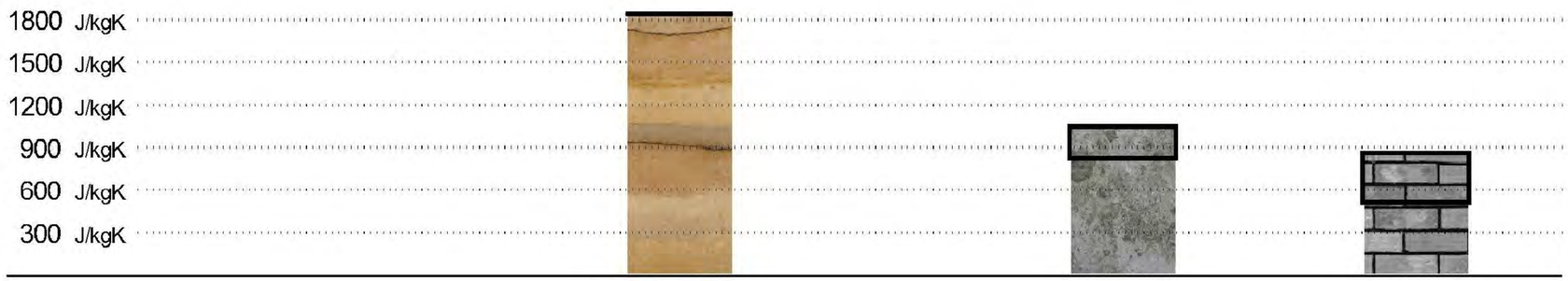
general





THERMAL MASS





	Rammed earth	**Concrete**	**Brick masonry**
	unstabilized / stabilized	portland cement	standard
Specific heat capacity, J/kgK	~ 1830	835 - 1050	500 - 850



WHAT COULD BE THE ULTIMATE BENEFIT FROM THERMAL MASS IN MODERATE CLIMATE ?

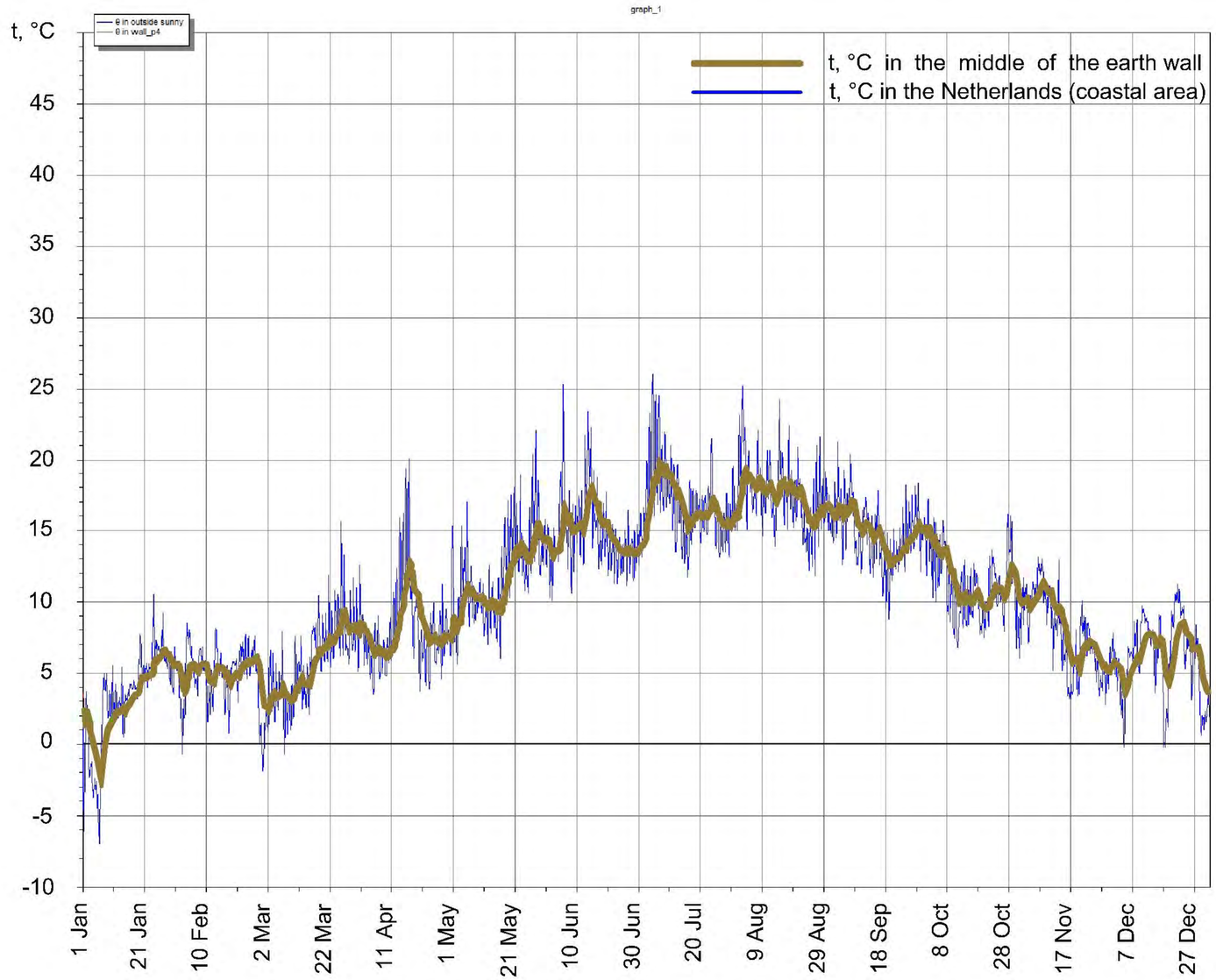


	Rammed earth	Concrete	Brick masonry
	unstabilized / stabilized	portland cement	standard
Specific heat capacity, J/kgK	~ 1830	835 - 1050	500 - 850

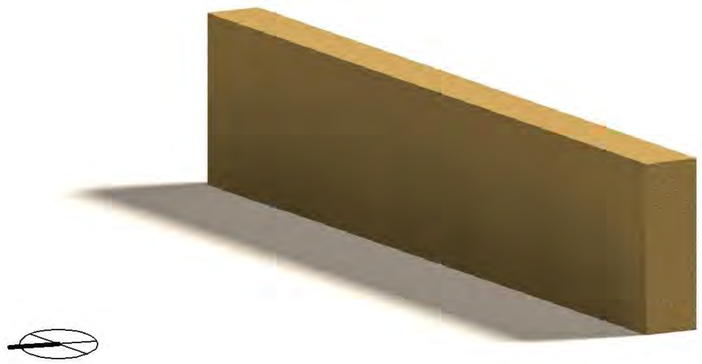
THERMAL MASS

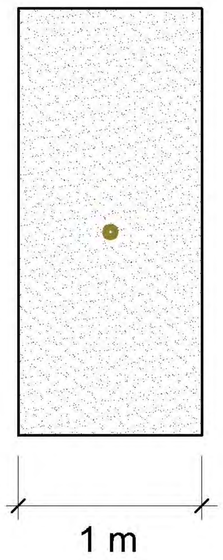


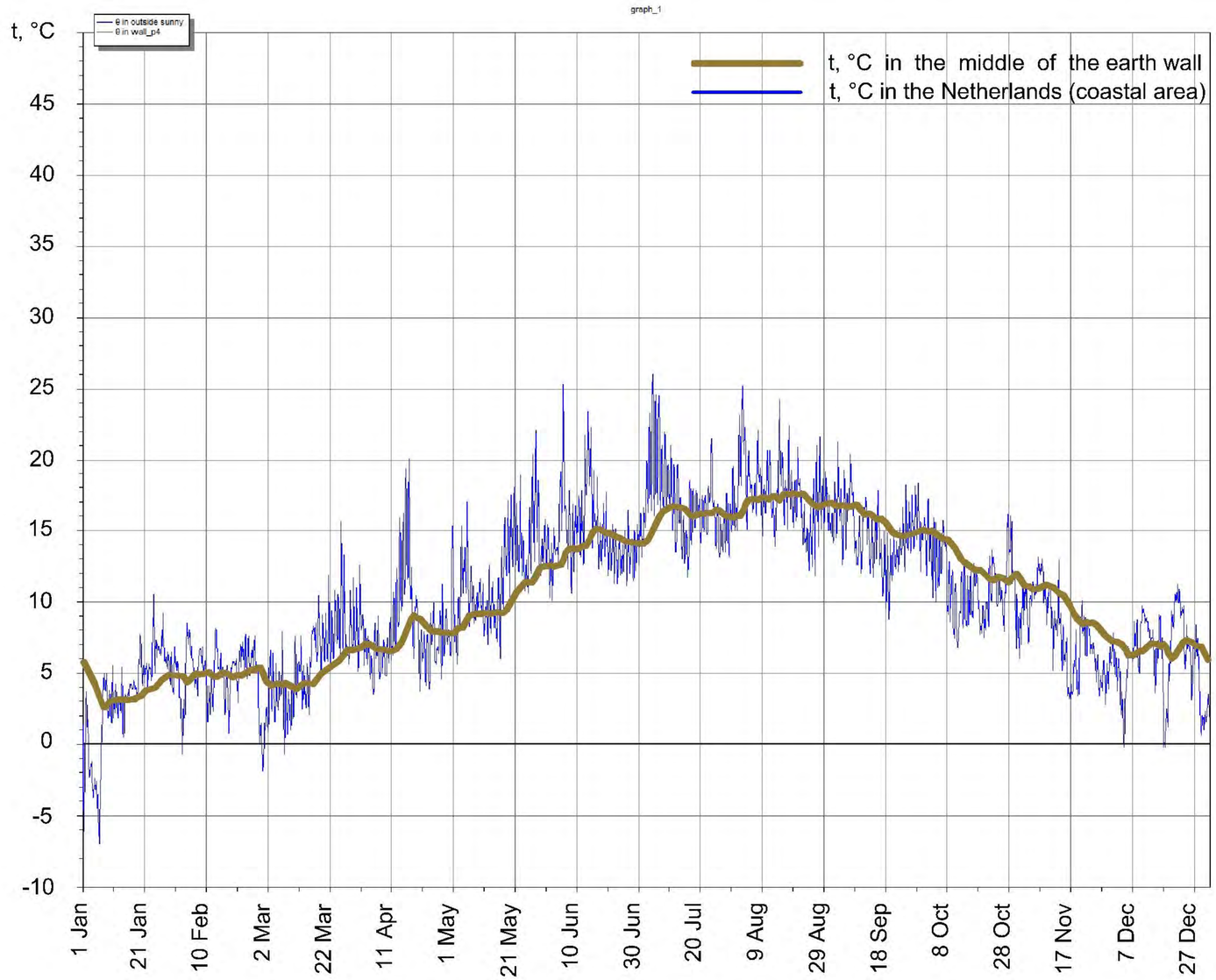




THERMAL MASS

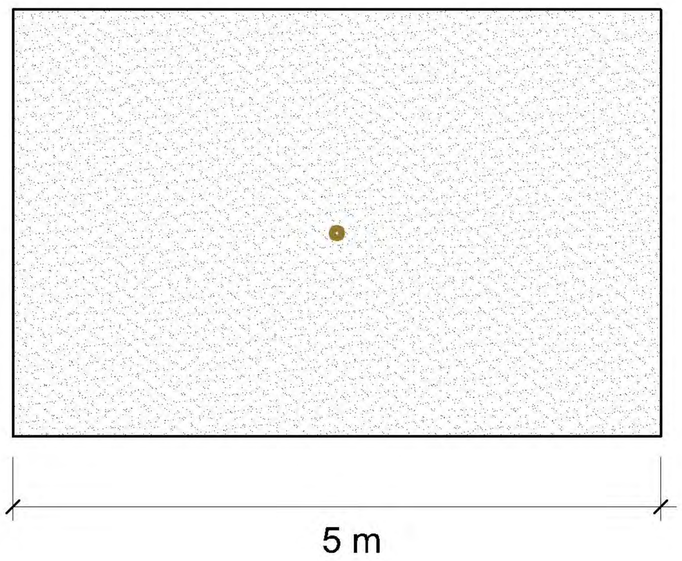


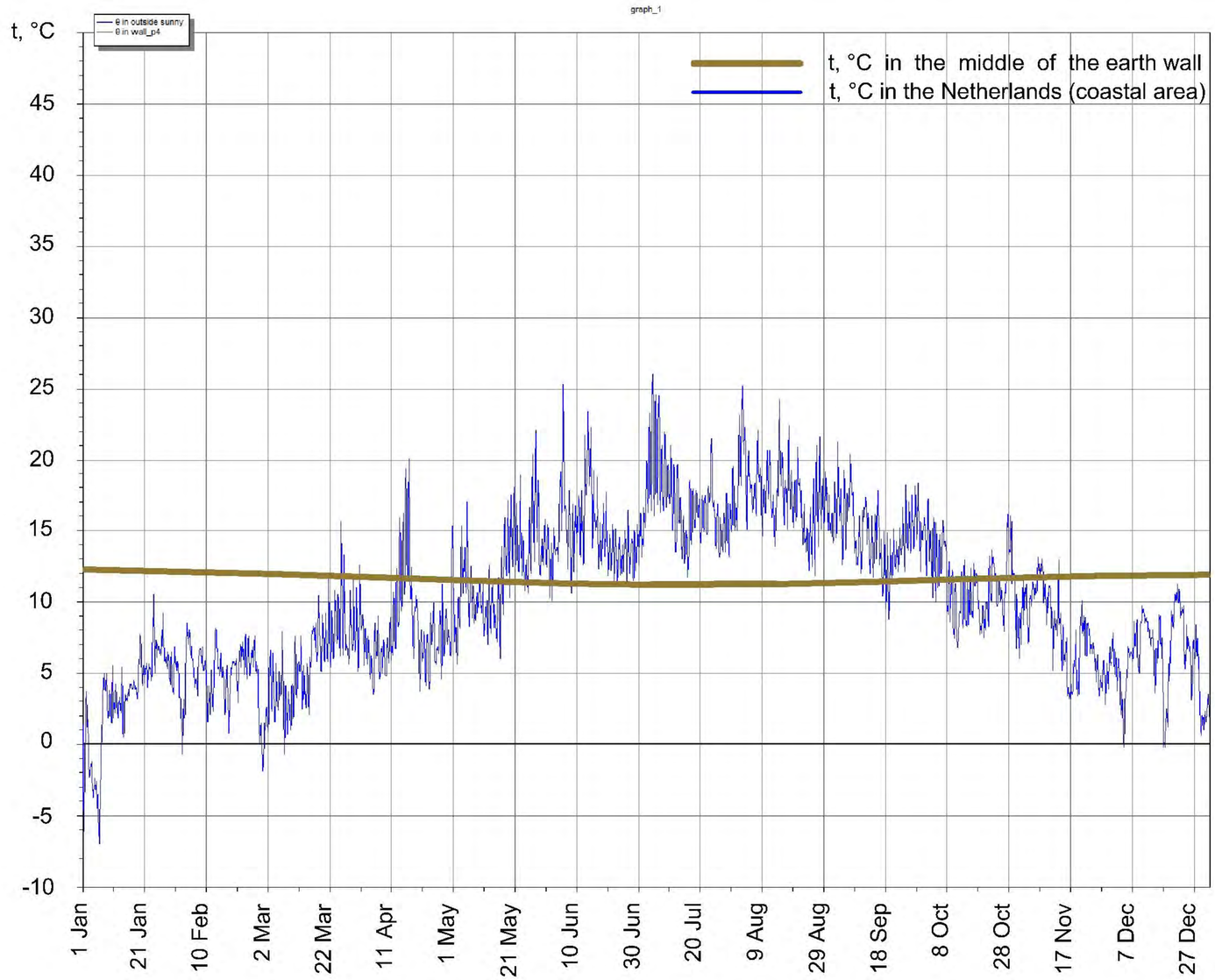




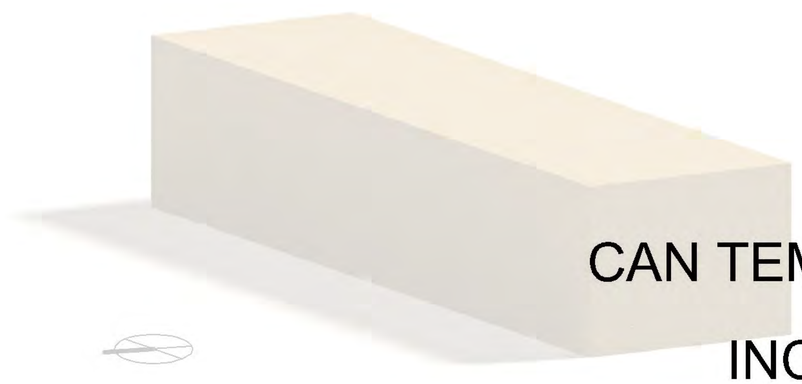
THERMAL MASS

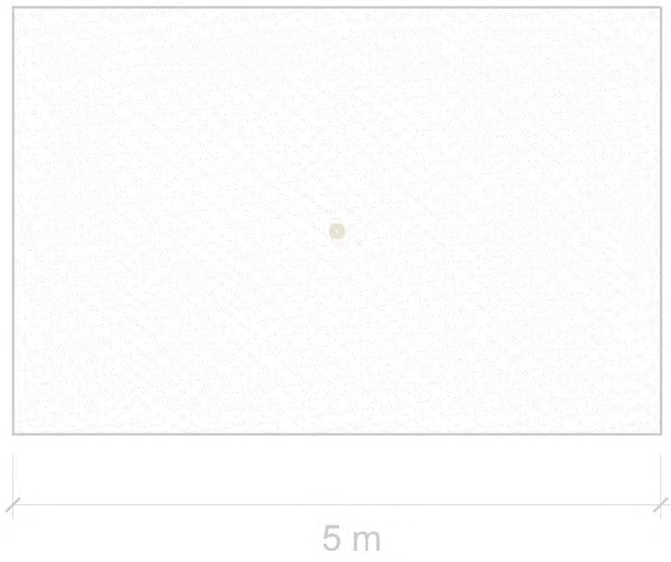


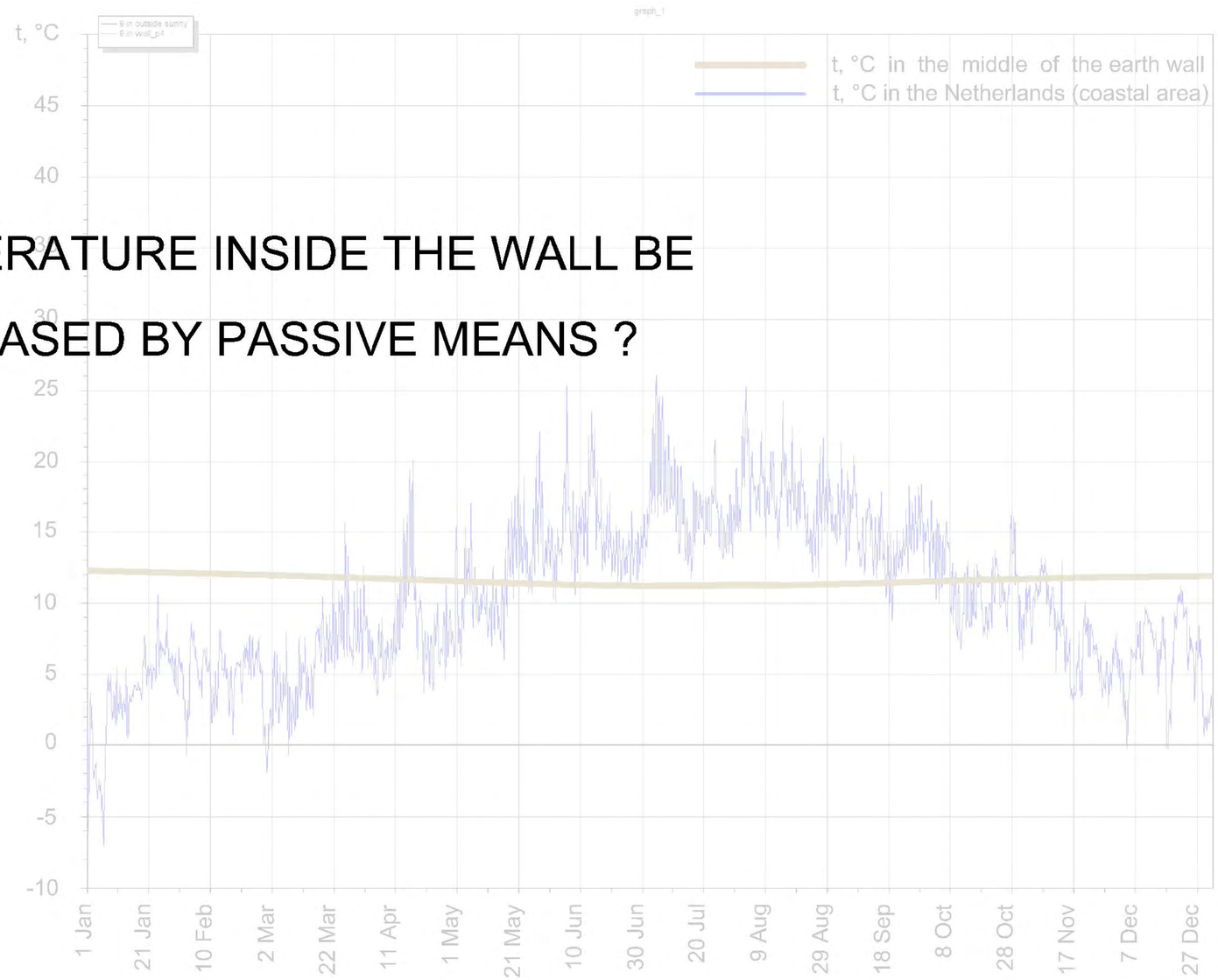




THERMAL MASS



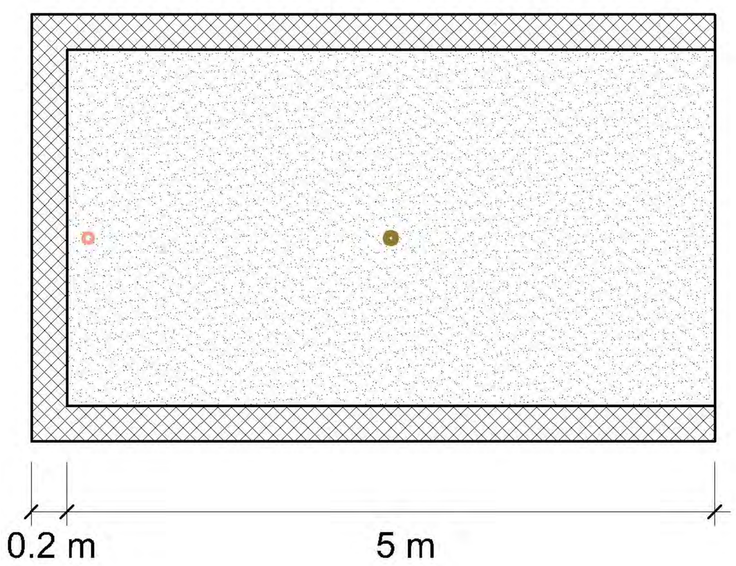


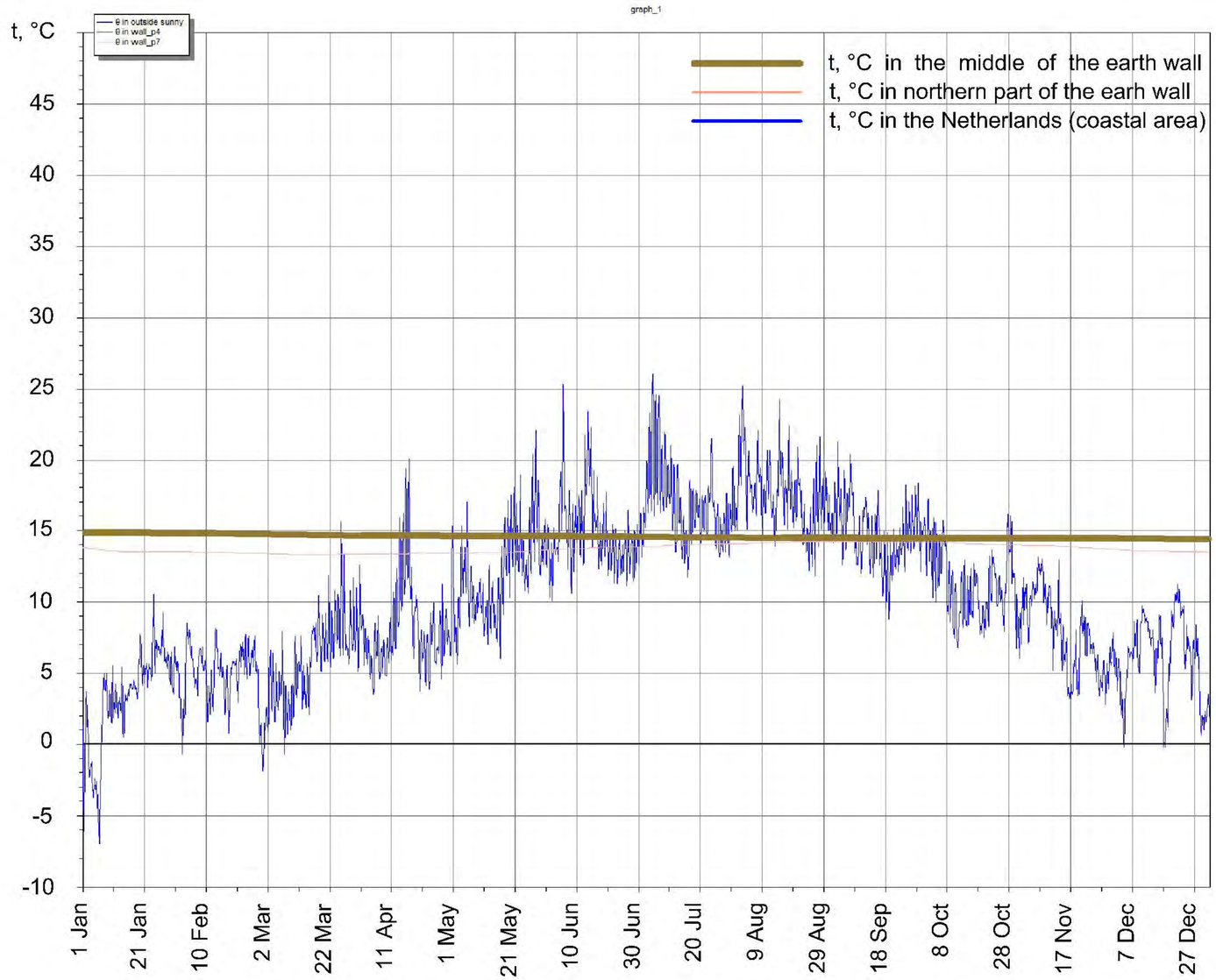


CAN TEMPERATURE INSIDE THE WALL BE INCREASED BY PASSIVE MEANS ?

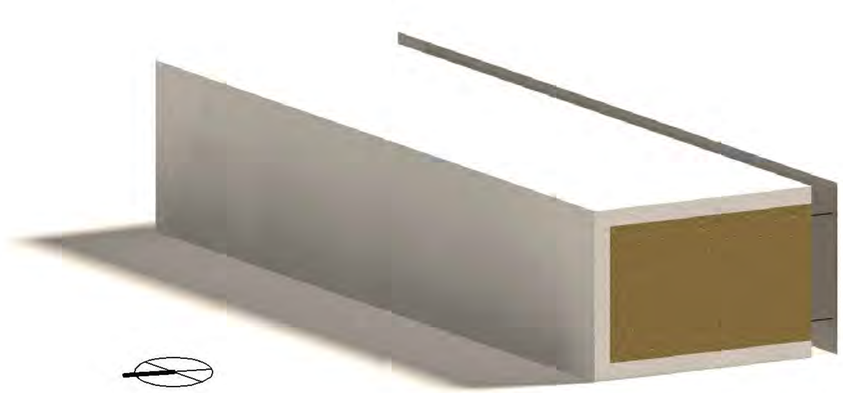
THERMAL MASS

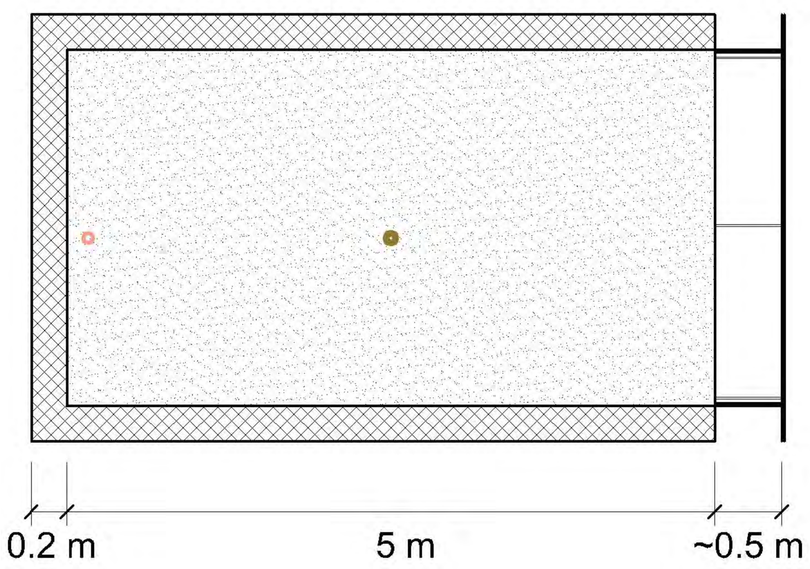


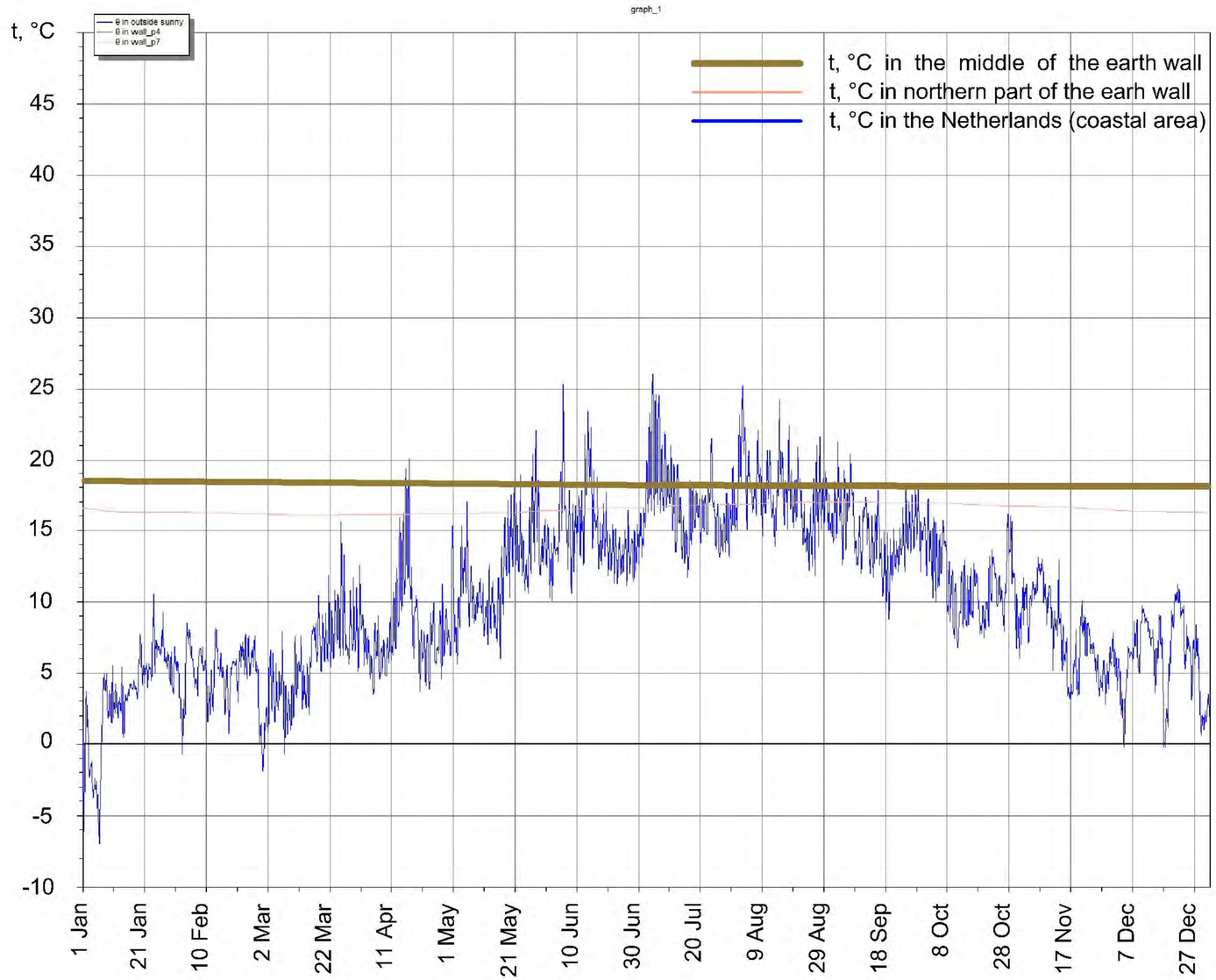




THERMAL MASS

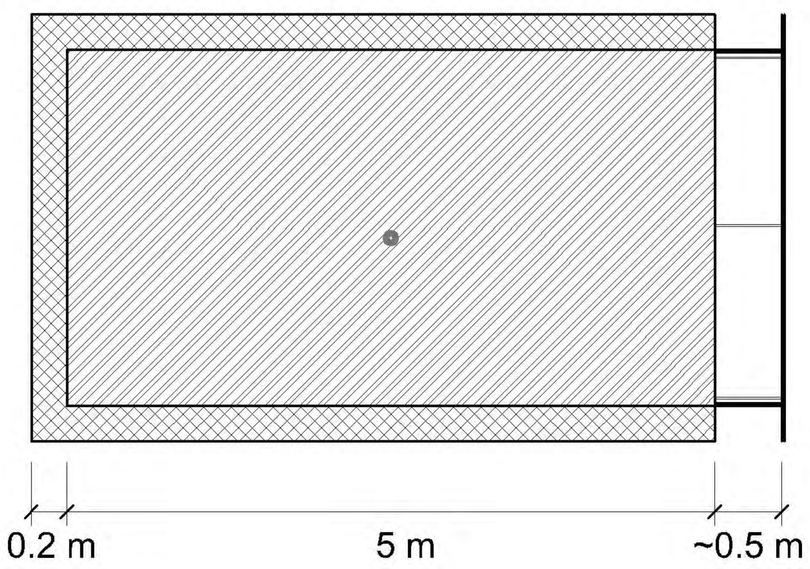


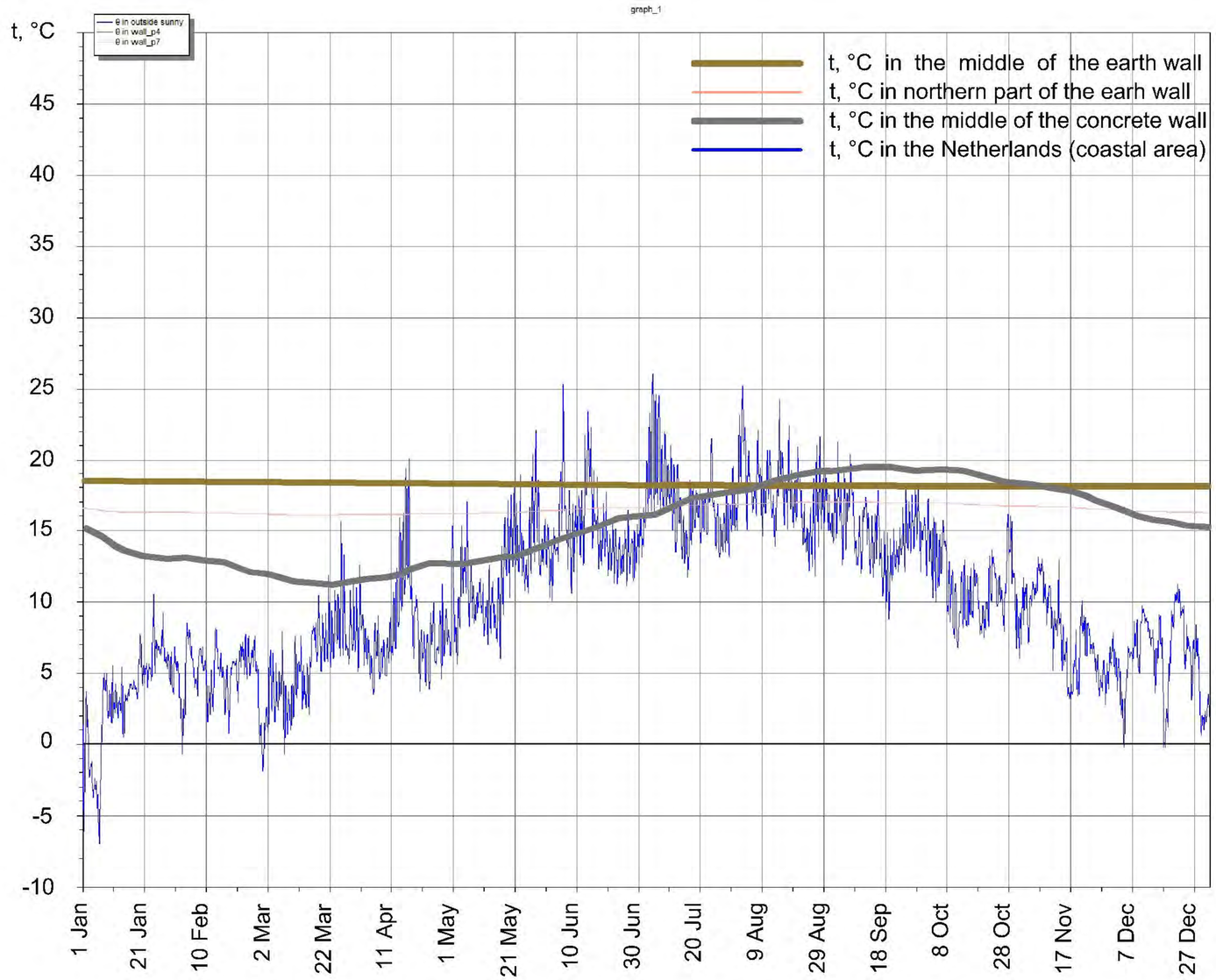




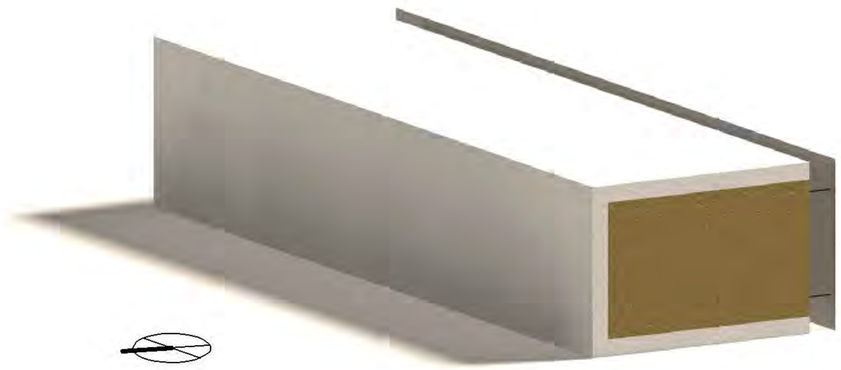
THERMAL MASS

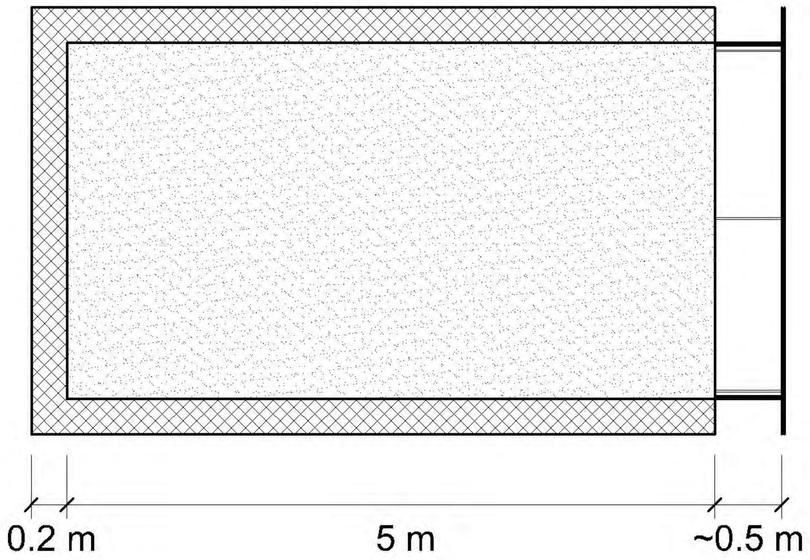




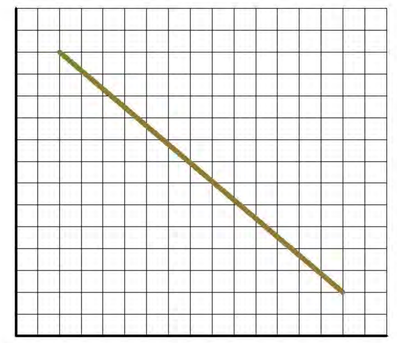


THERMAL MASS

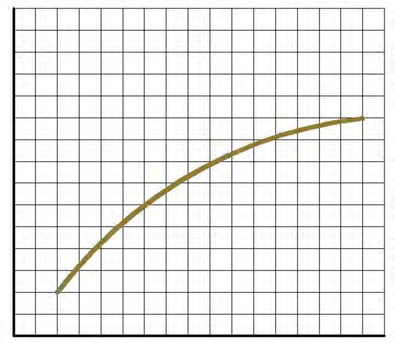




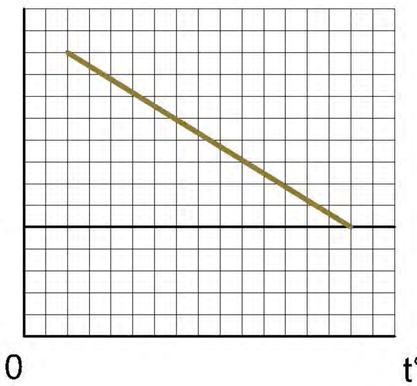
porosity



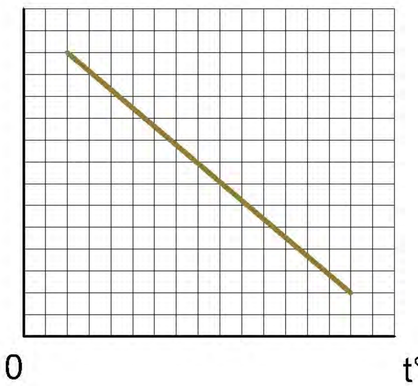
insulation thickness



earth m3 / glass m2

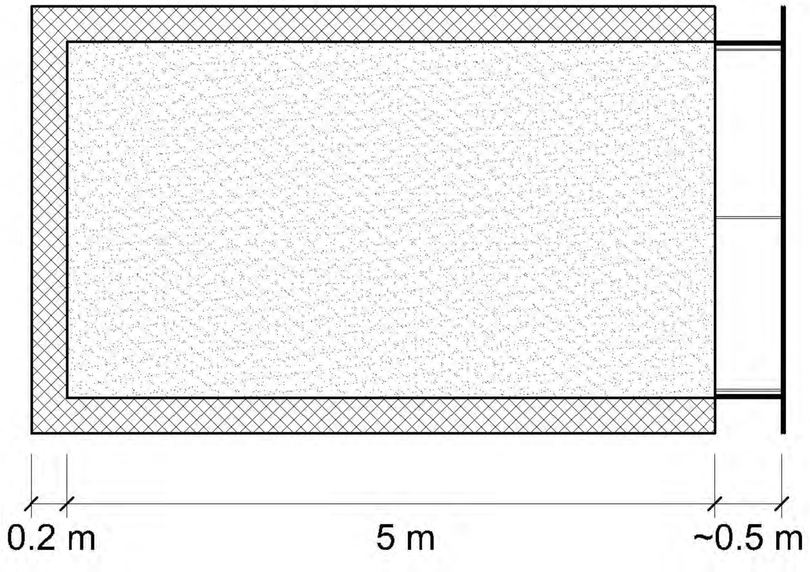


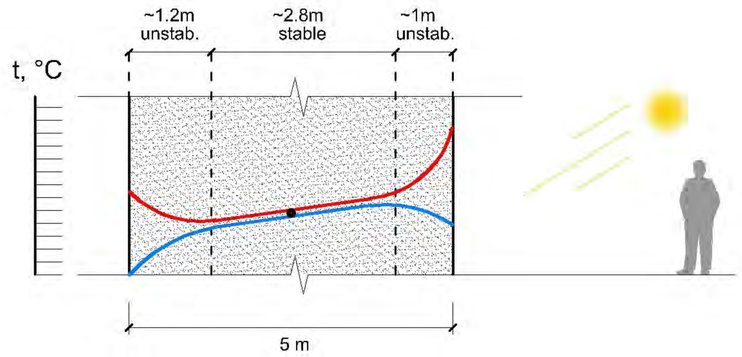
air change ratio in cavity

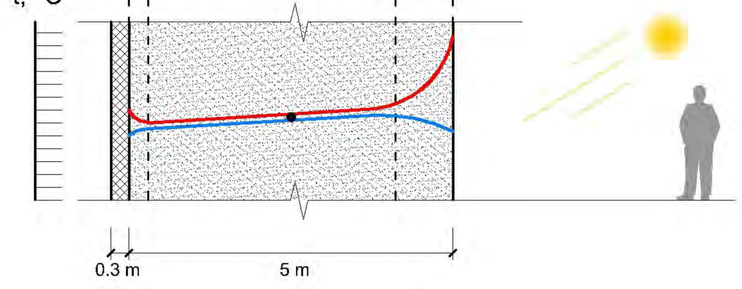


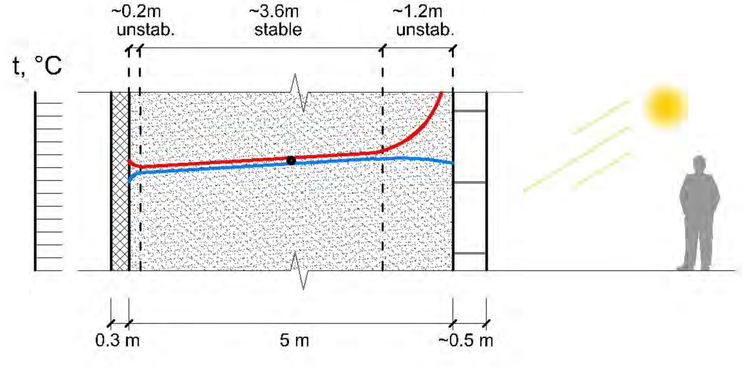
THERMAL MASS



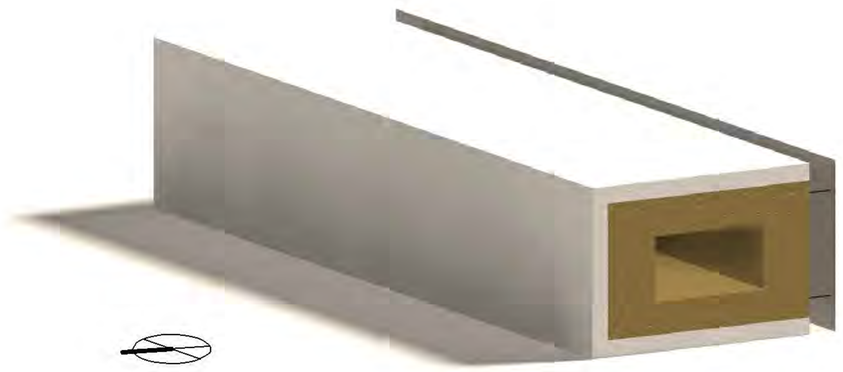


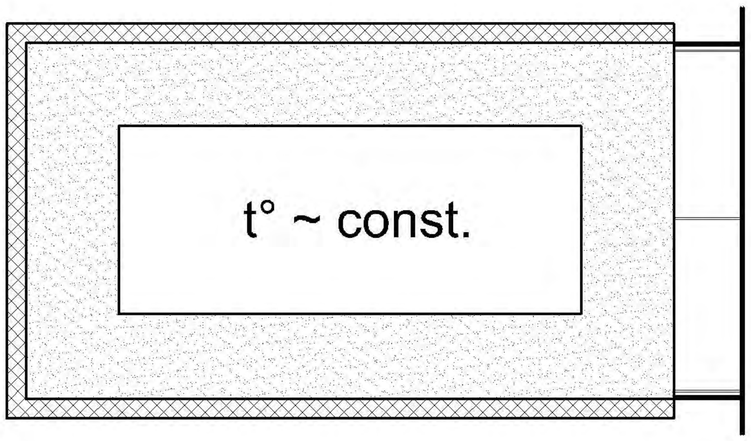






THERMAL MASS





- earth volume (m3) / glass area (m2) = approx. 5

- max. insulation u-value ~0.2 W/m2K (min. R-value 5m2K/W)

- minimum porosity => maximum thermal transfer

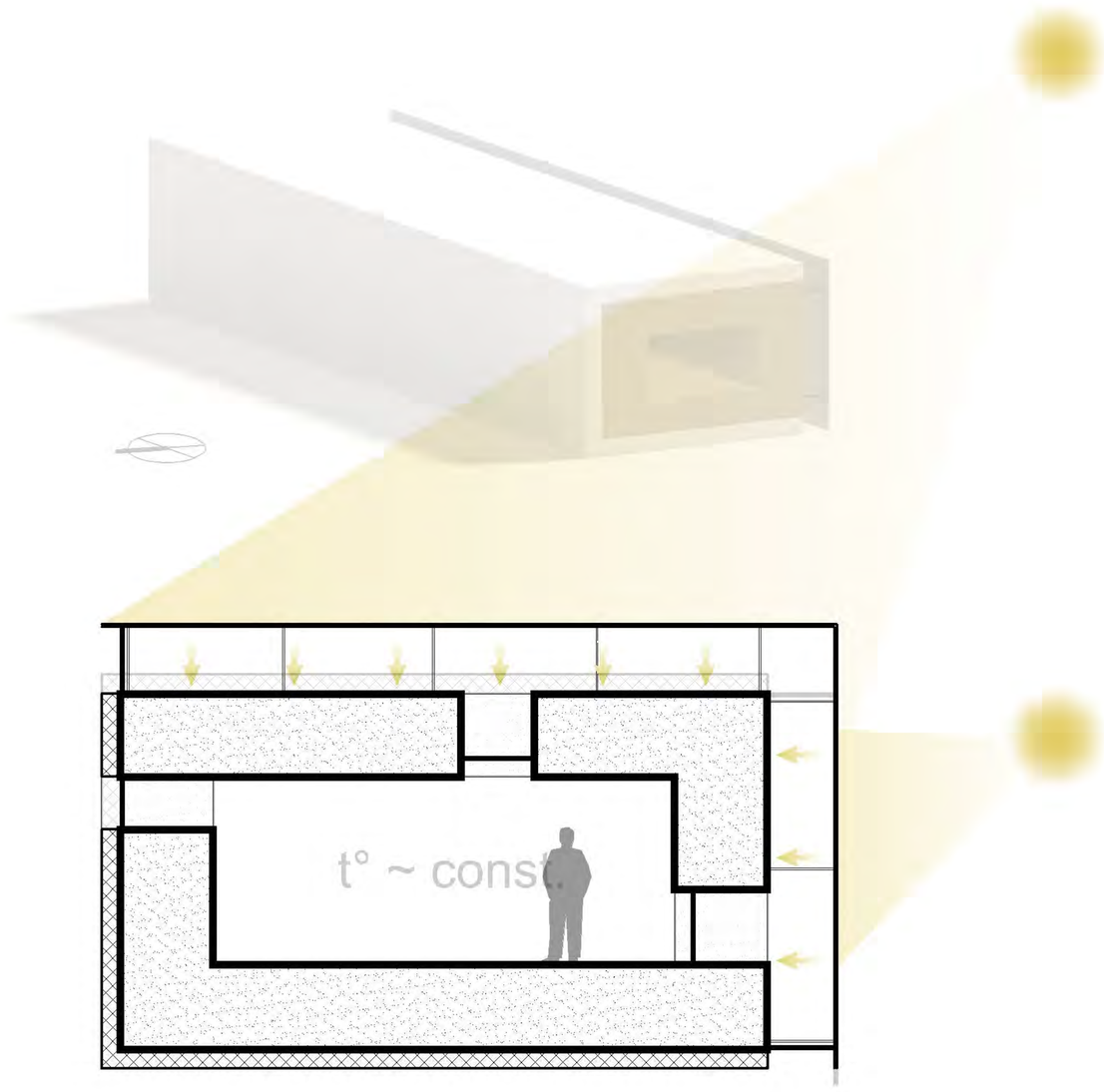
- low air change ration for the air cavity

- glass with low u-value and high radiation transmission

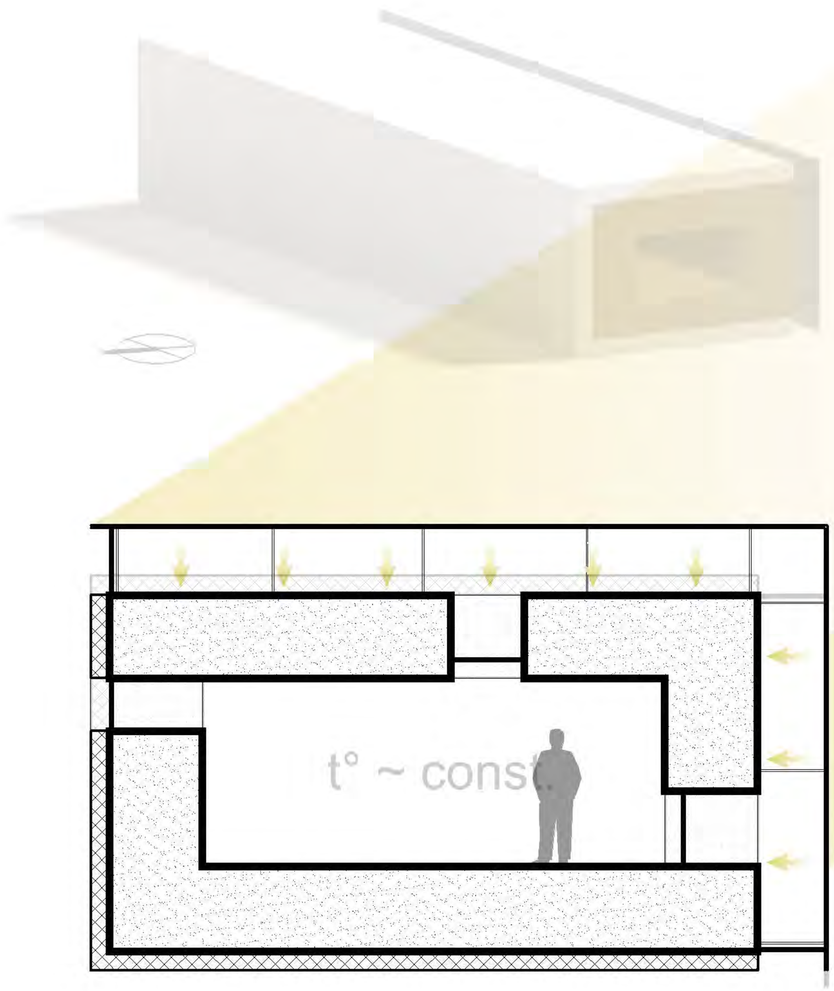
- ventilation system with high heat exchange factor

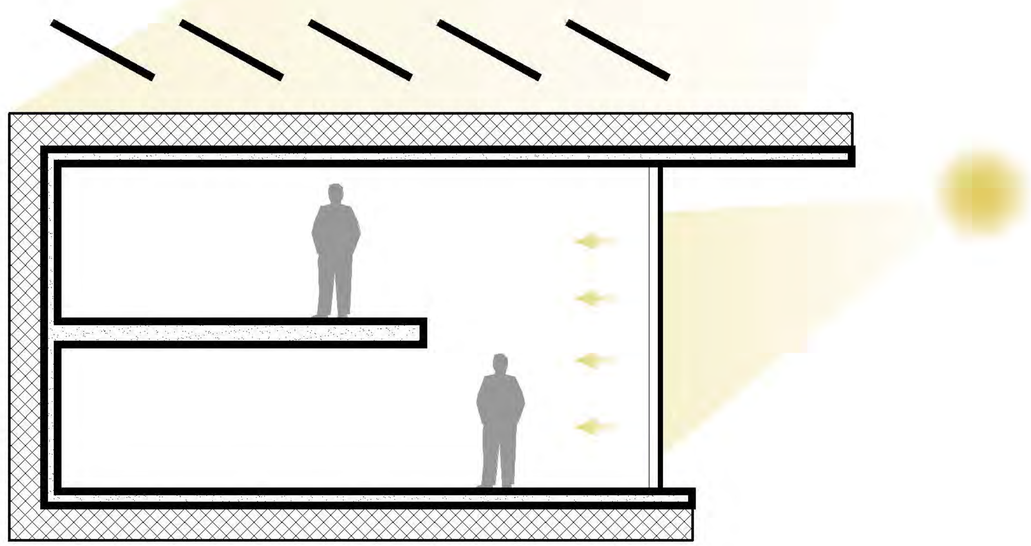
- internal heat generation/loss balanced (energy generated by humans, lighting, electric devices preferably equal to heat loss through windows and heat exchangers (ventilation)

THERMAL MASS



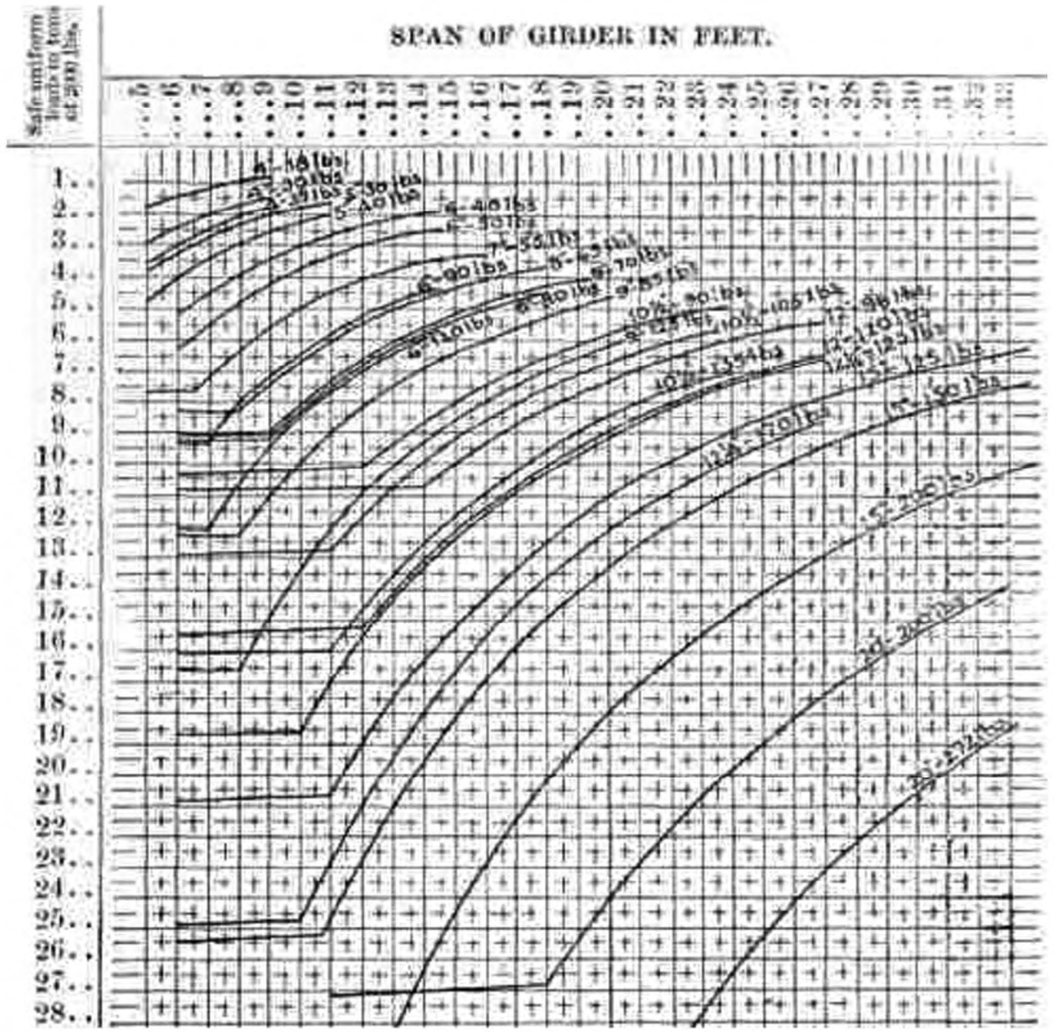
THERMAL MASS



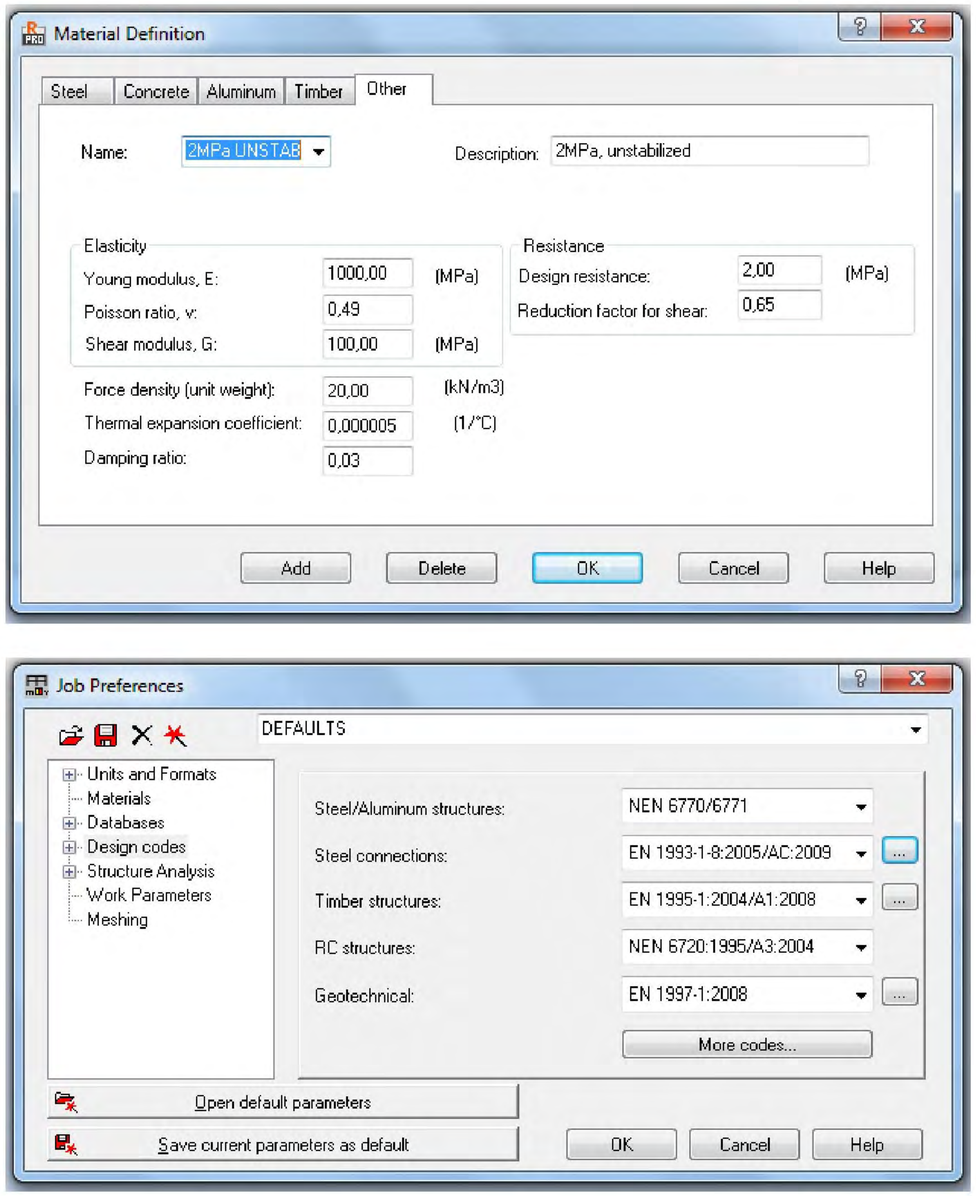


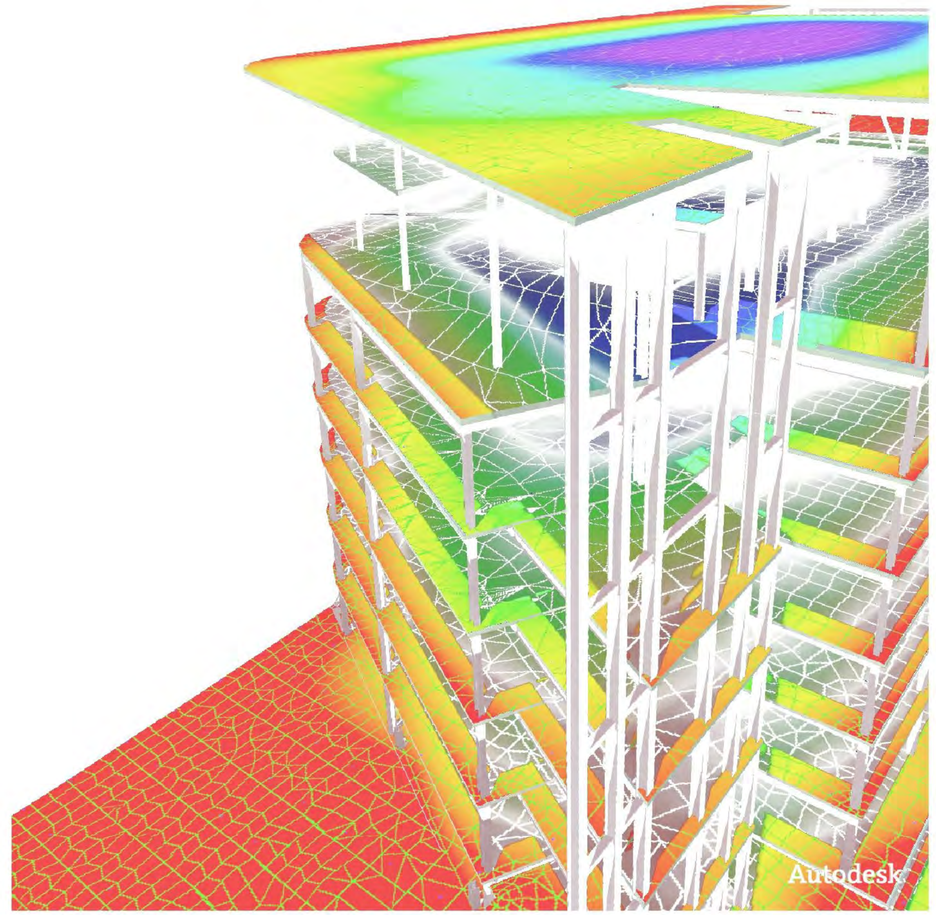
CAN VOIDS BE MADE INSIDE EARTH WALL?

STRUCTURAL POTENTIAL

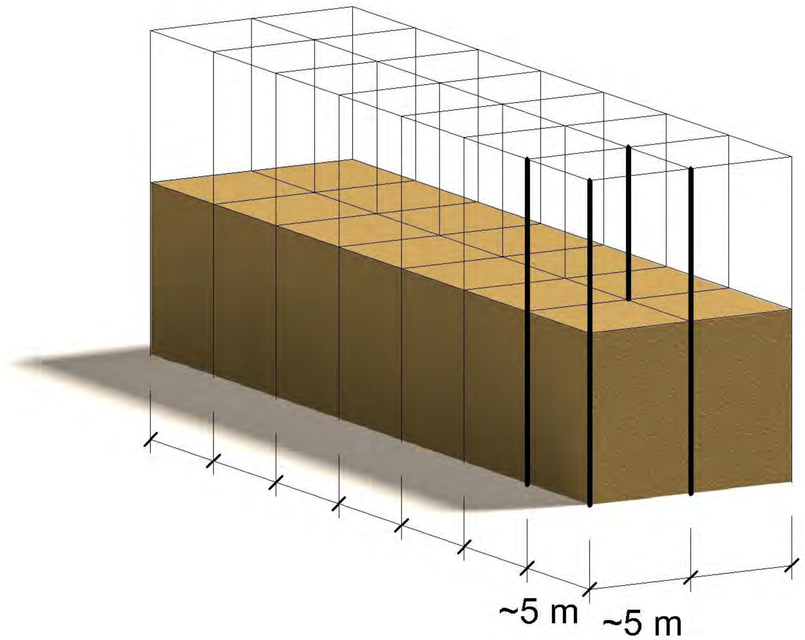


STRUCTURAL POTENTIAL

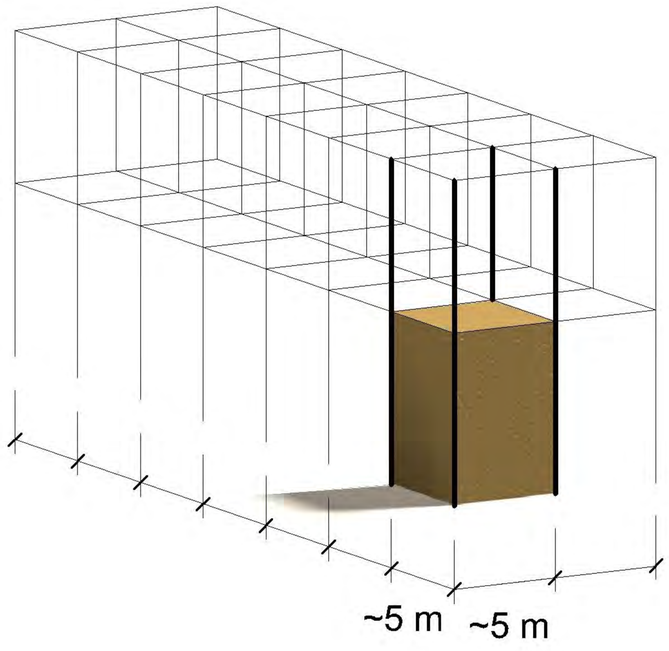




STRUCTURAL POTENTIAL



- VERTICAL TONGUE-IN-GROOVE
  EXPANSION JOINTS ~EACH 5 m

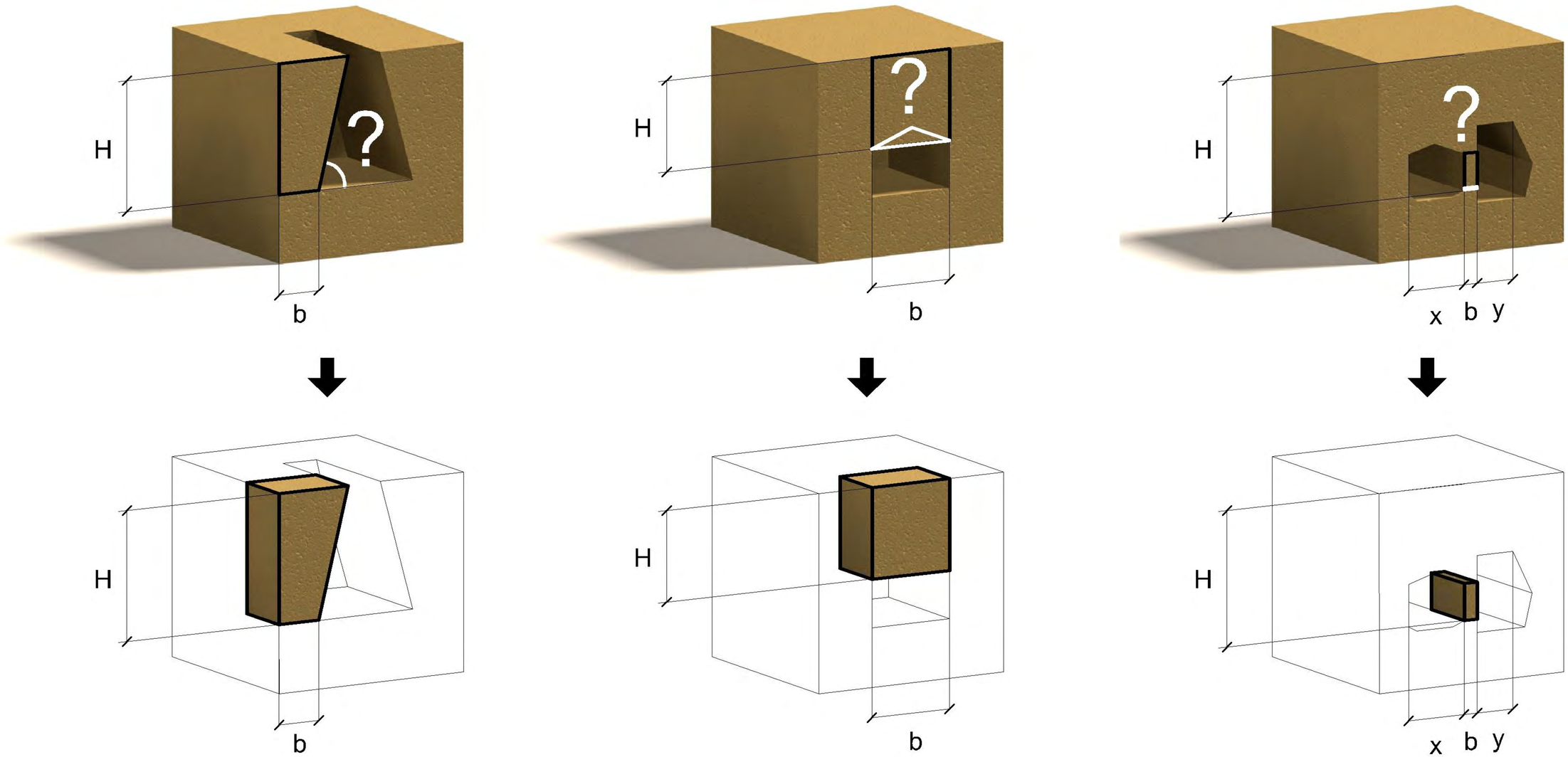


- SINGLE ELEMENT AS PRIMARY UNIT
  SELECTED FOR FURTHER ANALYSIS

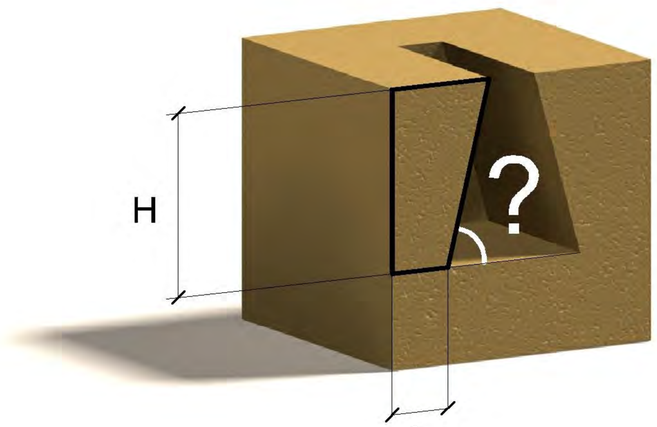
TESTS

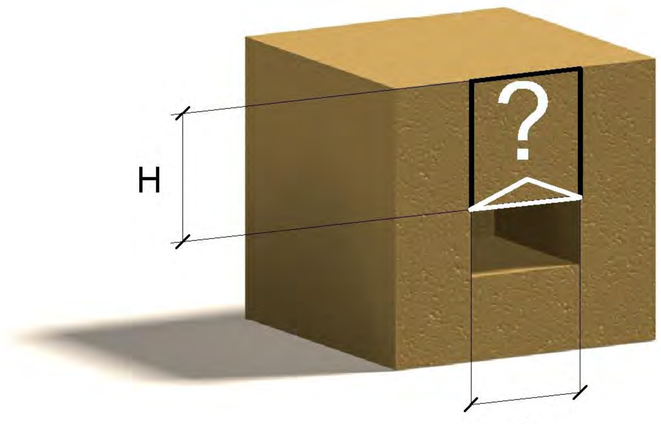


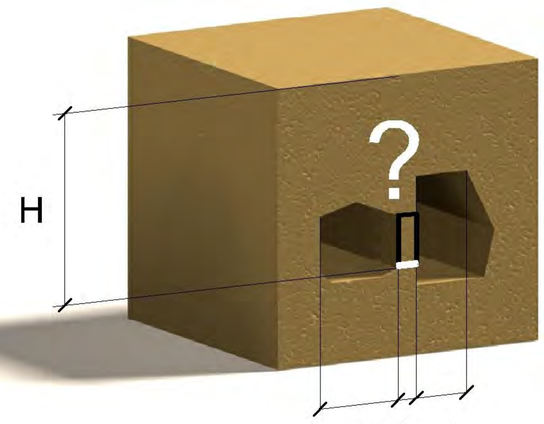
STRUCTURAL POTENTIAL

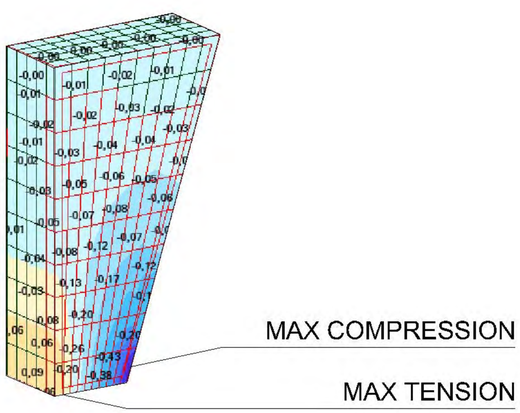


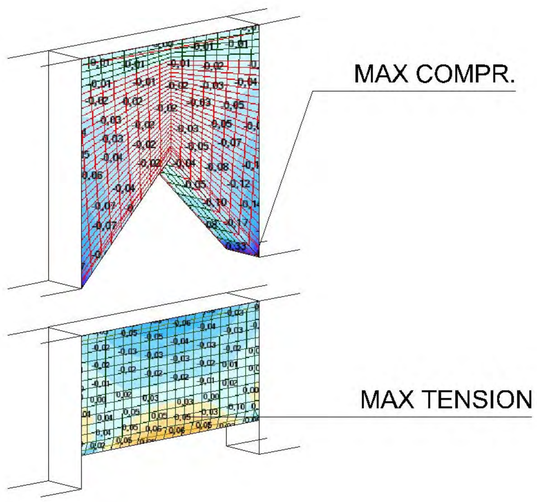
STRUCTURAL POTENTIAL

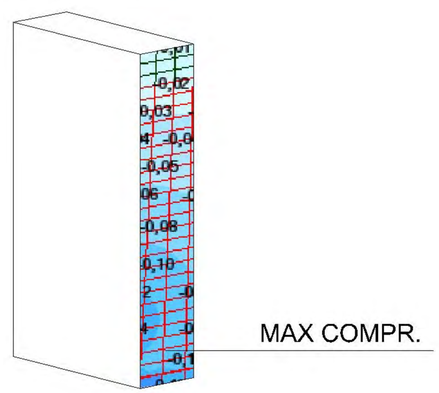




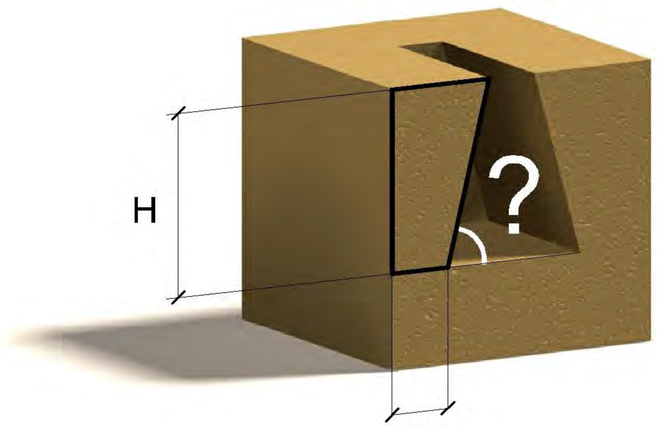


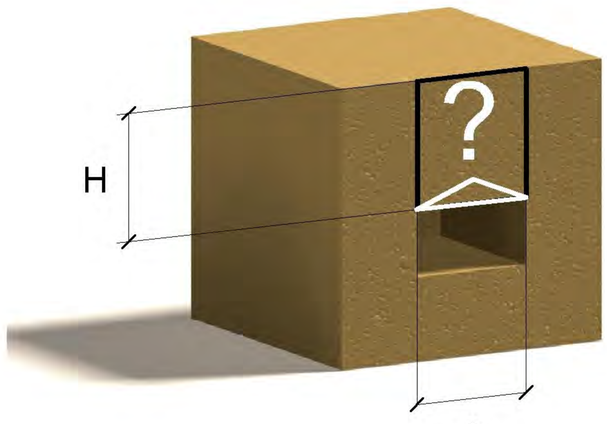


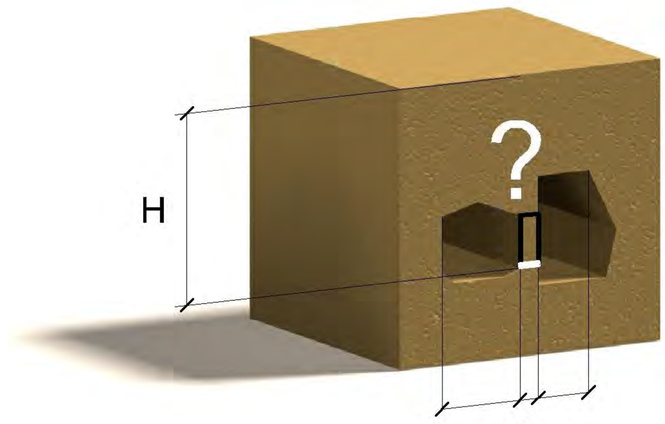


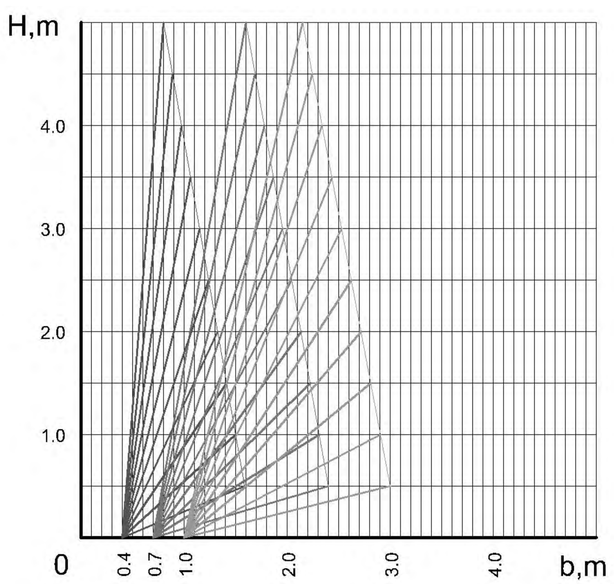


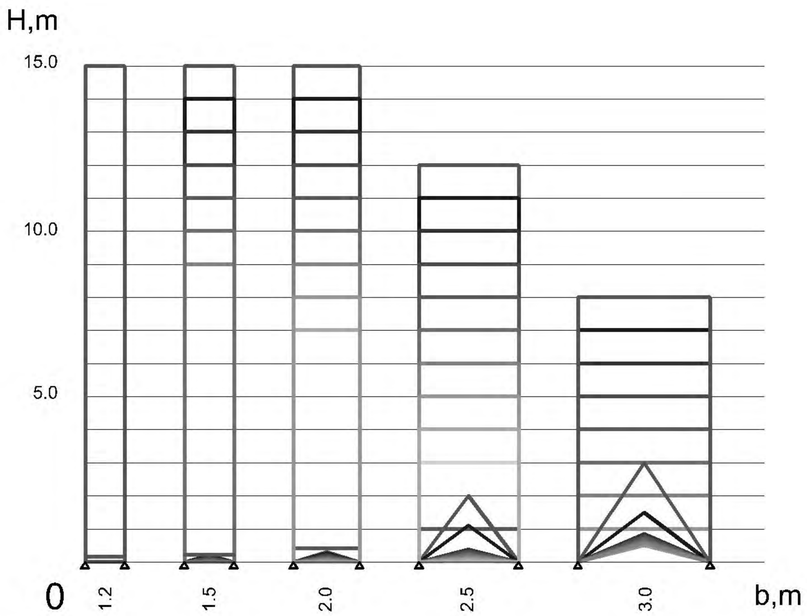
STRUCTURAL POTENTIAL

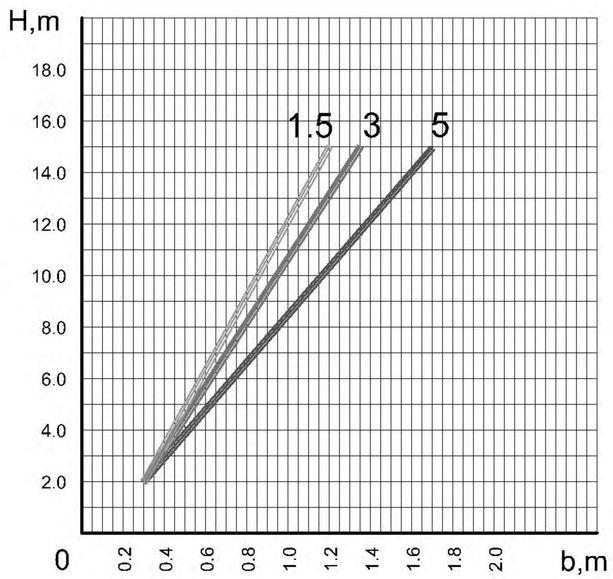




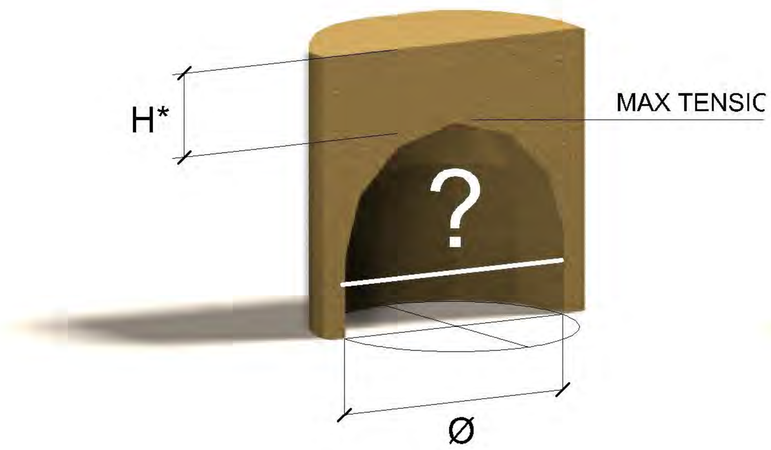


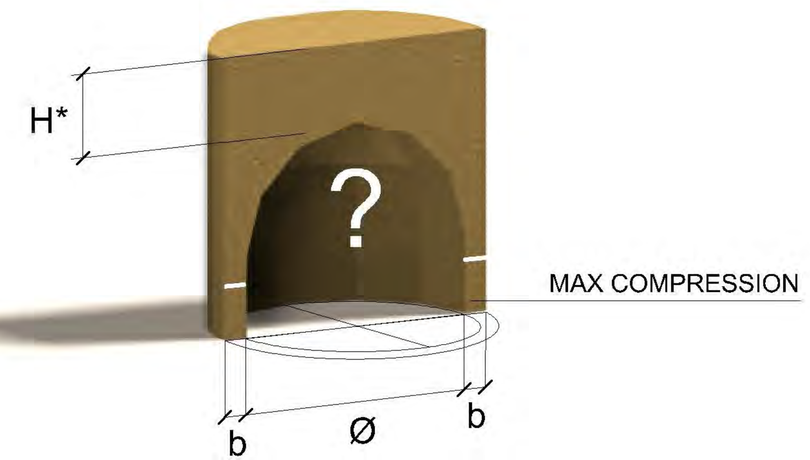


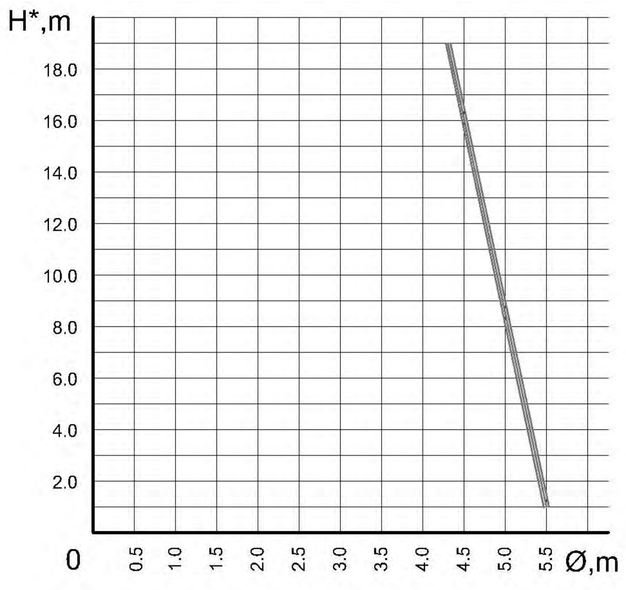


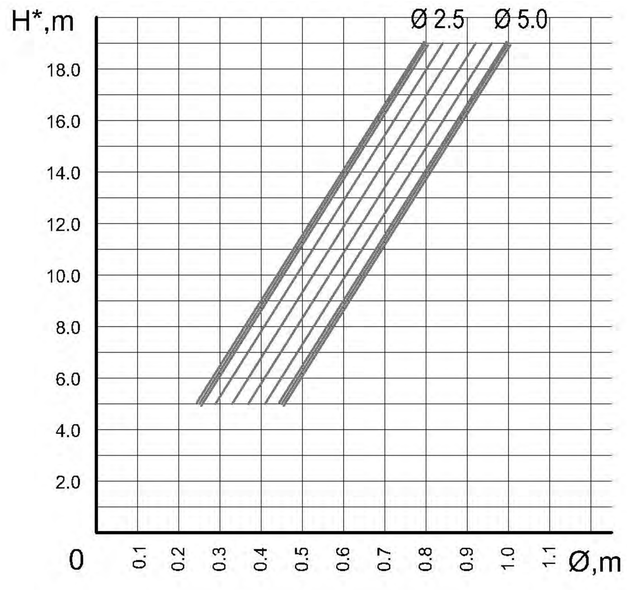


STRUCTURAL POTENTIAL









* - load on top divided by 2 due to voids

STRUCTURAL POTENTIAL

RAMMED EARTH



- expansion joints max. after each 5 meters;
- slow. 1m3 output requires ~ 6 man hours;
- preferred special formwork to ensure good accessibility with pneumatic tamper;
- skilled labor required

+ aesthetics (subjective)

POURED EARTH



+ minimal shrinkage and no strict requirements for expansion joints;
+ at least 6 times faster than traditional ramming (1m3 output requires ~ 1 man hour);
+ cheaper;
+ no special formwork needed;
+ does not require special skills.

STRUCTURAL POTENTIAL

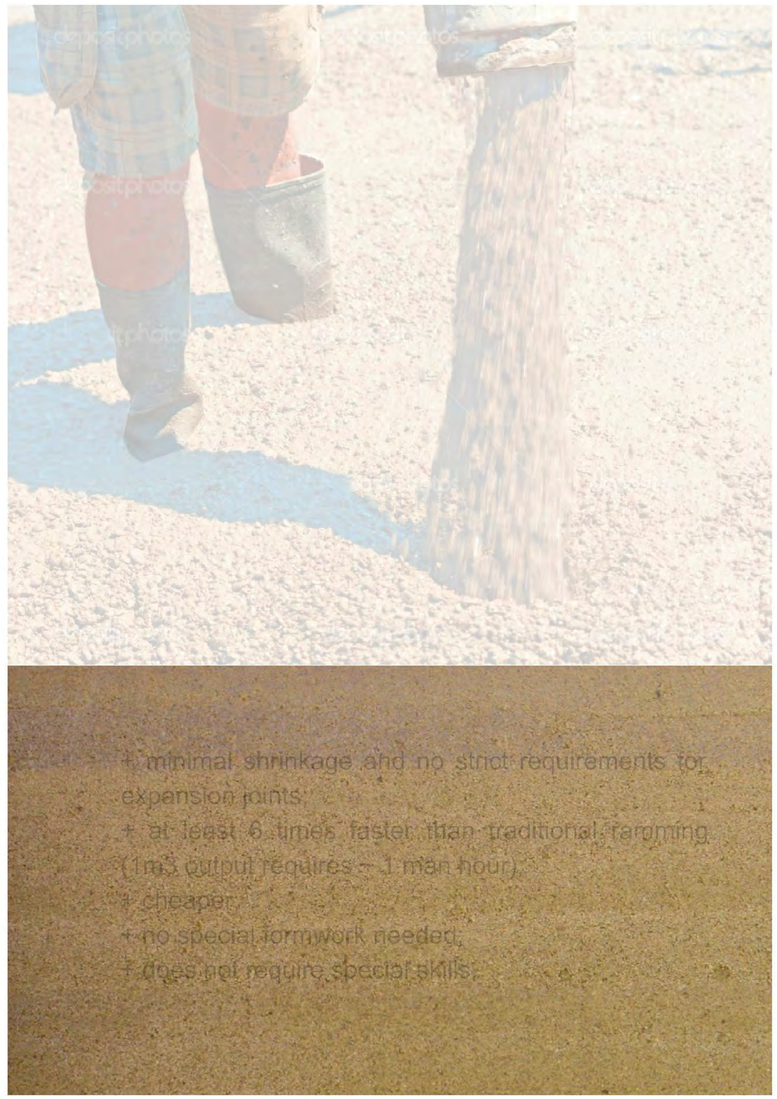
RAMMED EARTH



- expansion joints max. after each 5 meters;
- slow: 1m3 output requires ~ 6 man hours;
- preferred special formwork to ensure good accessibility with pneumatic tamper;
- skilled labor required.

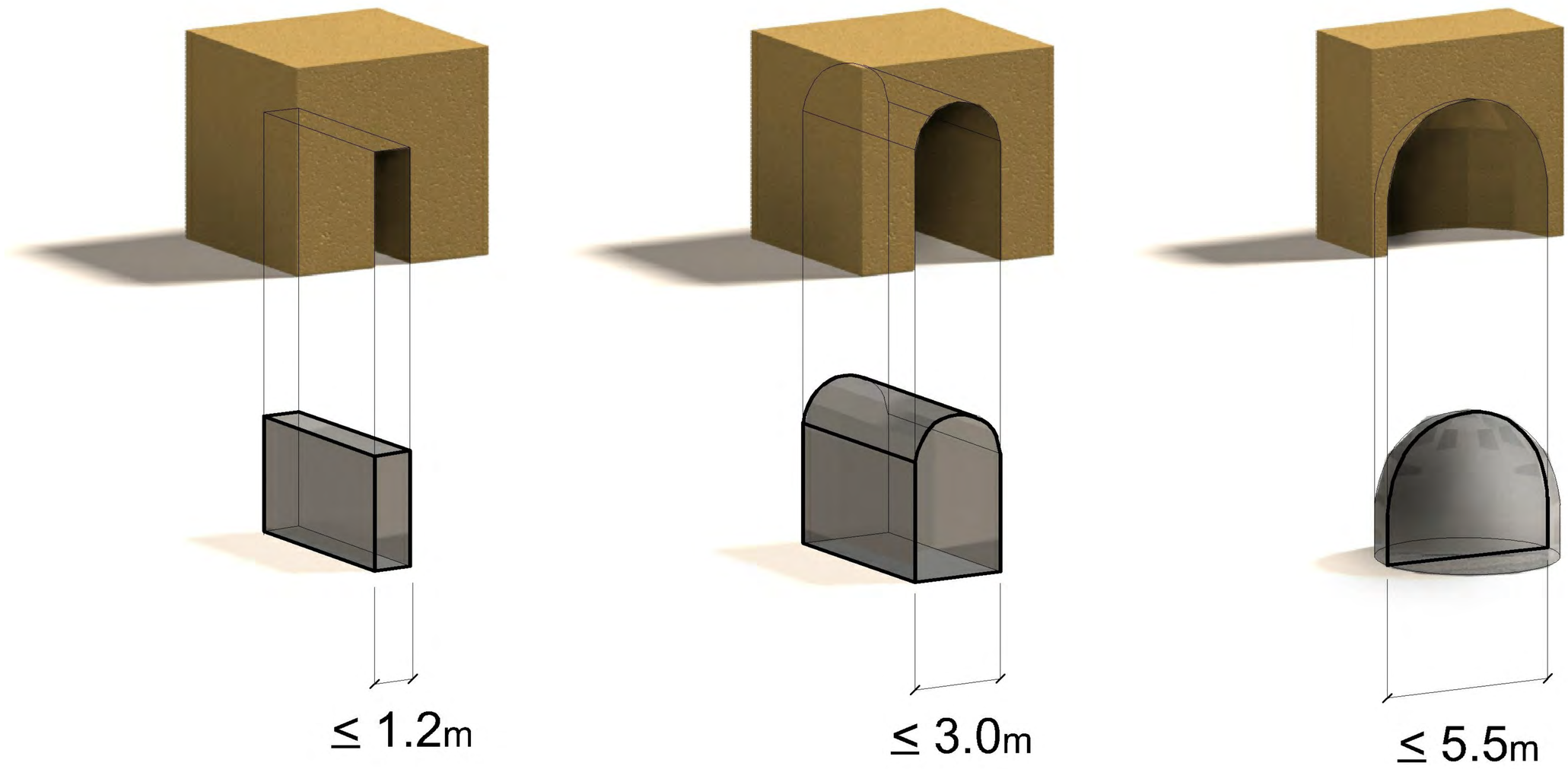
+ aesthetics (subjective)

POURED EARTH



+ minimal shrinkage and no strict requirements for expansion joints;
+ at least 6 times faster than traditional ramming (1m3 output requires ~ 1 man hour);
+ cheaper;
+ no special formwork needed;
+ does not require special skills.

STRUCTURAL POTENTIAL



DESIGN CONCEPT

function

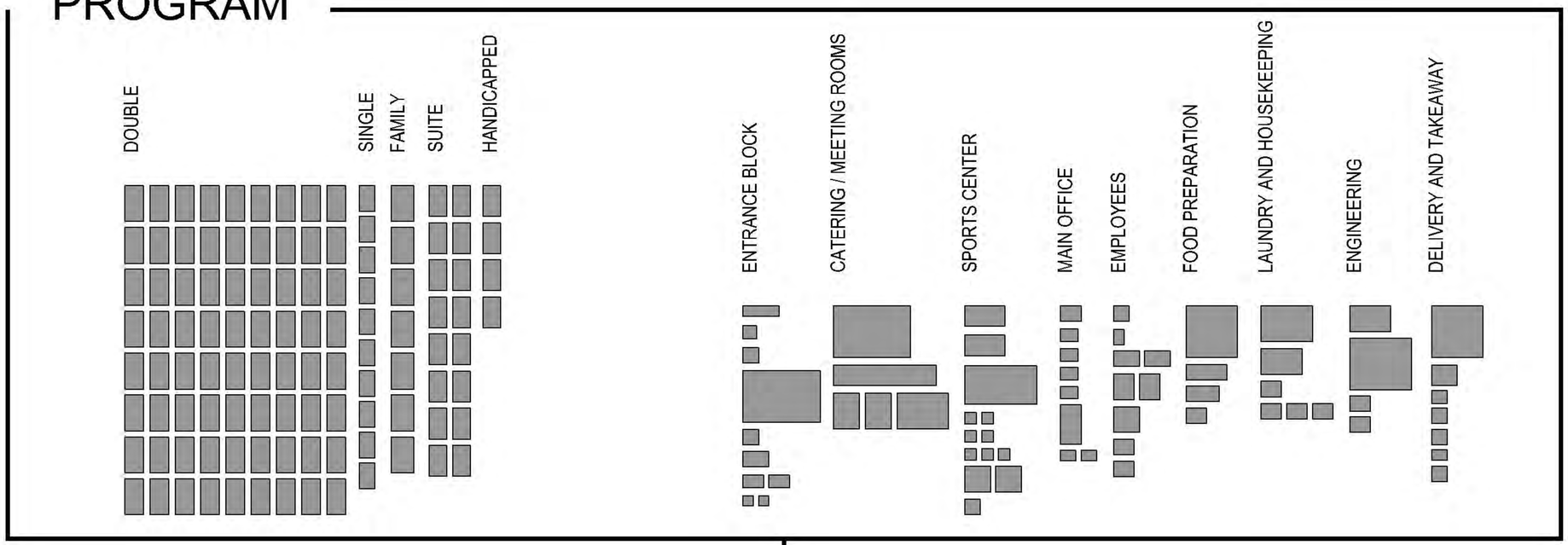
location

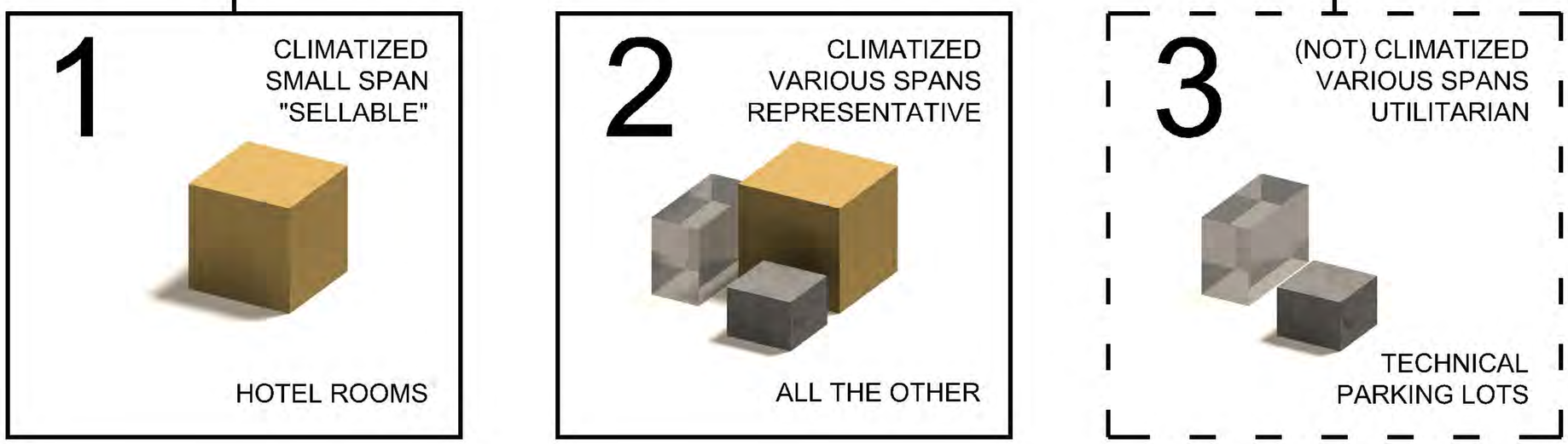
volumetric study

THEMATIC HOTEL
- structural aspect
- accessibility
- daylight requirements
- economical factor

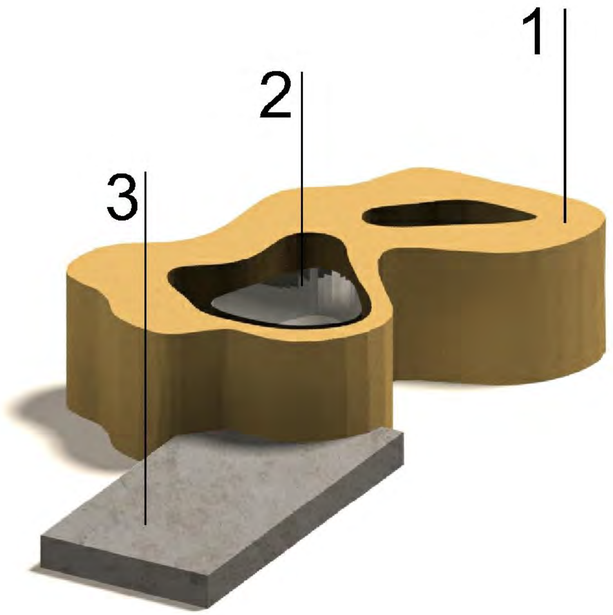
VOLUMETRIC STUDY

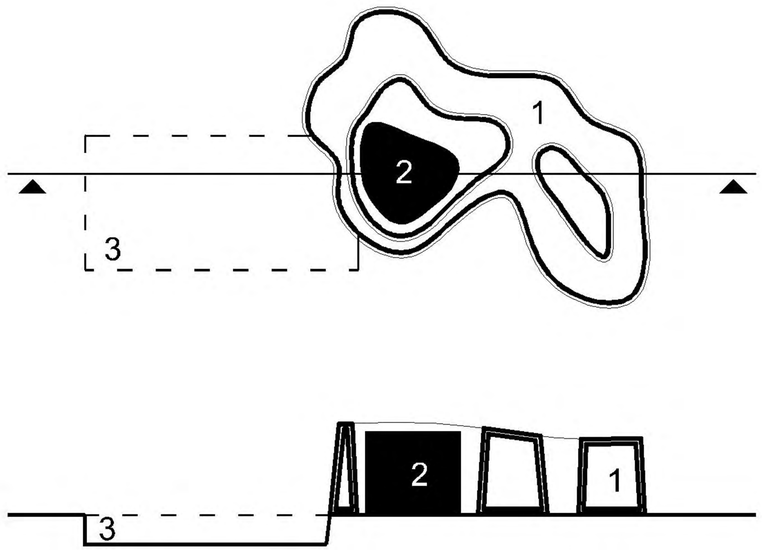
PROGRAM





VOLUMETRIC STUDY

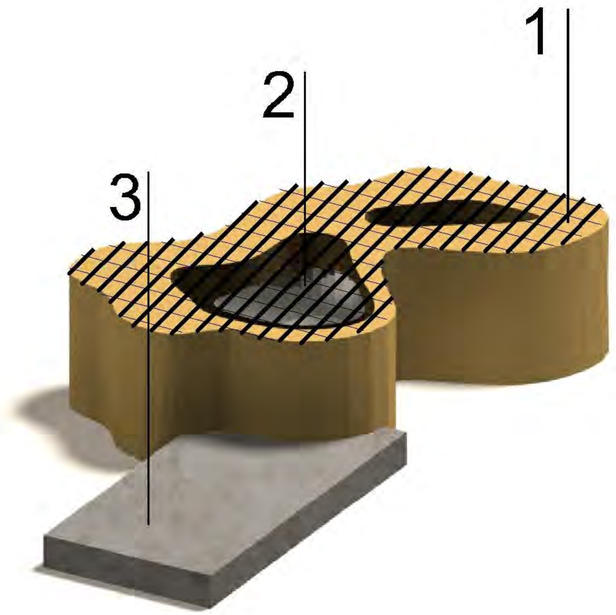


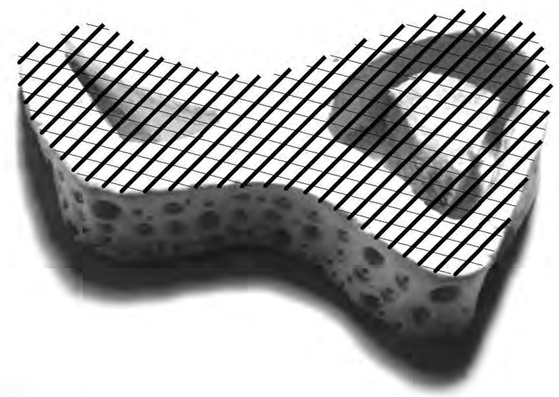


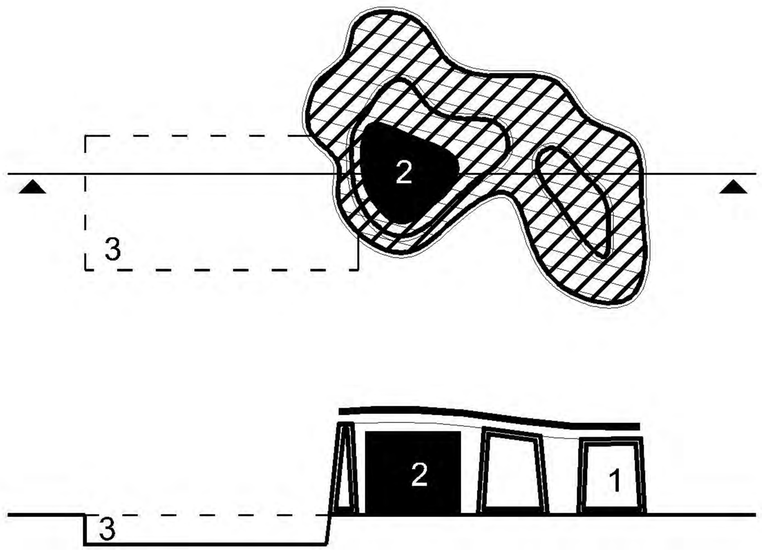


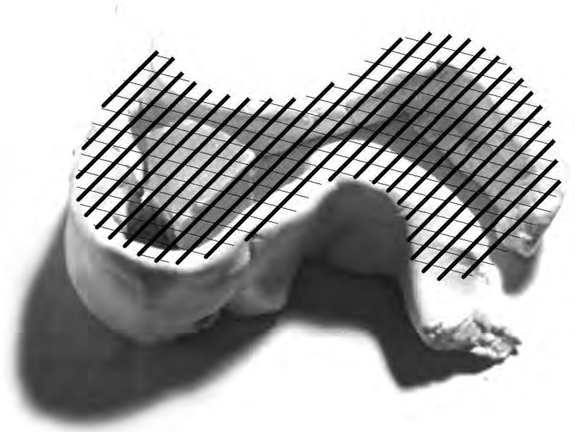


VOLUMETRIC STUDY

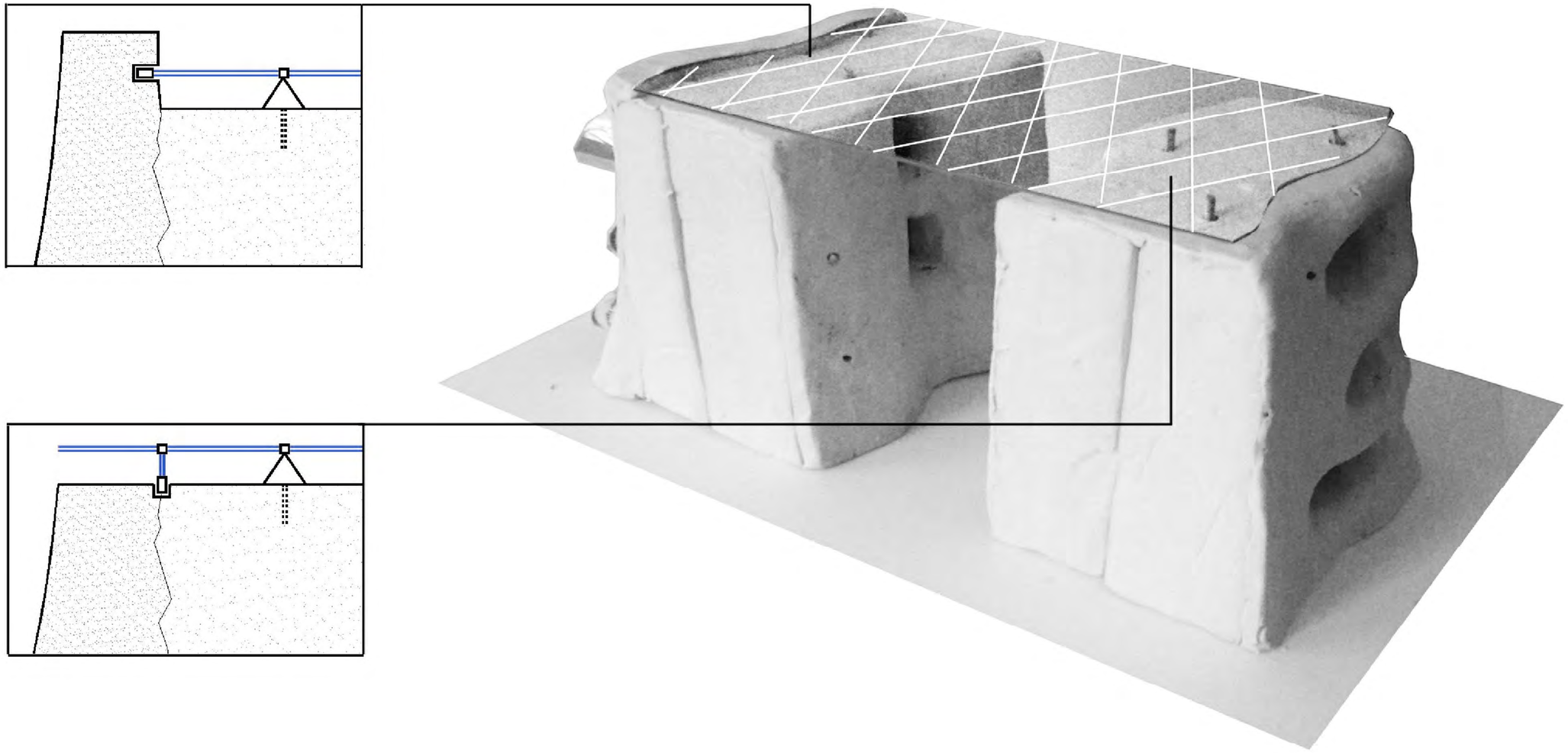








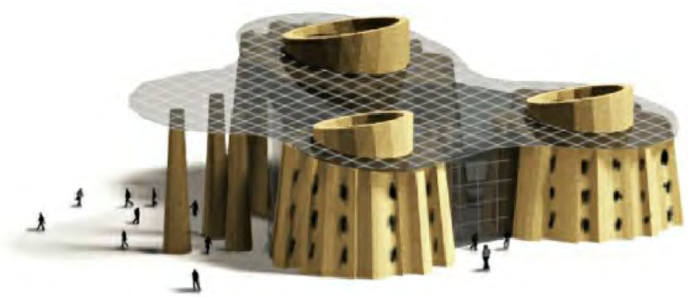
VOLUMETRIC STUDY

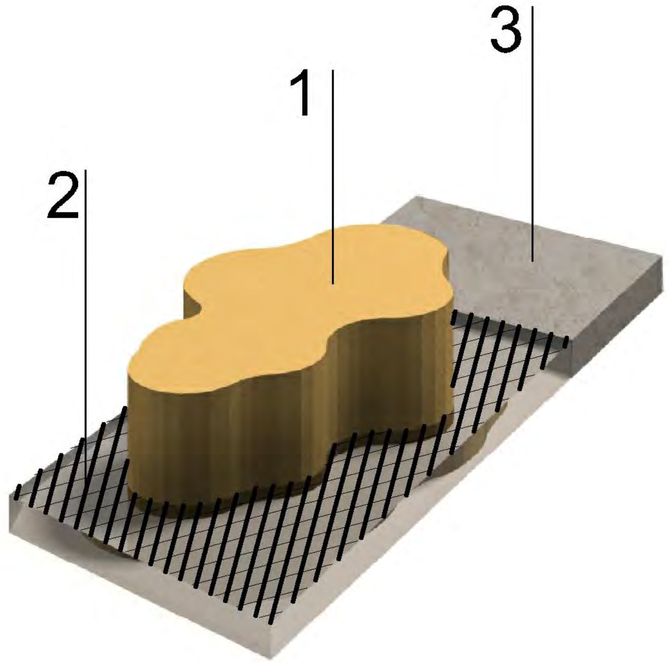


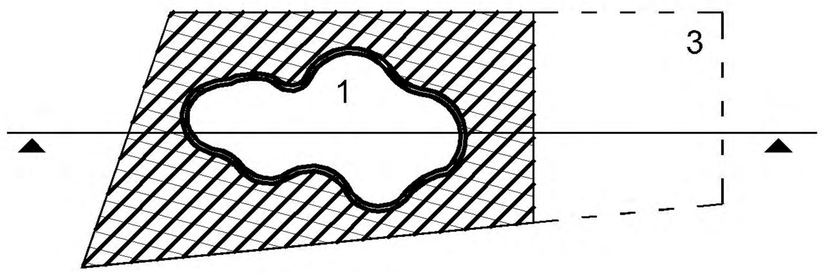
VOLUMETRIC STUDY

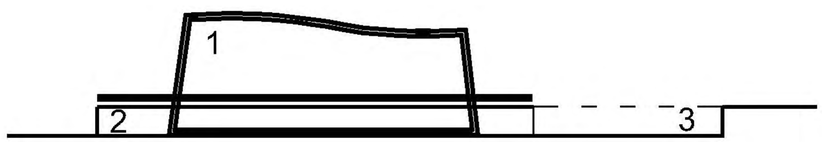




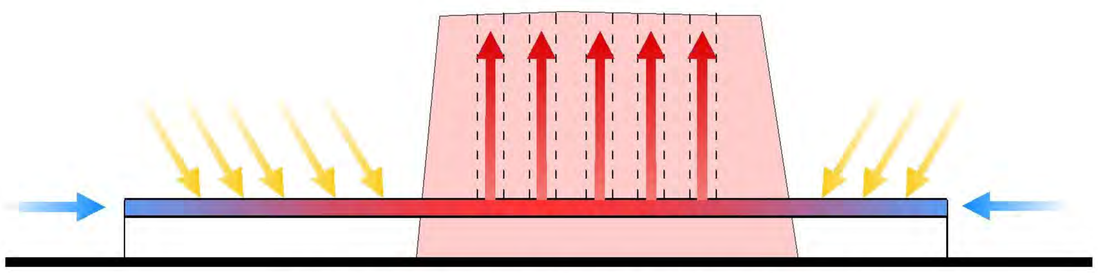




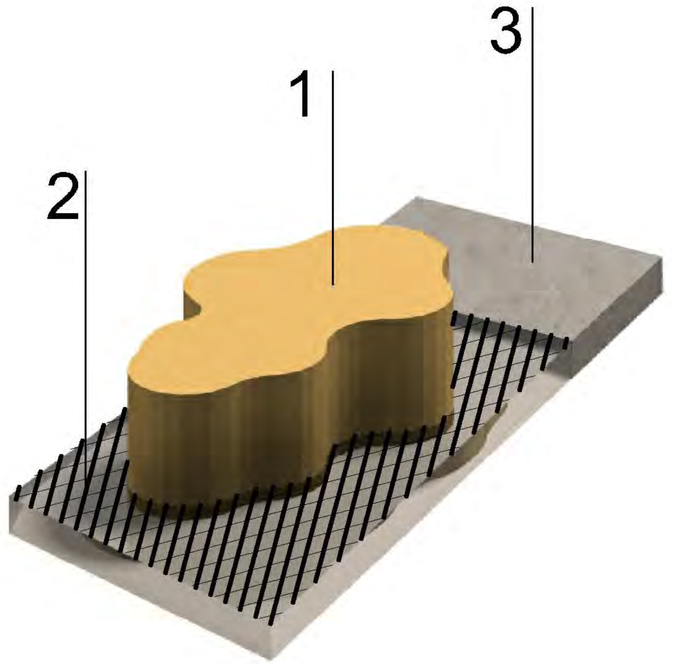


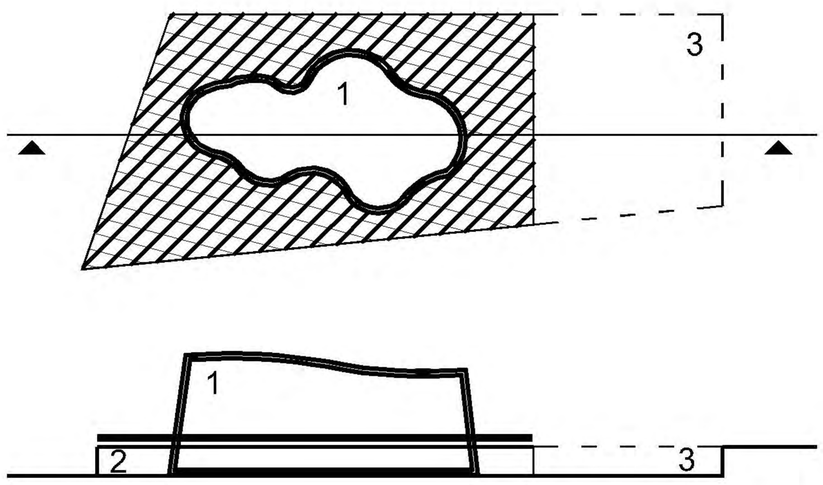


VOLUMETRIC STUDY

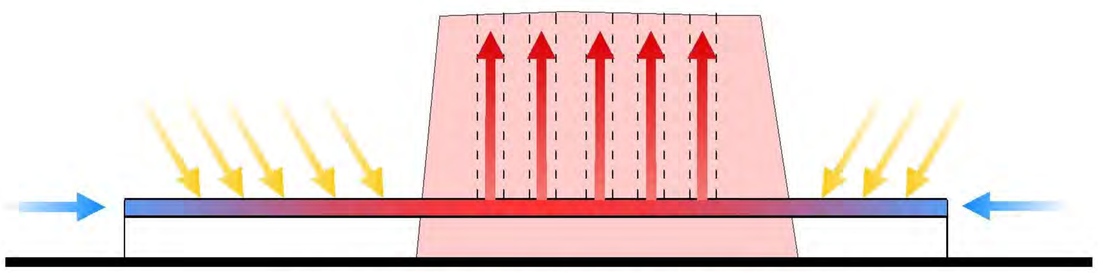


GLASS AREA (M2) / EARTH VOLUME (M3) = 1 / 5
TERMAL SATURATION OCCURS IN ~ 2 YEARS

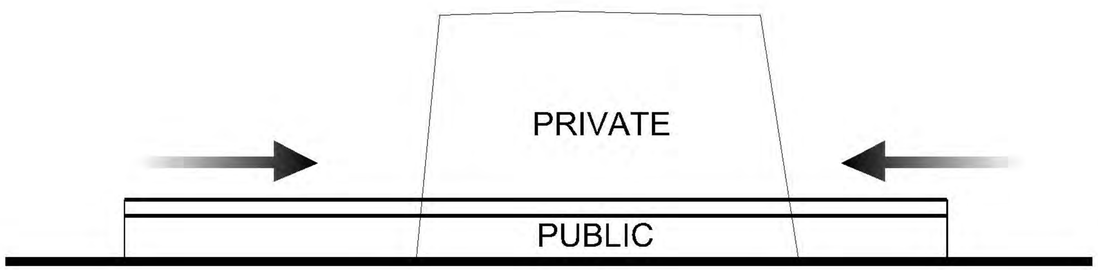


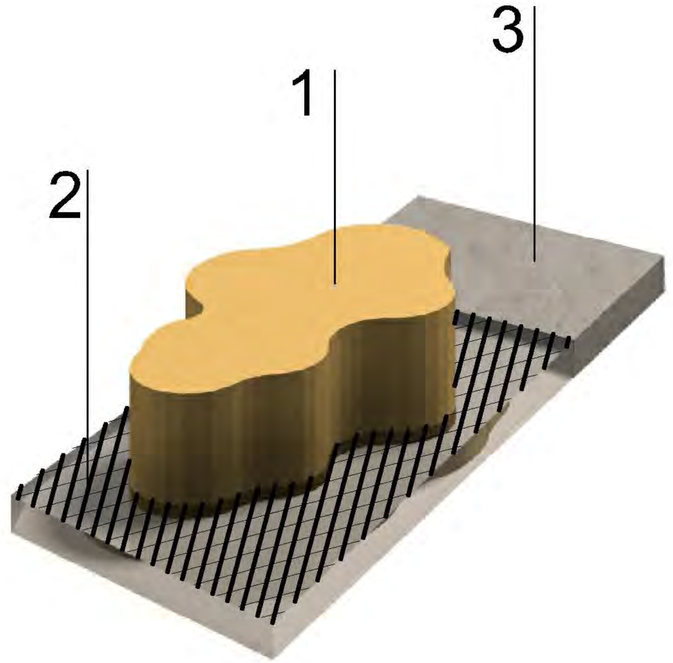


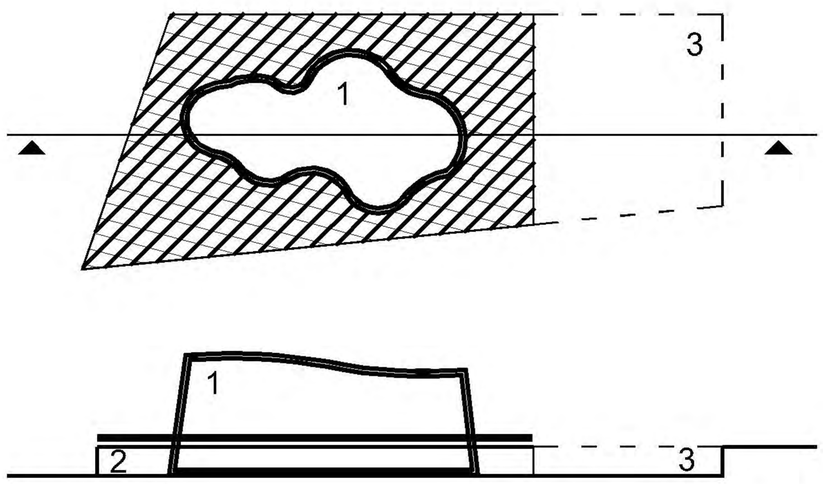
VOLUMETRIC STUDY



GLASS AREA (M2) / EARTH VOLUME (M3) = 1 / 5
TERMAL SATURATION OCCURS IN ~ 2 YEARS







LOCATION



LOCATION





LOCATION

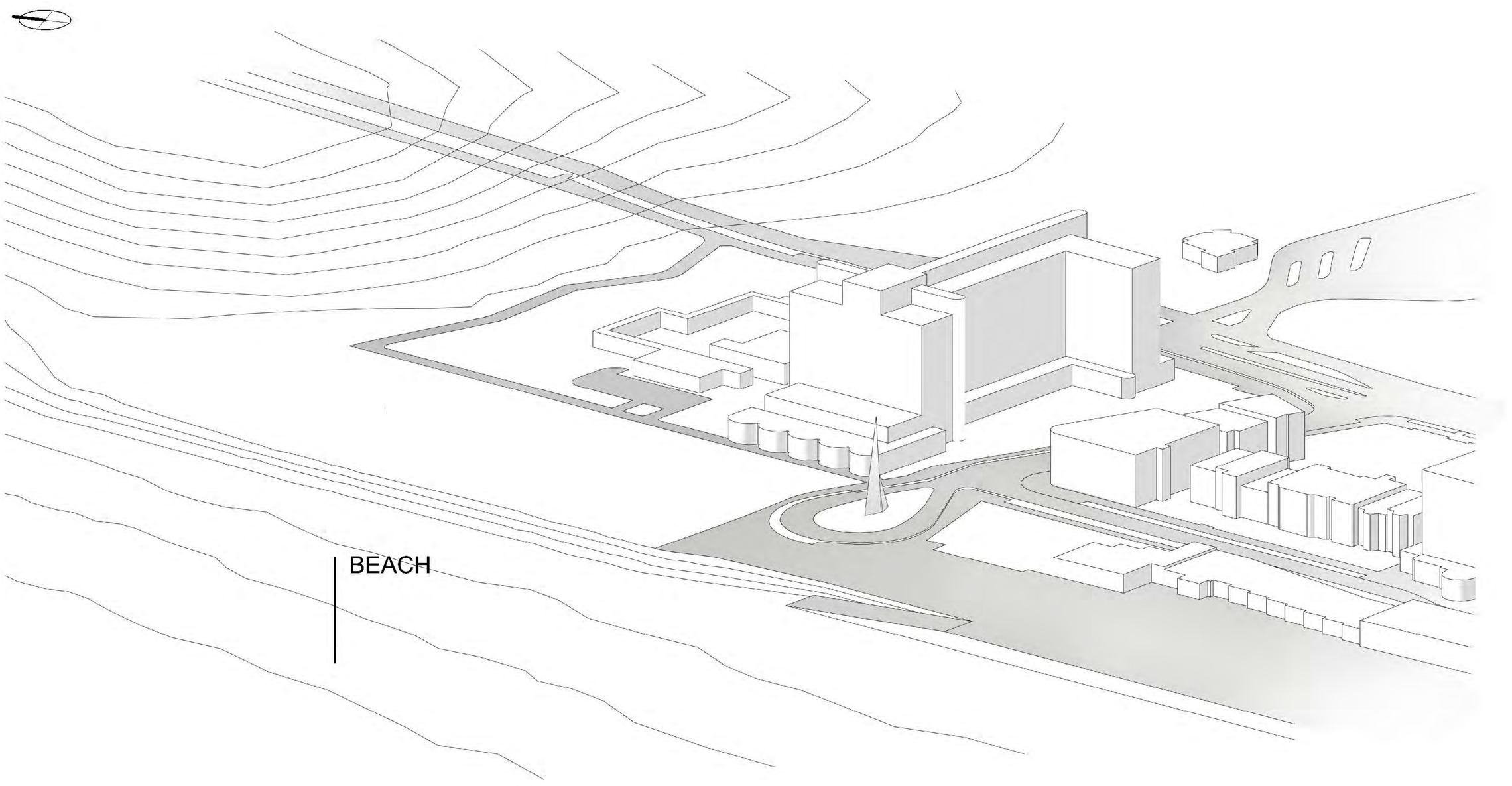


BUILDING
IN GENERAL

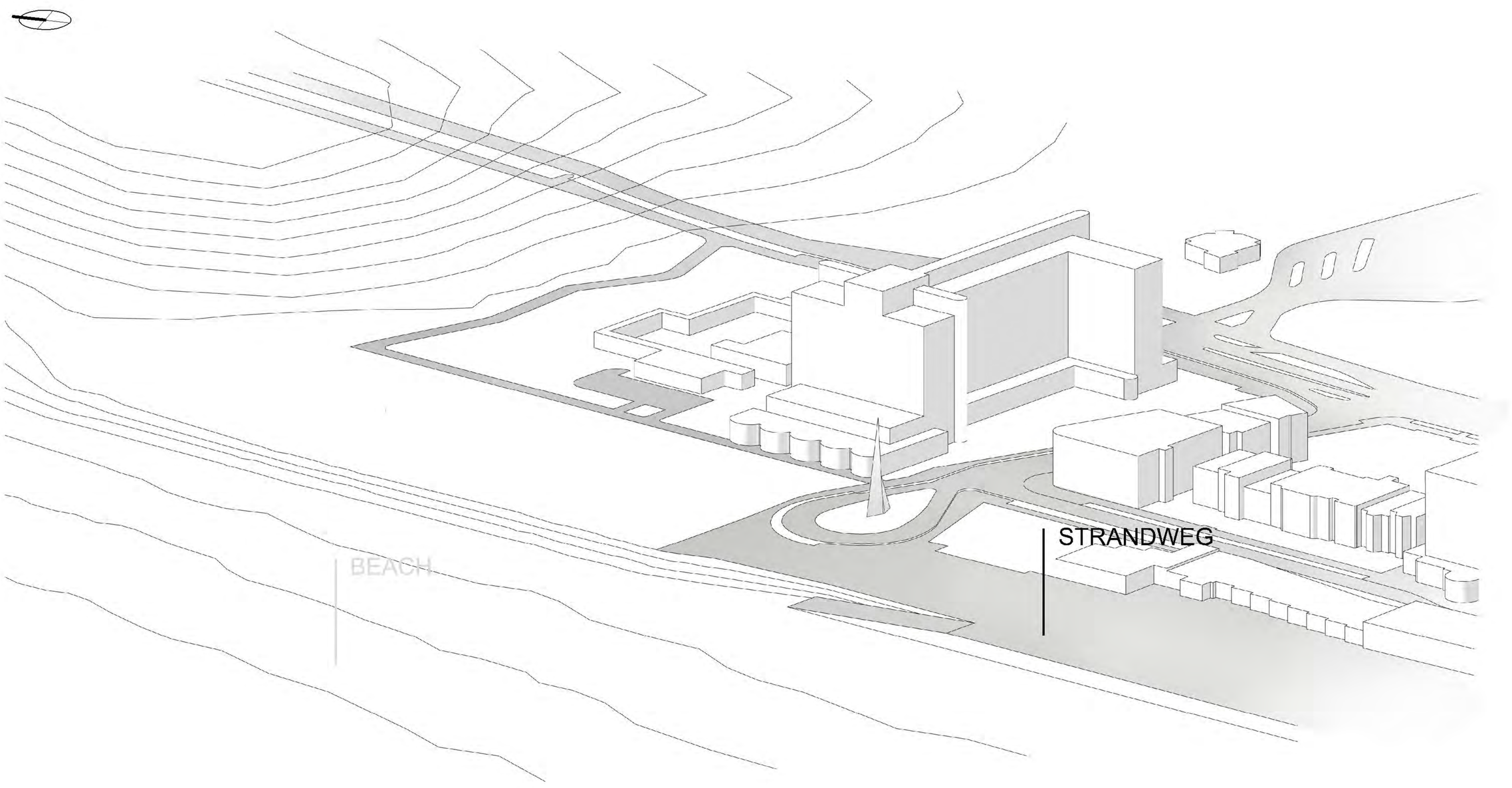
context

functional zoning

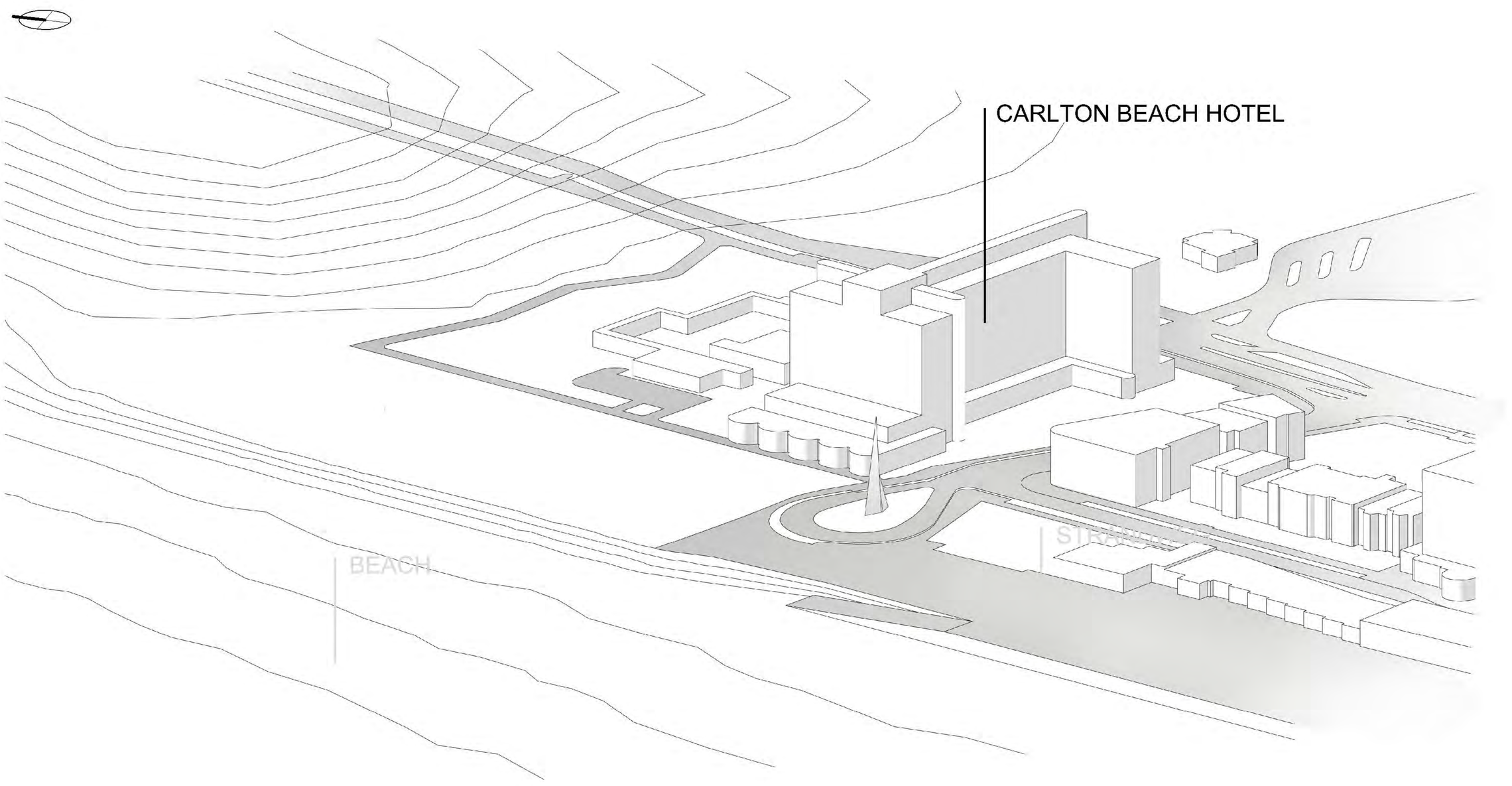
FINAL DESIGN



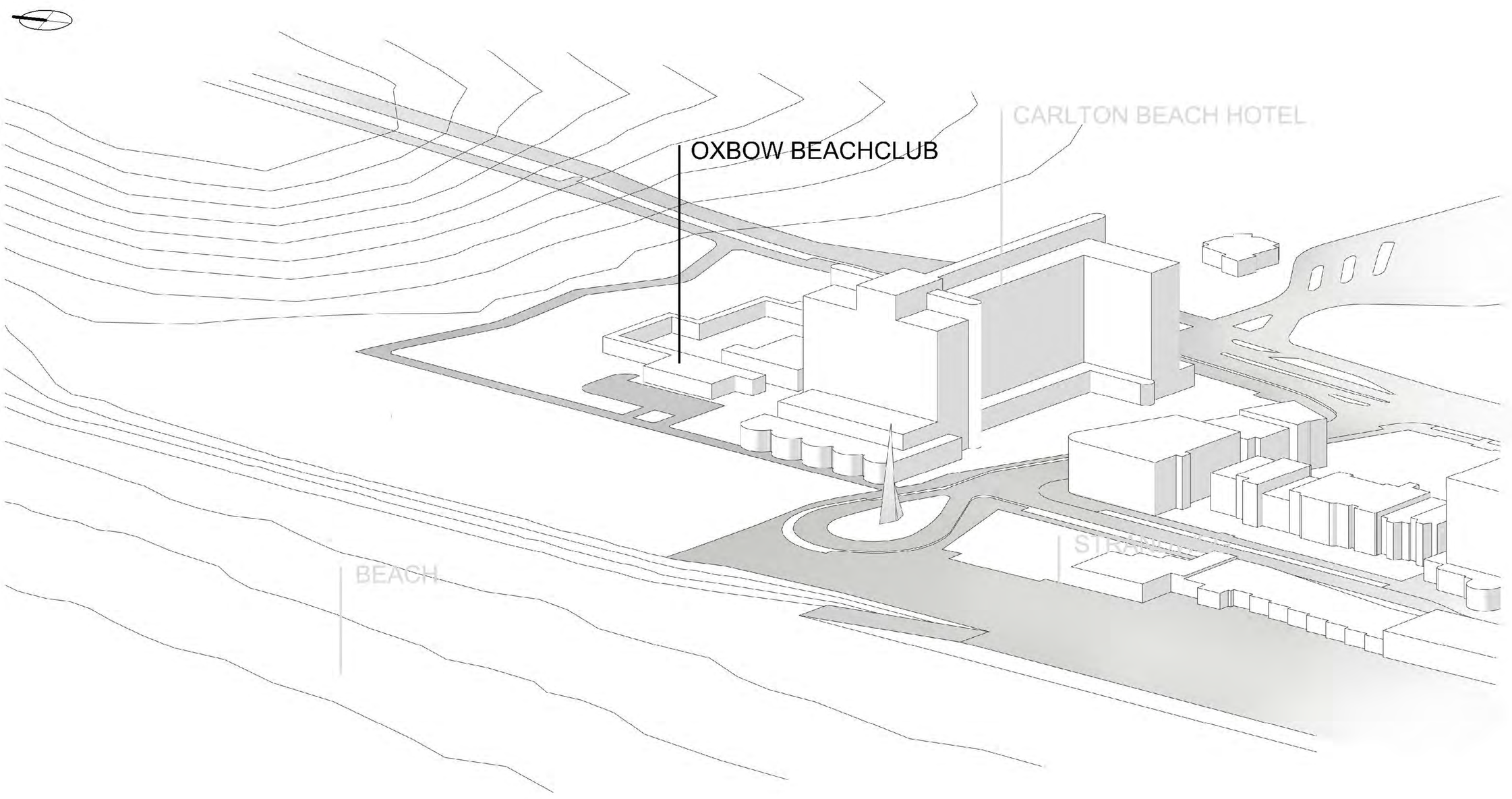
FINAL DESIGN



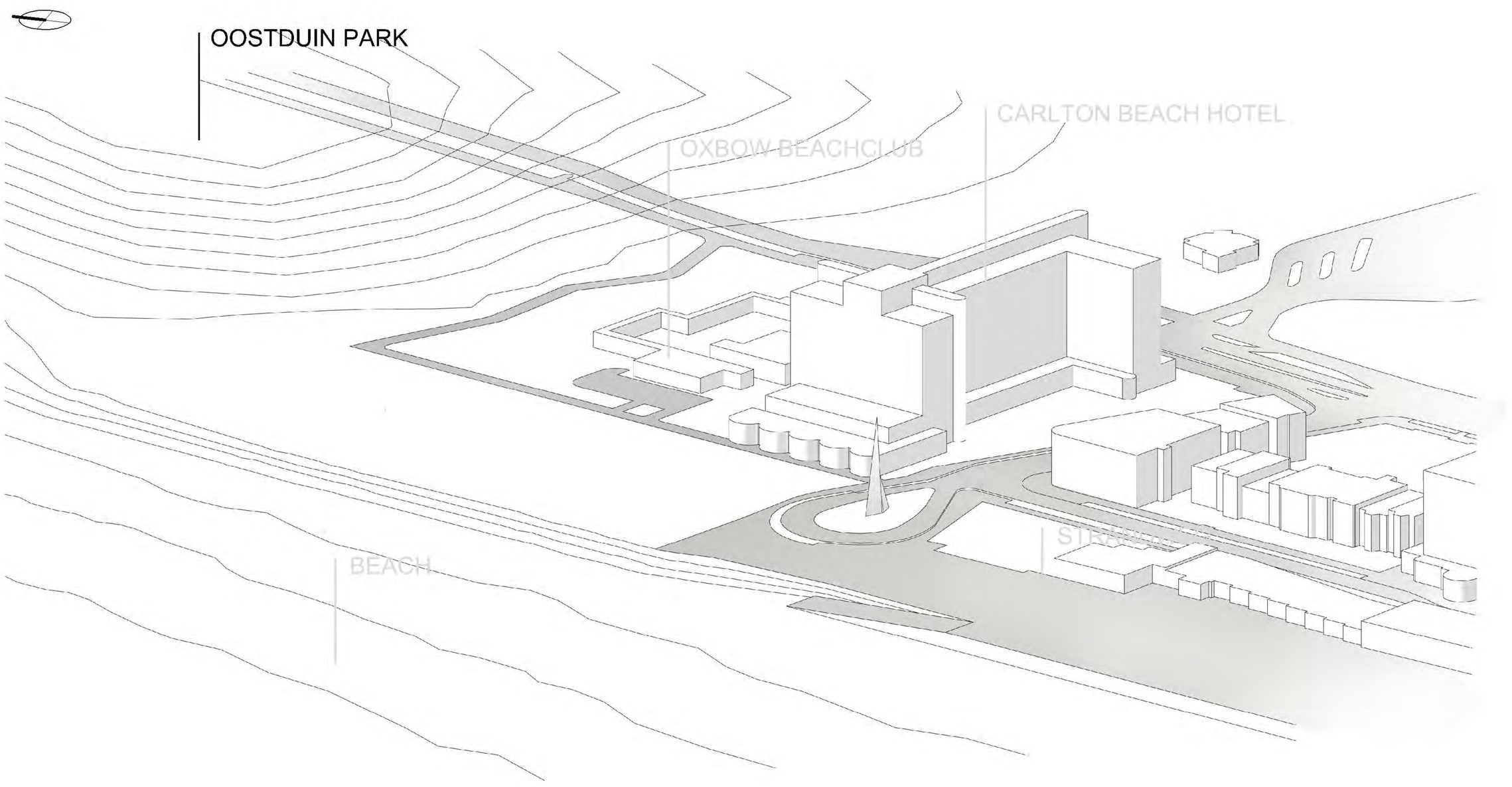
FINAL DESIGN



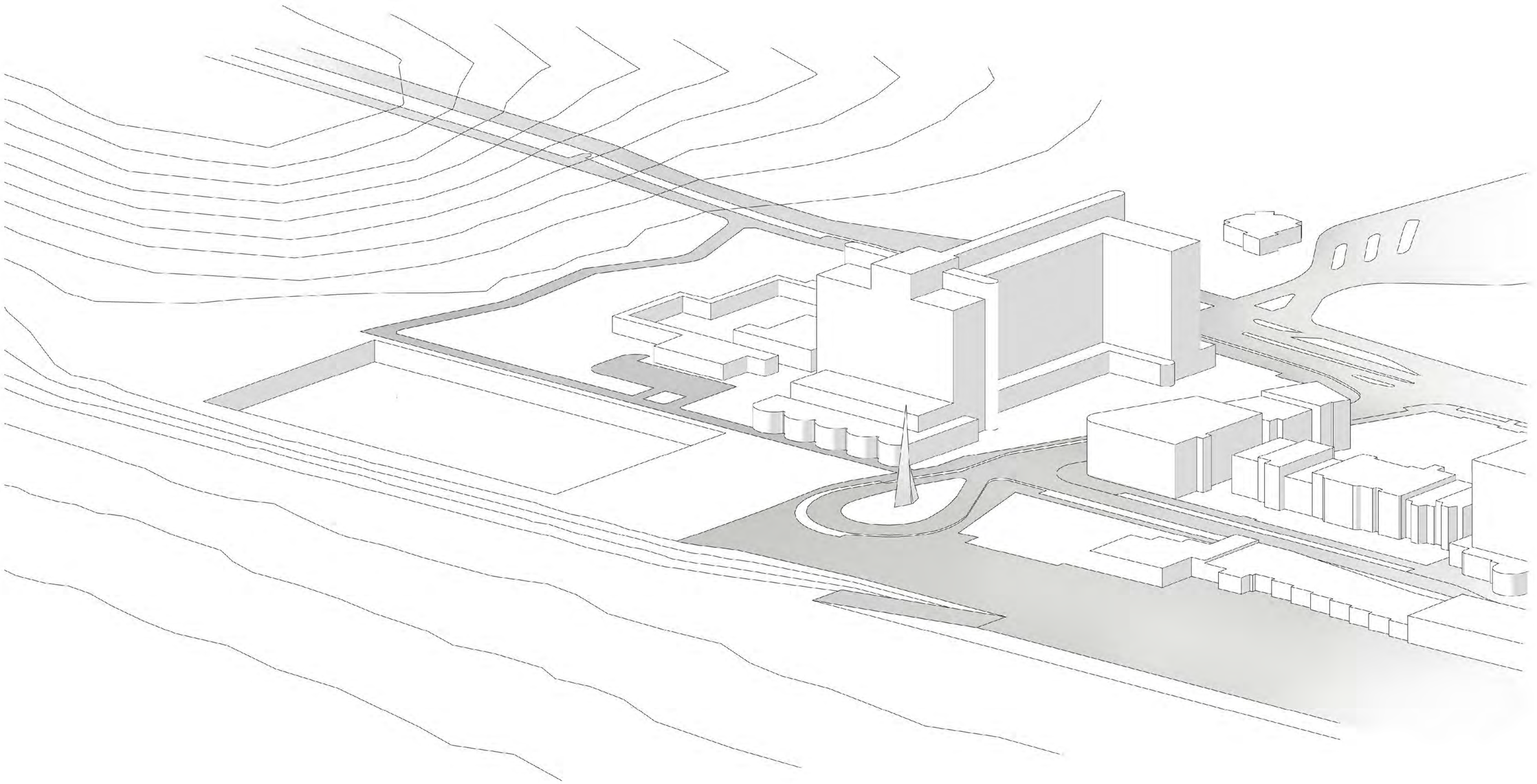
FINAL DESIGN



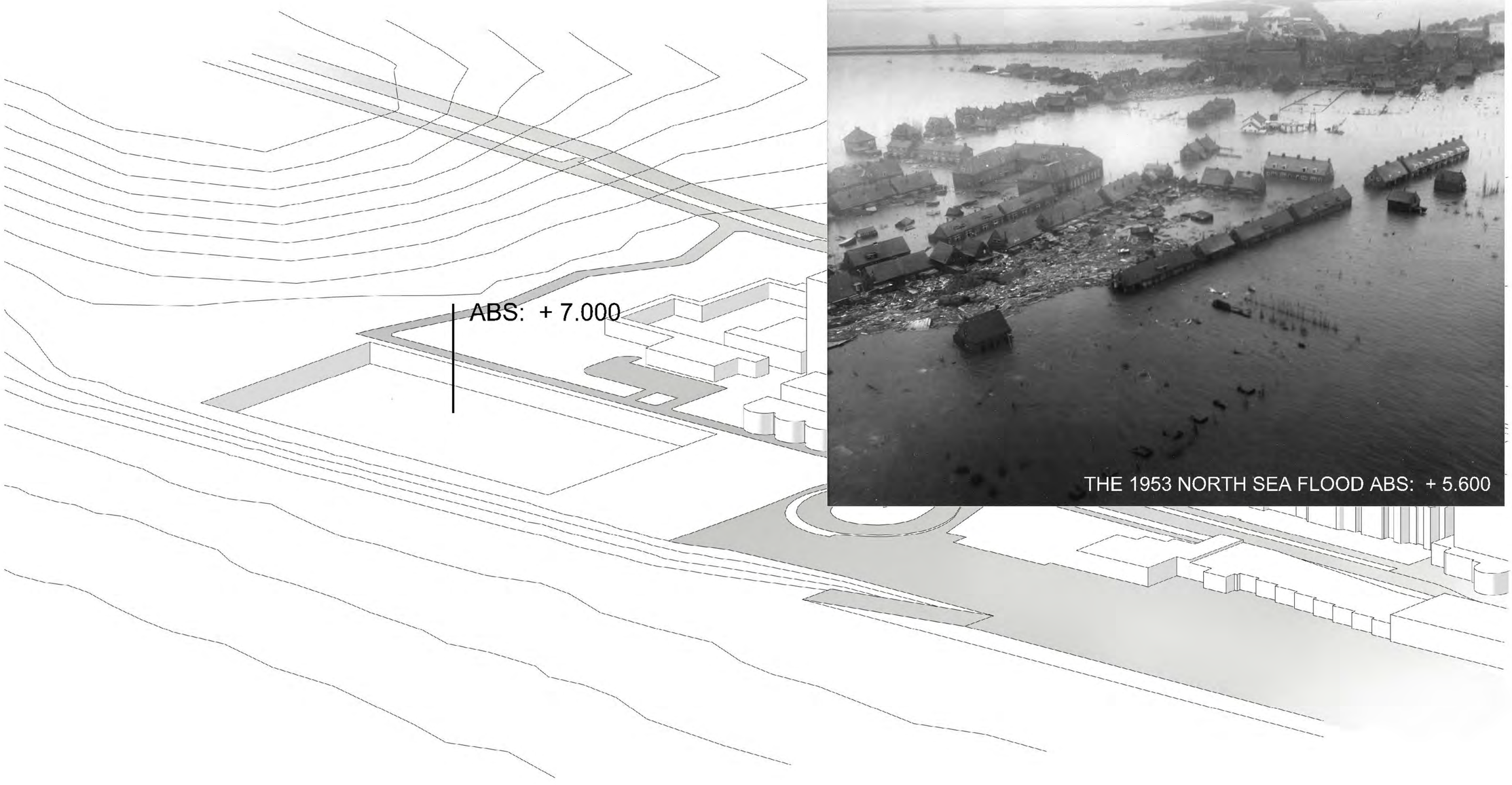
FINAL DESIGN



FINAL DESIGN

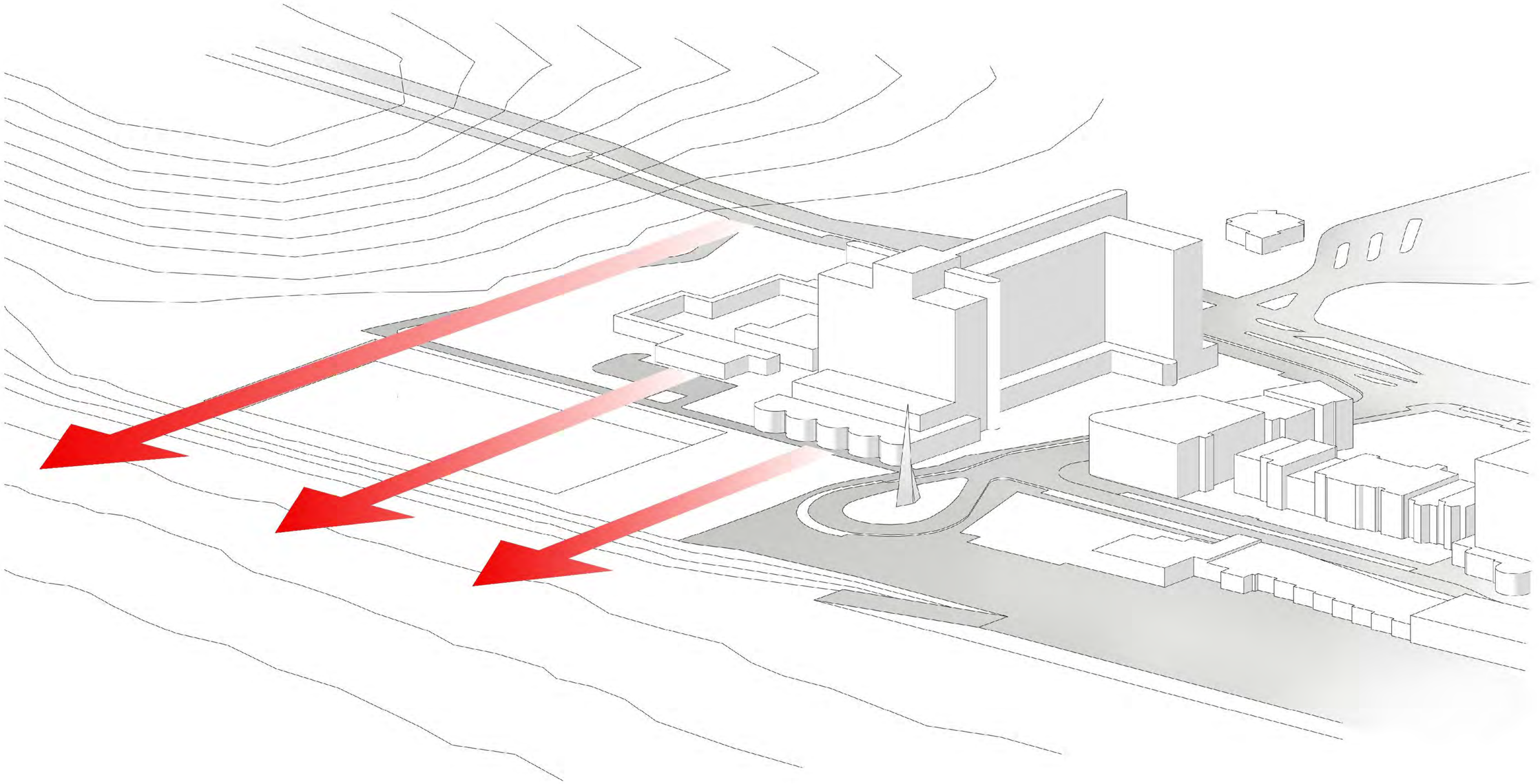


FINAL DESIGN

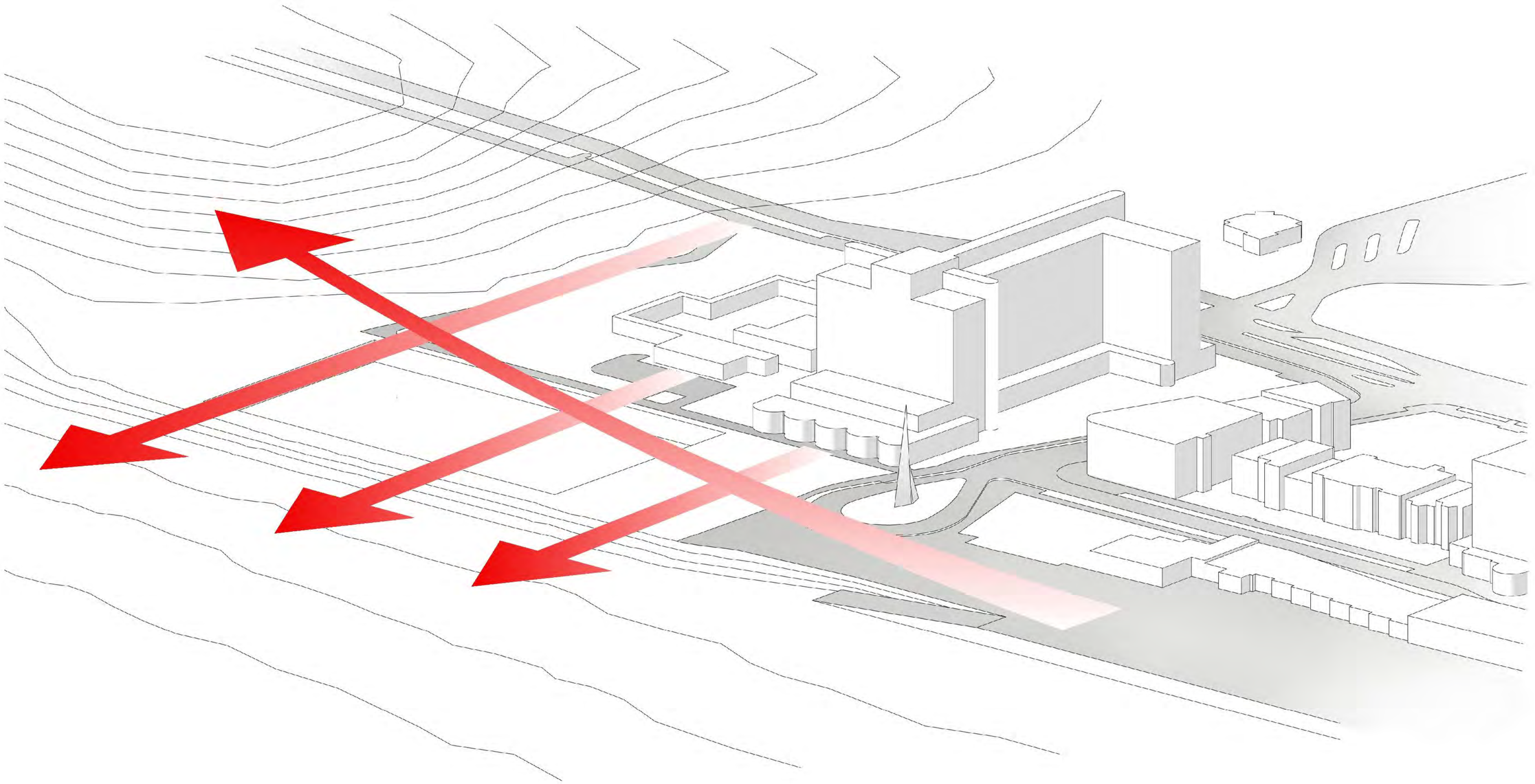


THE 1953 NORTH SEA FLOOD ABS: + 5.600

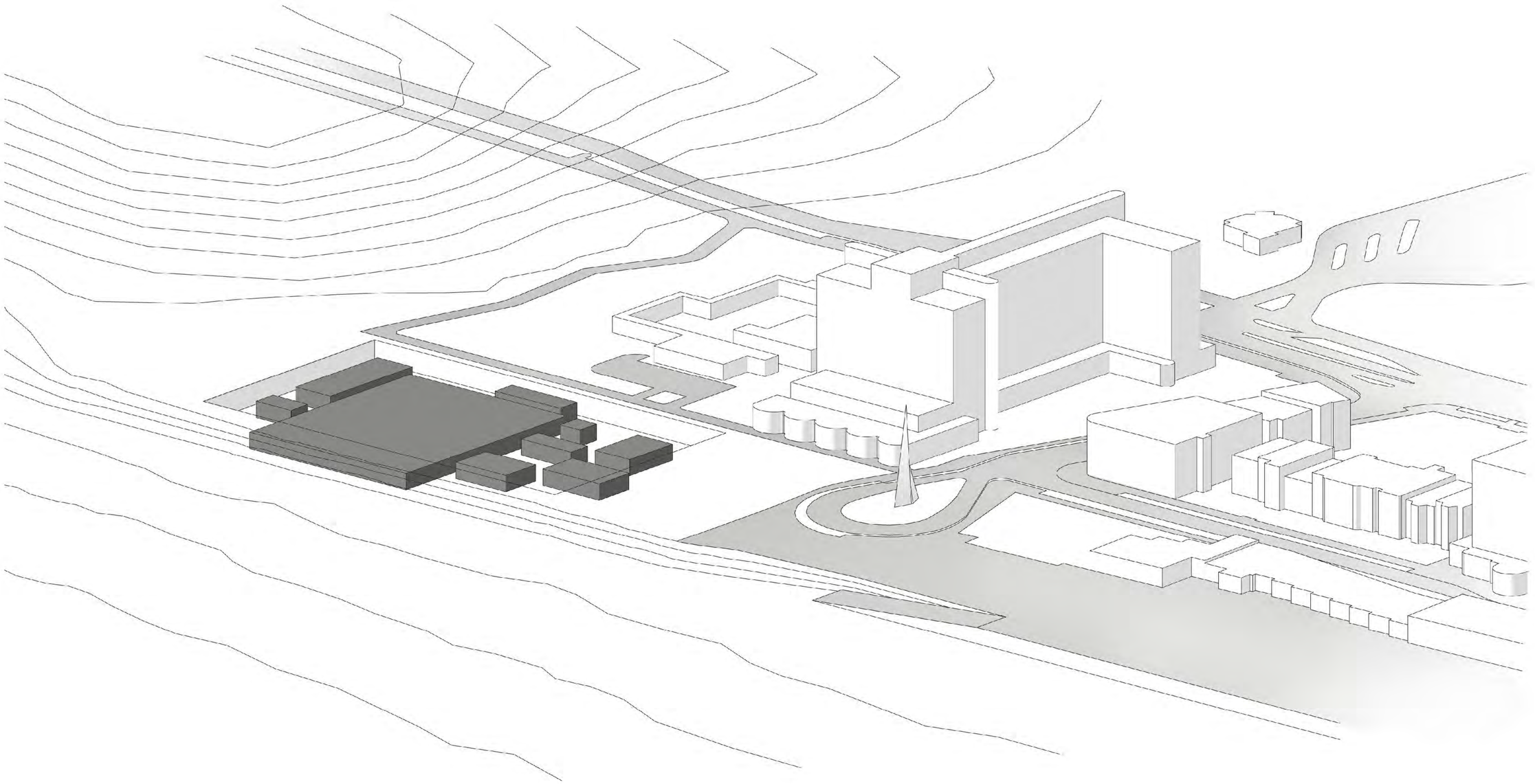
FINAL DESIGN



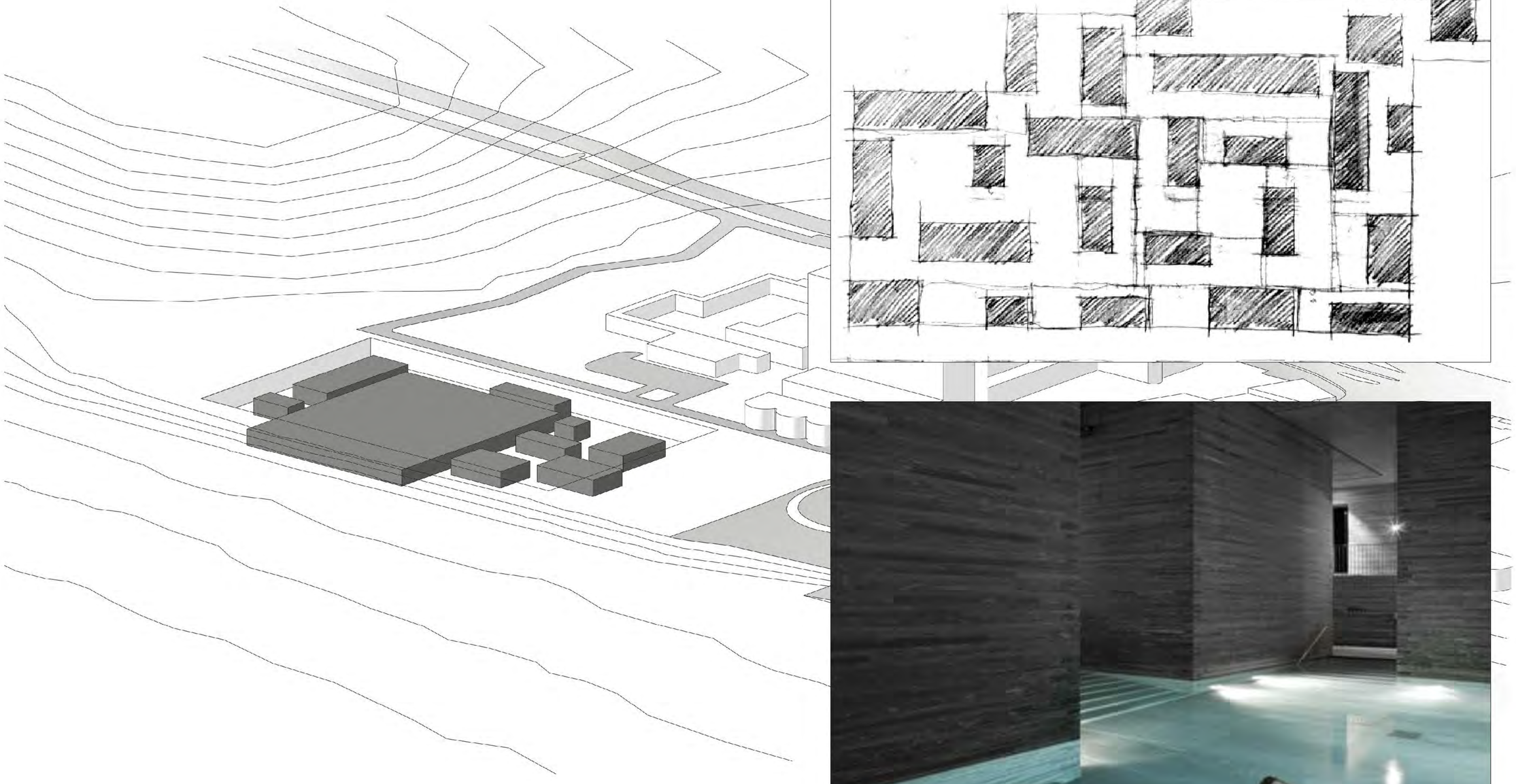
FINAL DESIGN

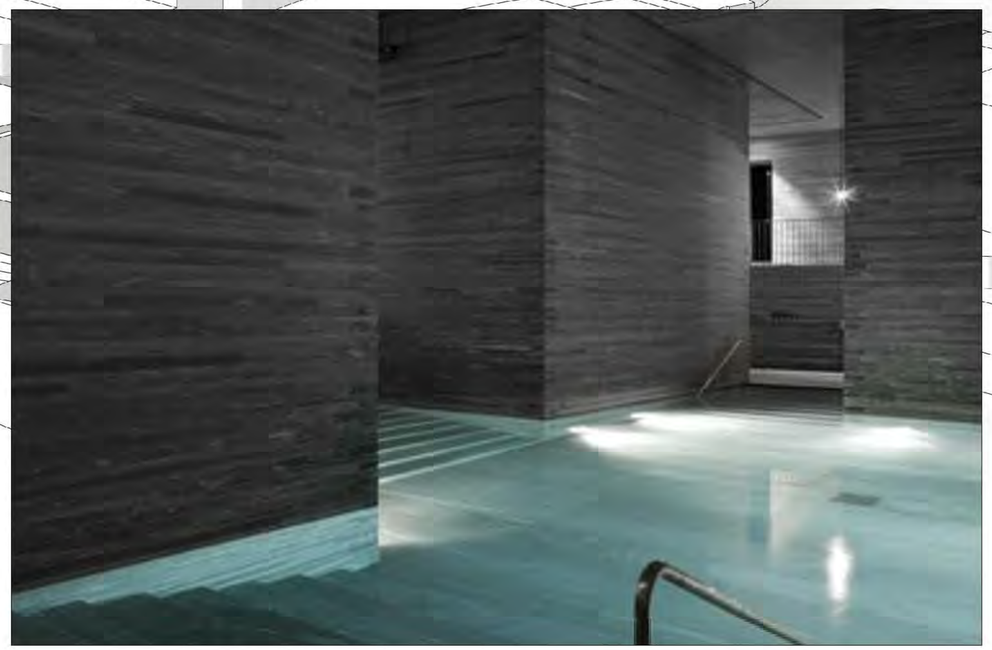


FINAL DESIGN

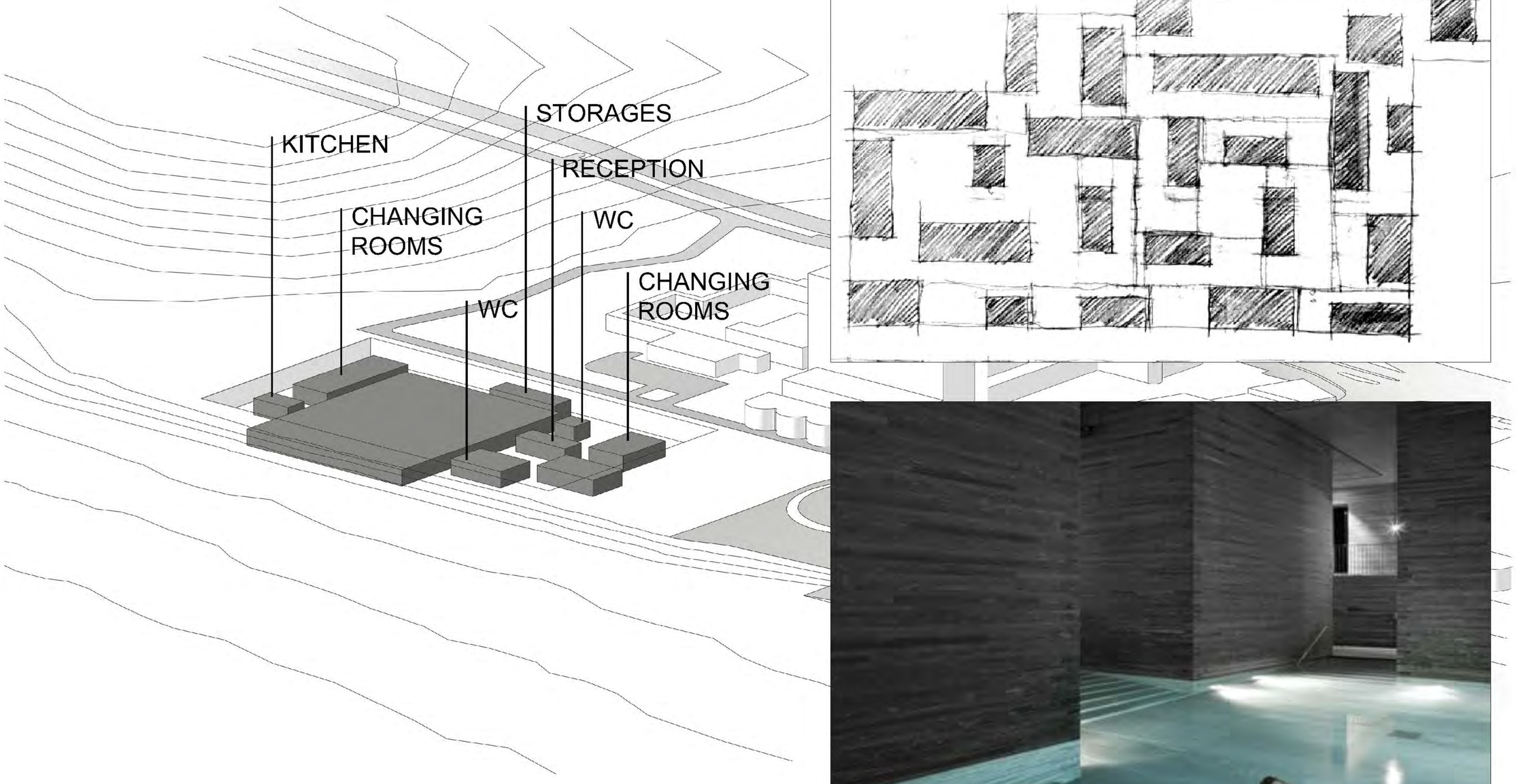


FINAL DESIGN



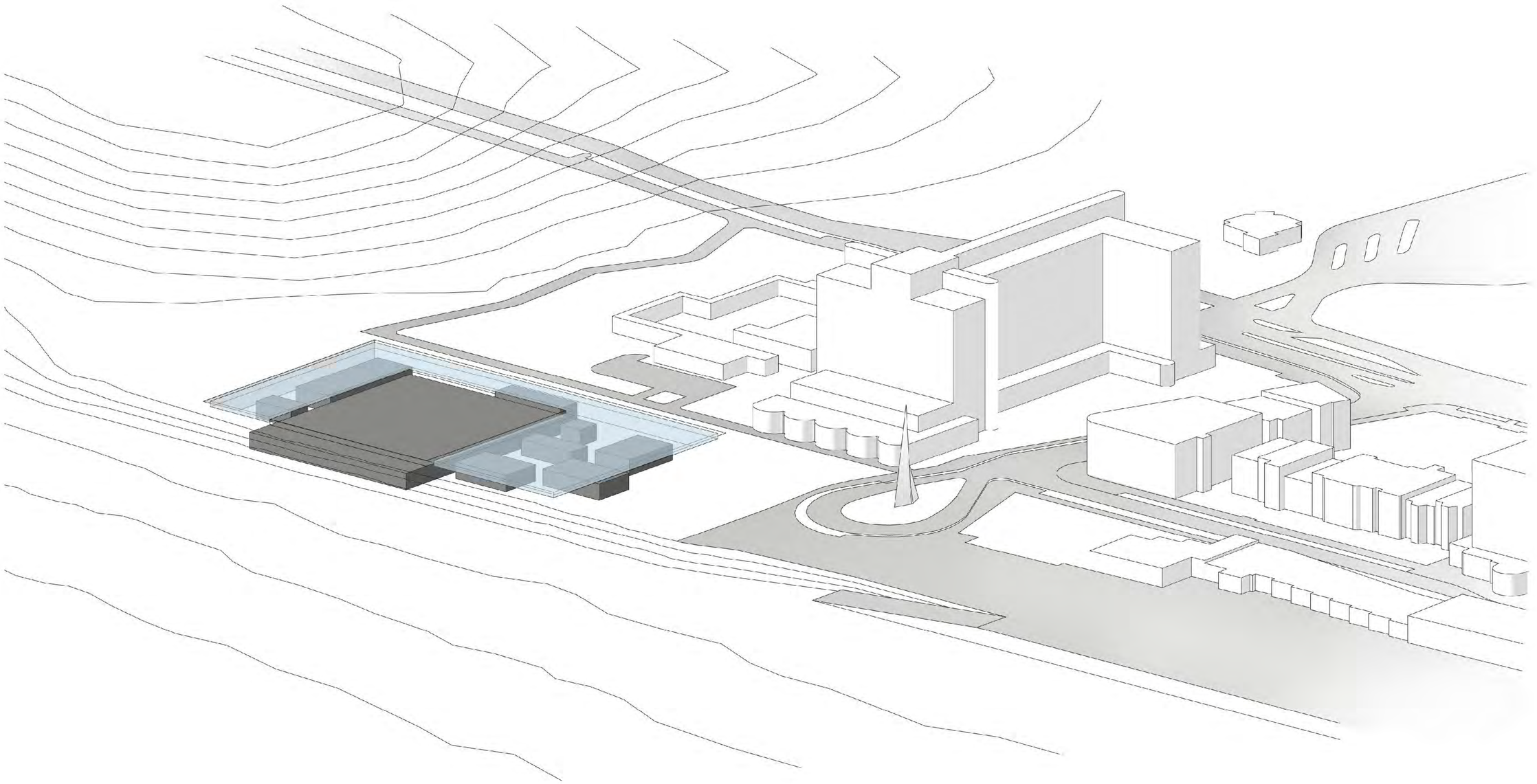


FINAL DESIGN

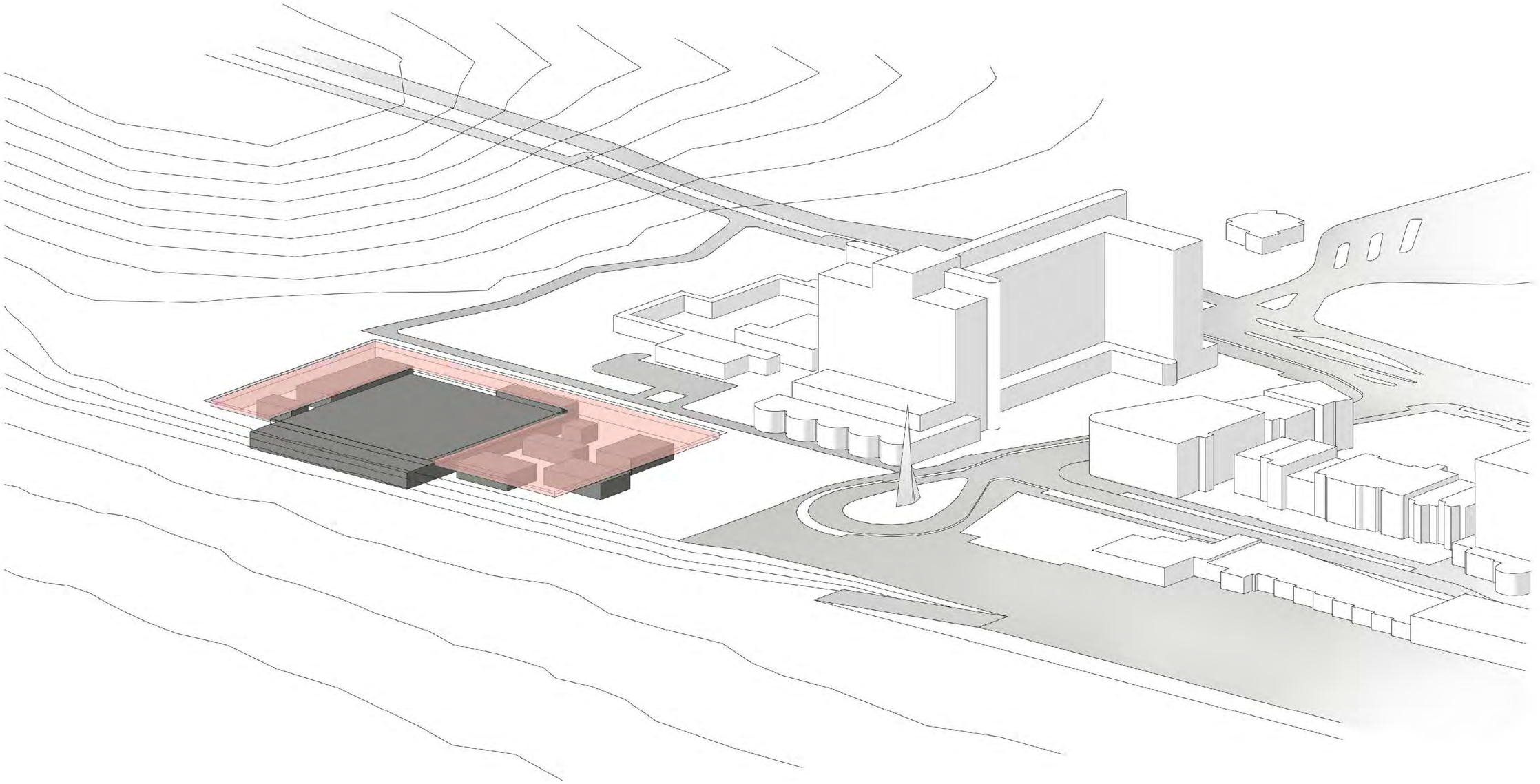




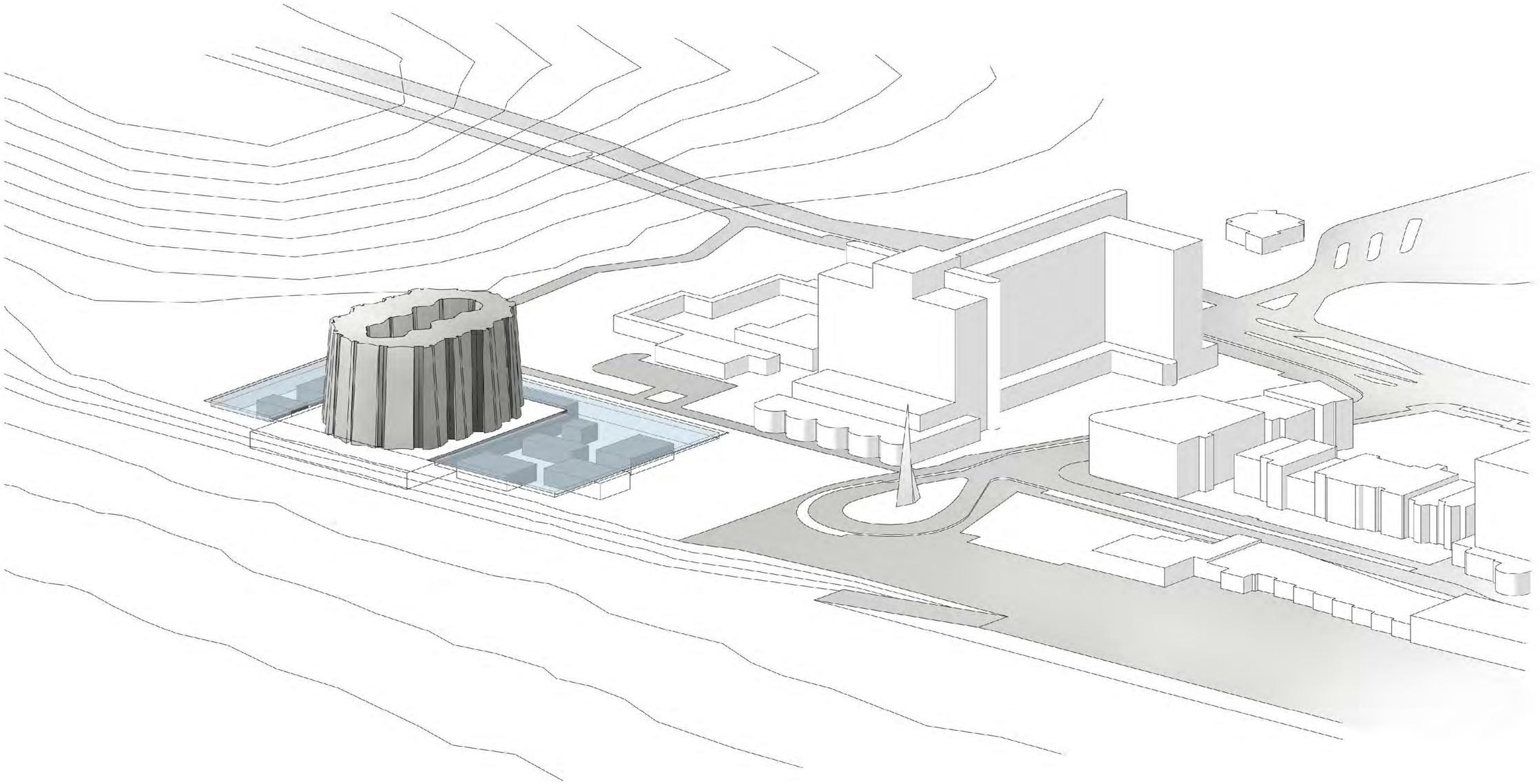
FINAL DESIGN



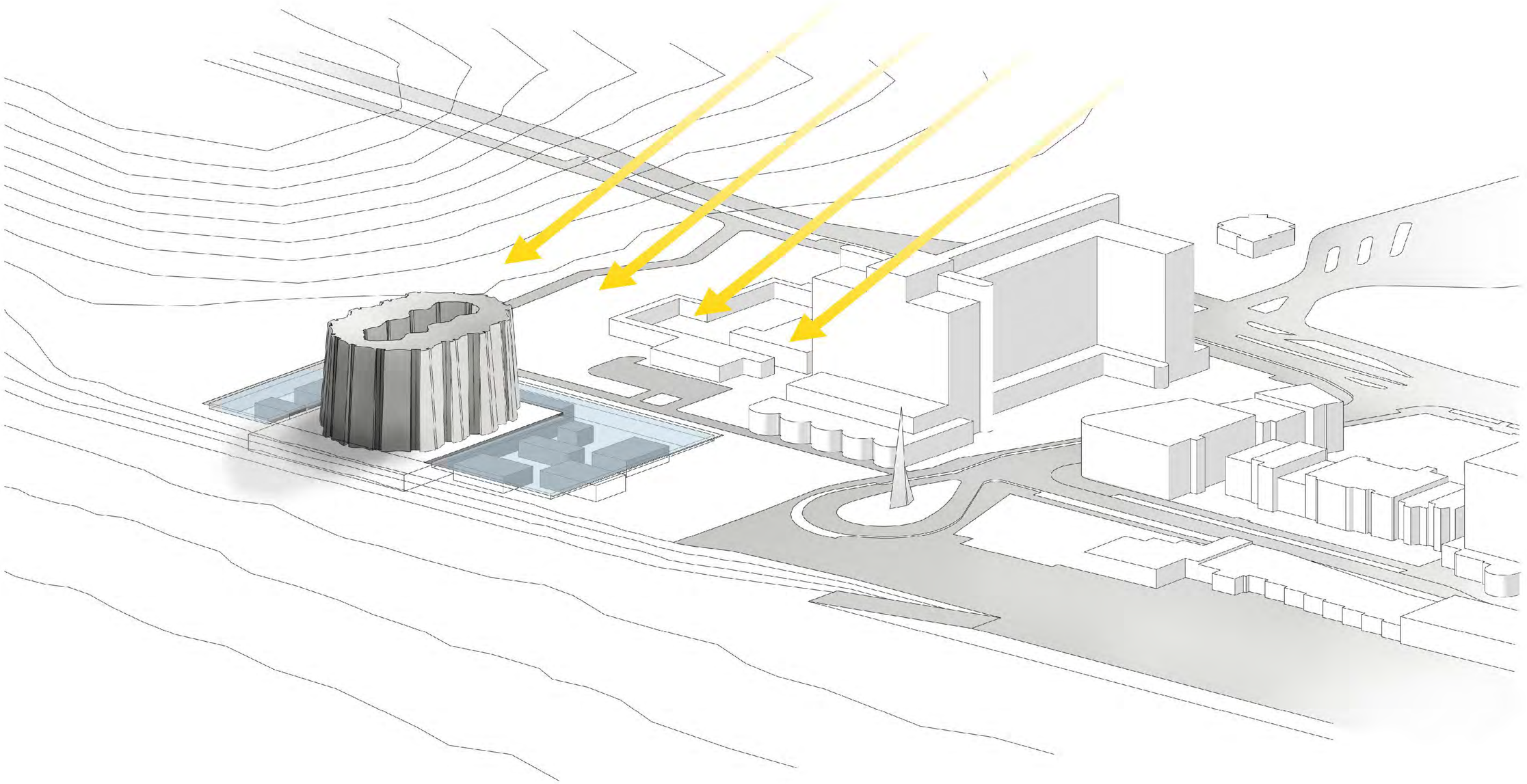
FINAL DESIGN



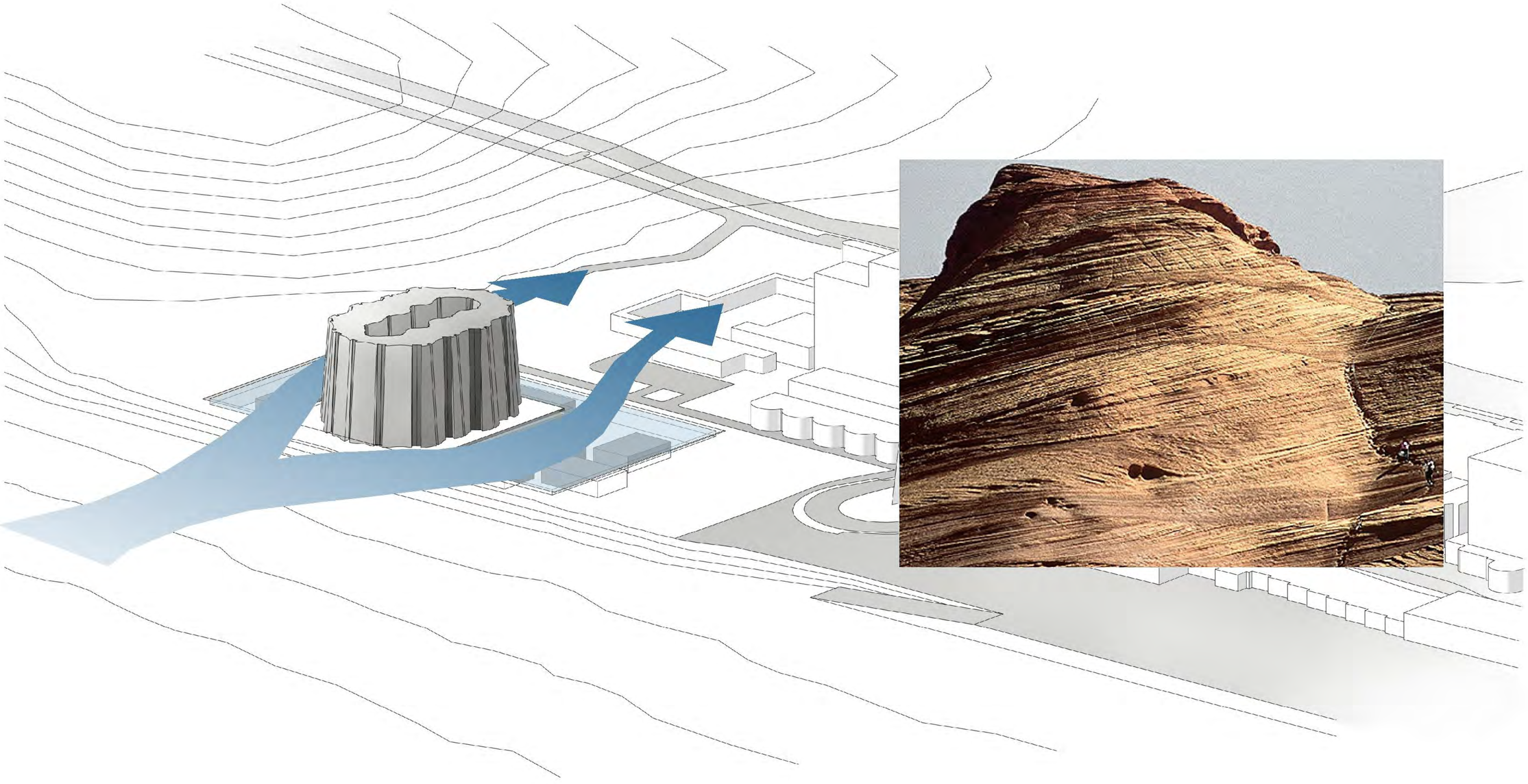
FINAL DESIGN



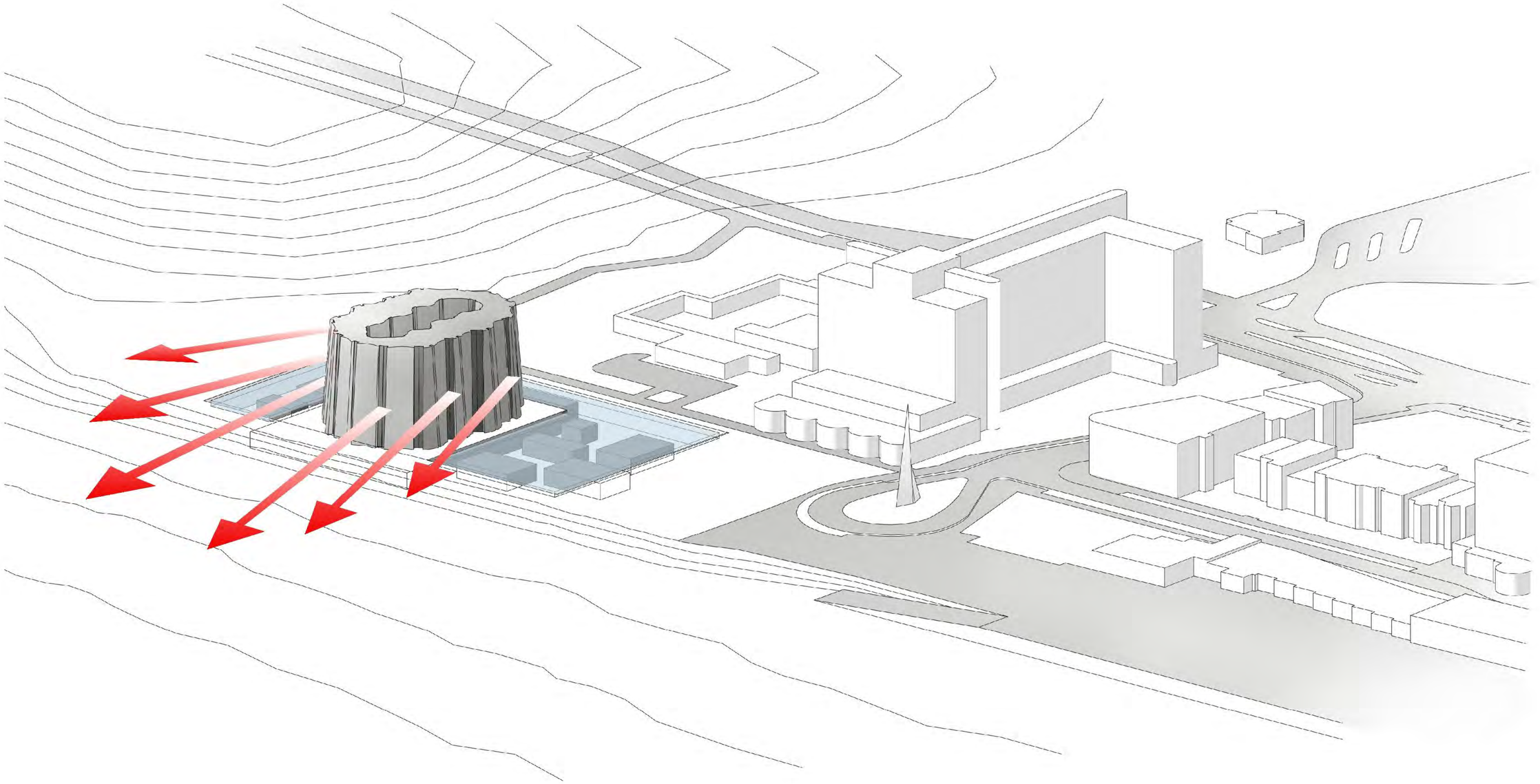
FINAL DESIGN



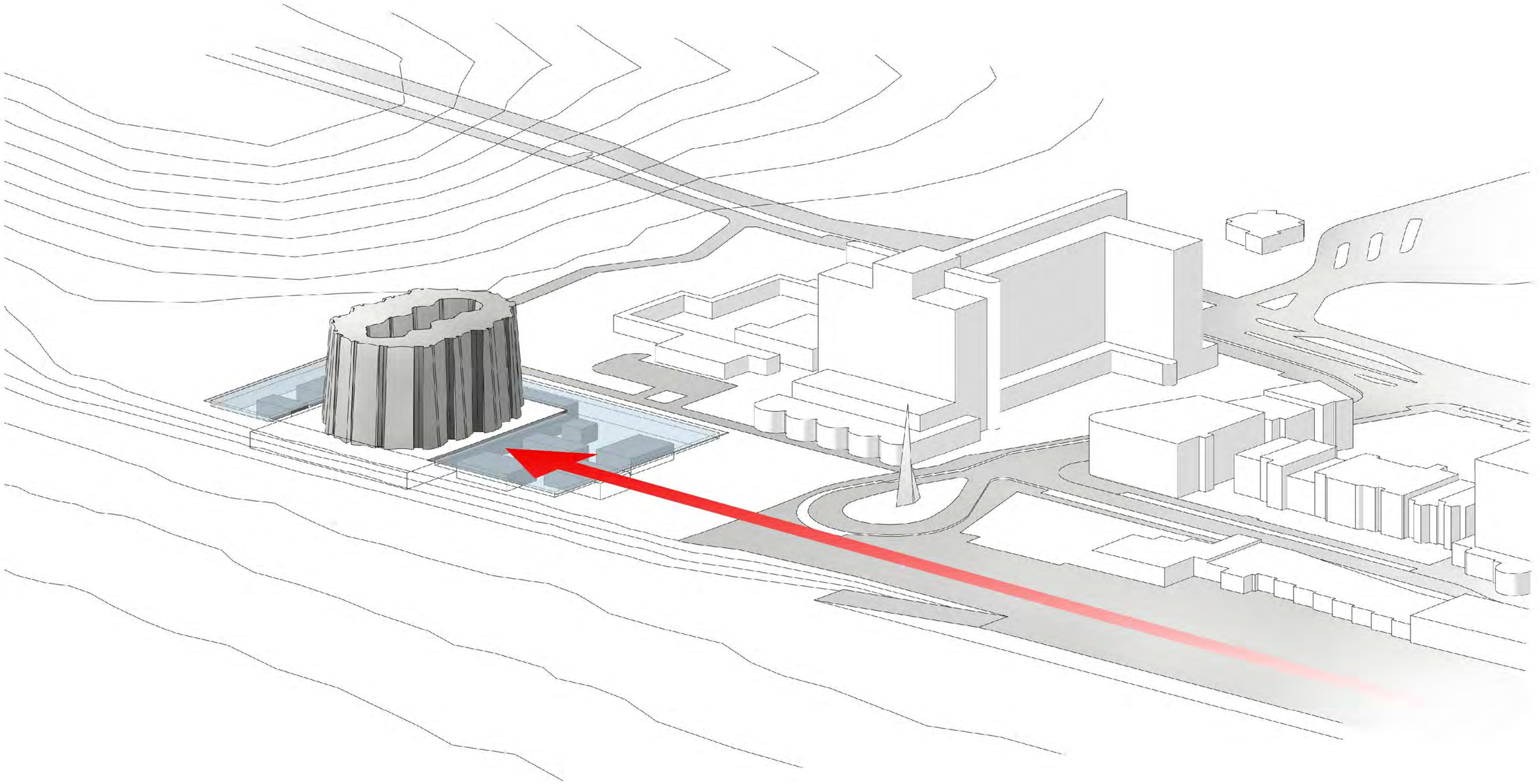
FINAL DESIGN



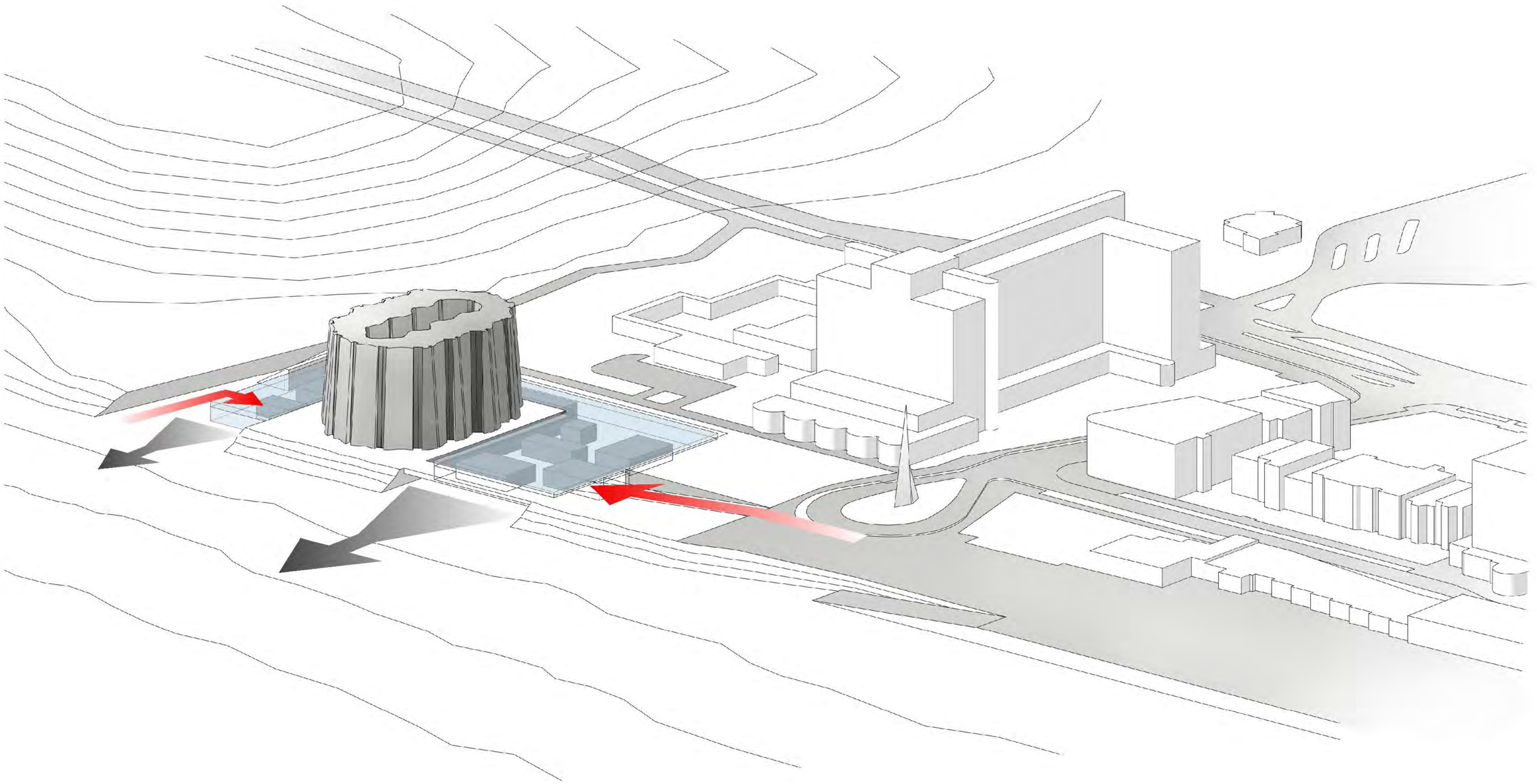
FINAL DESIGN



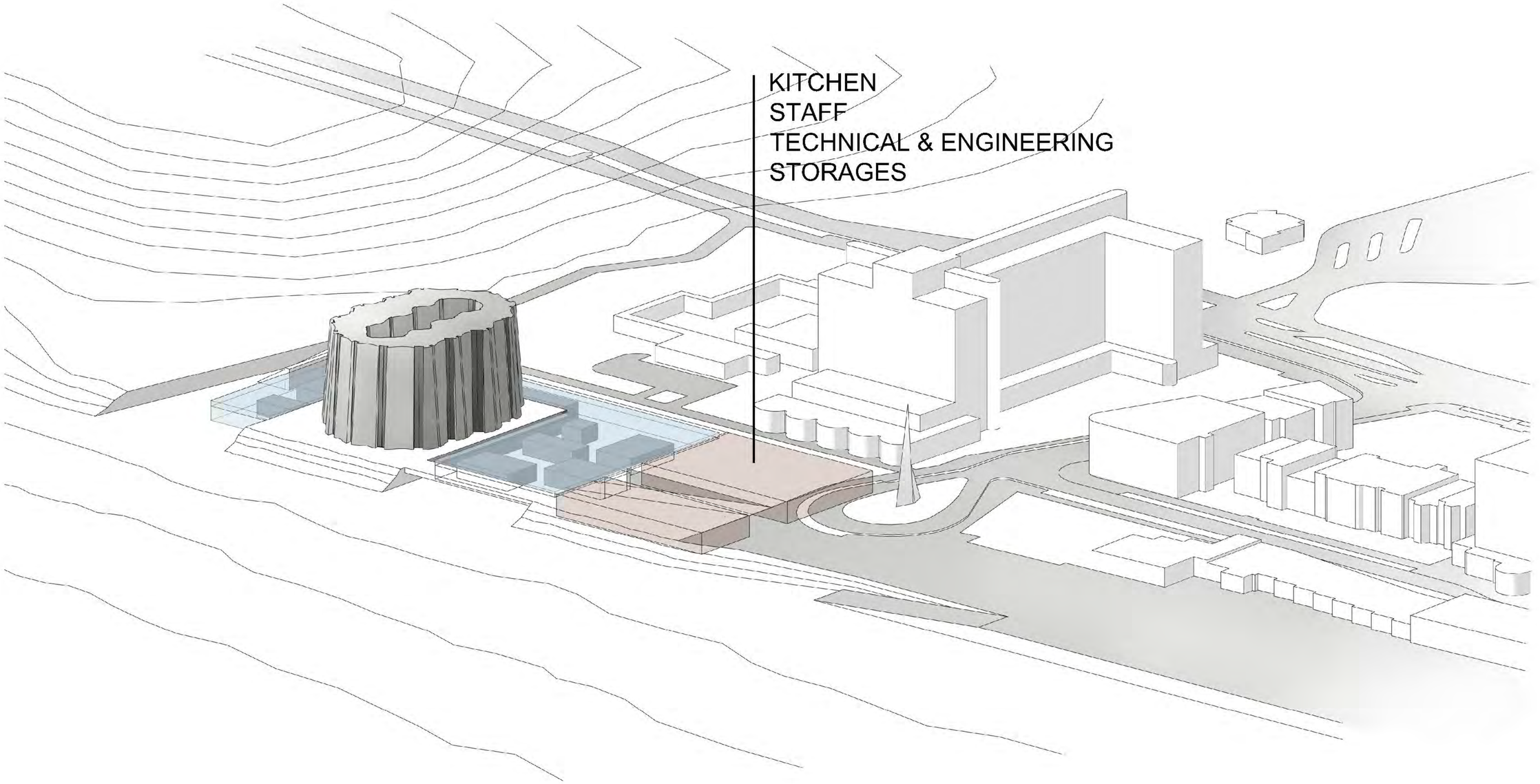
FINAL DESIGN



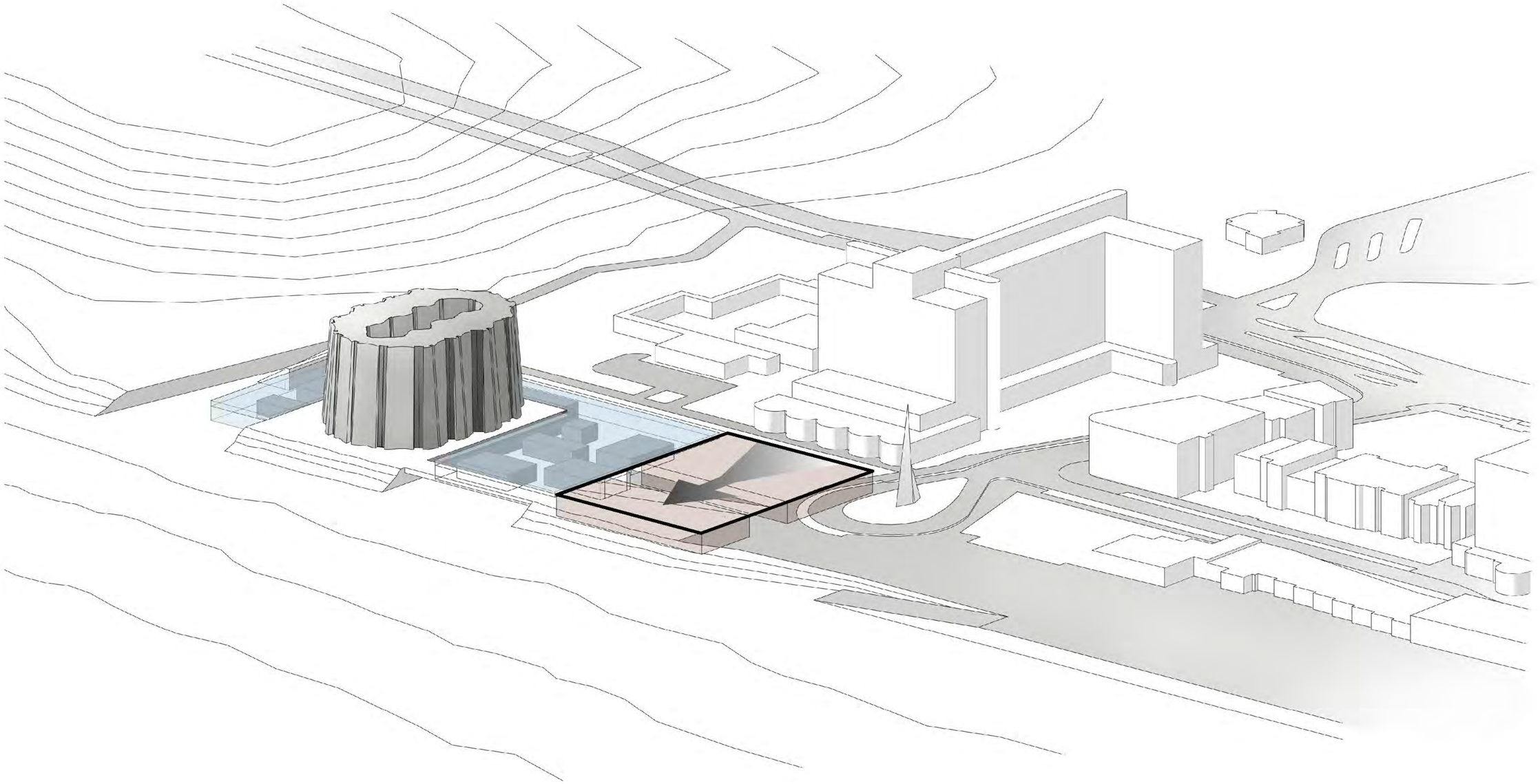
FINAL DESIGN



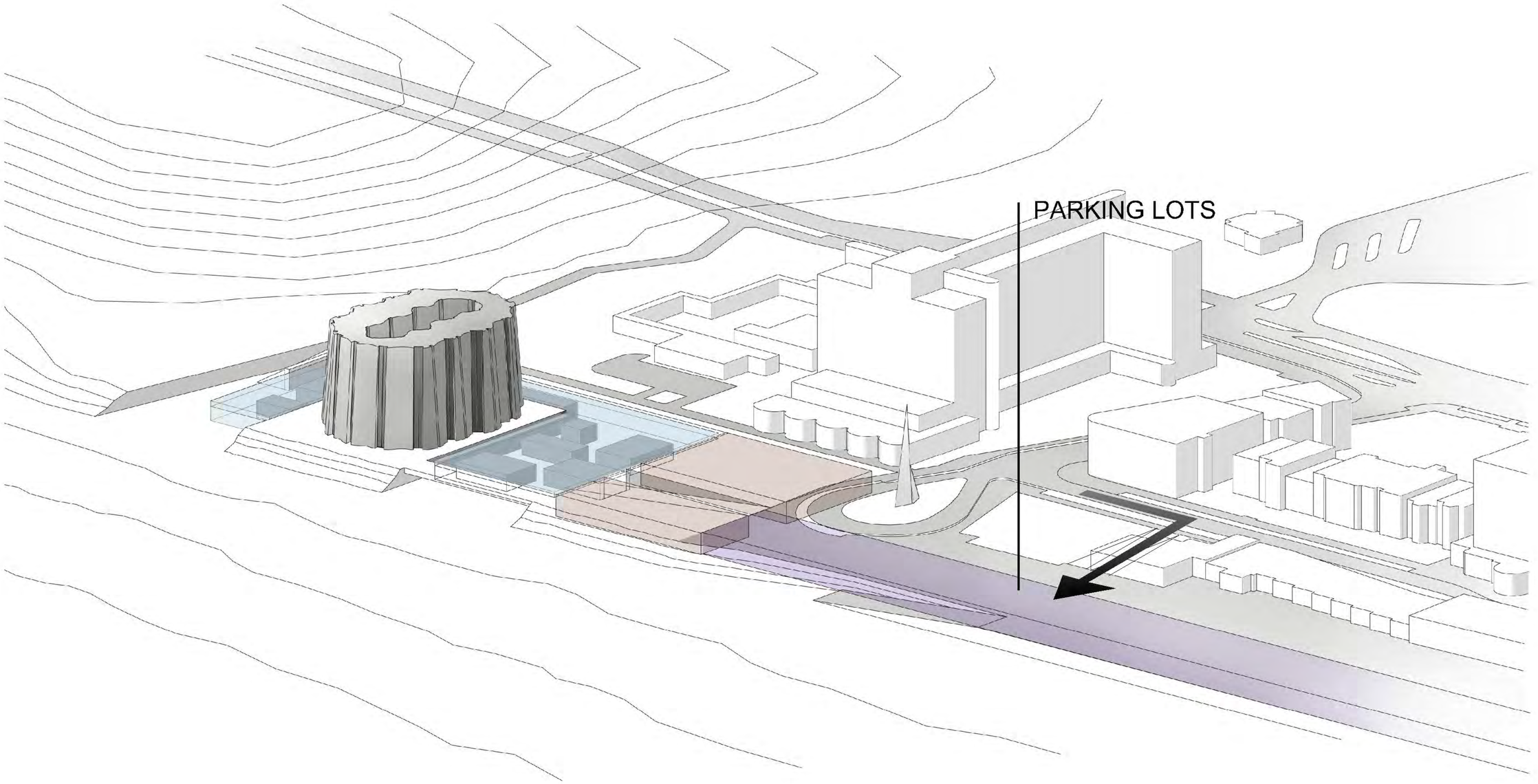
FINAL DESIGN



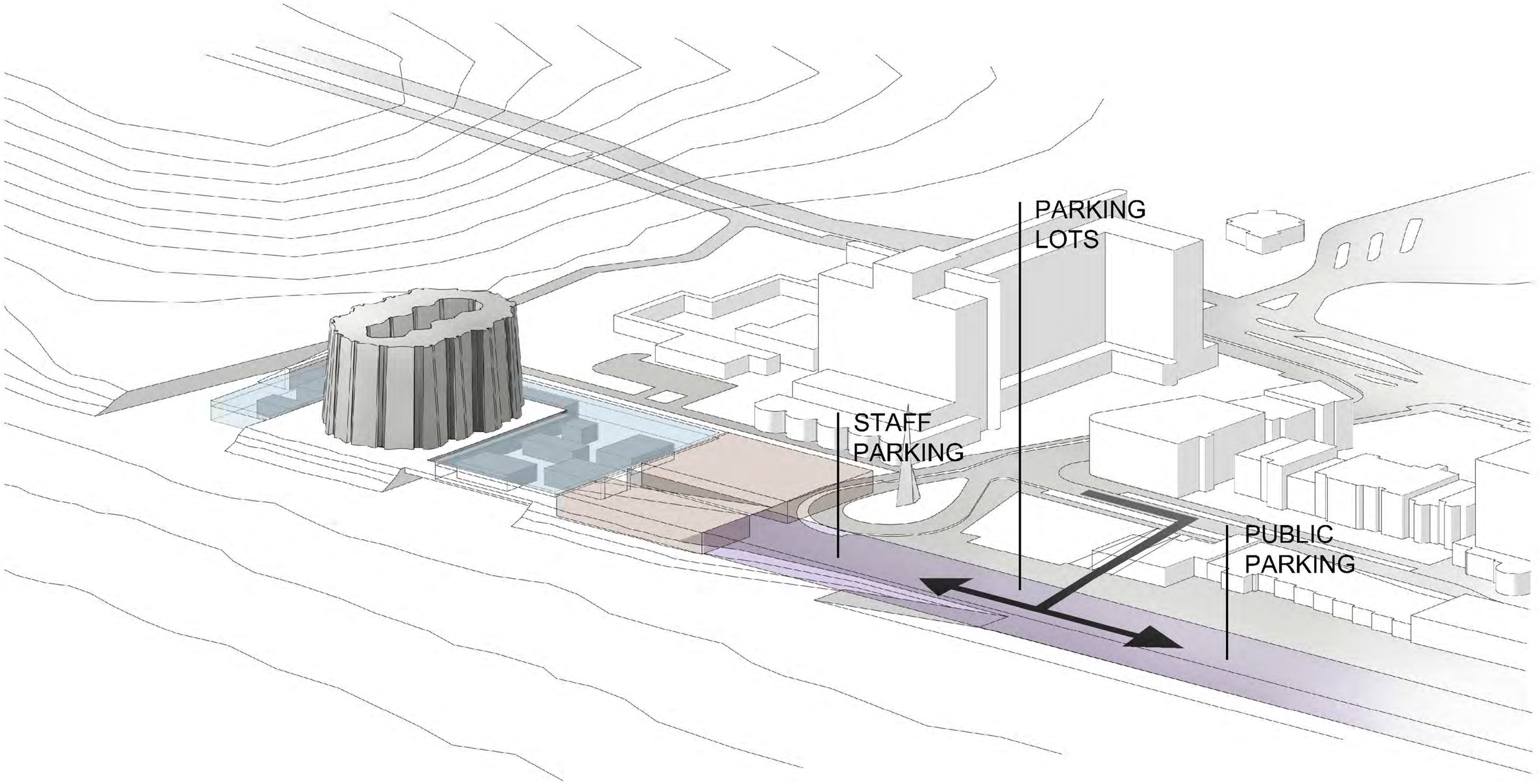
FINAL DESIGN



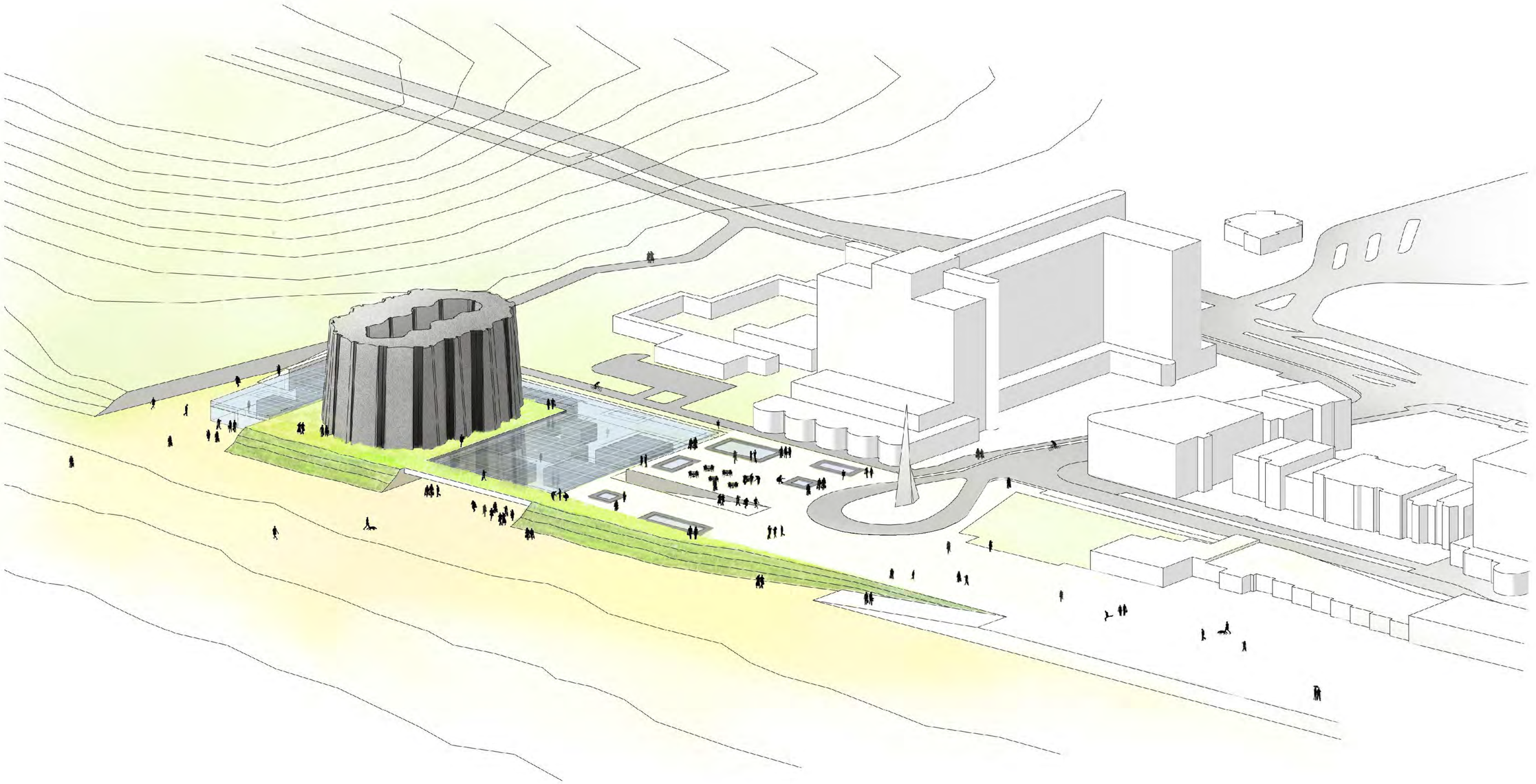
FINAL DESIGN



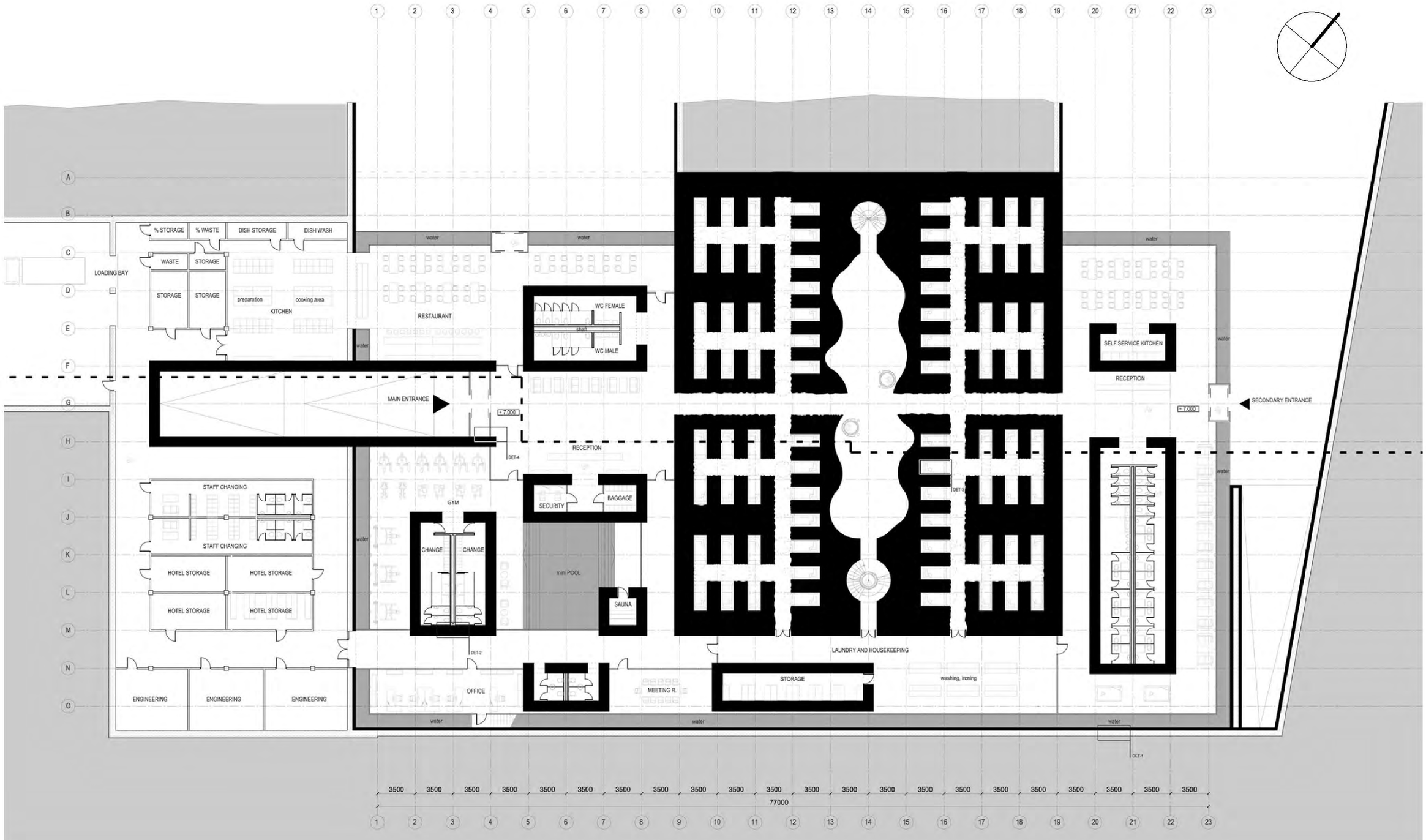
FINAL DESIGN



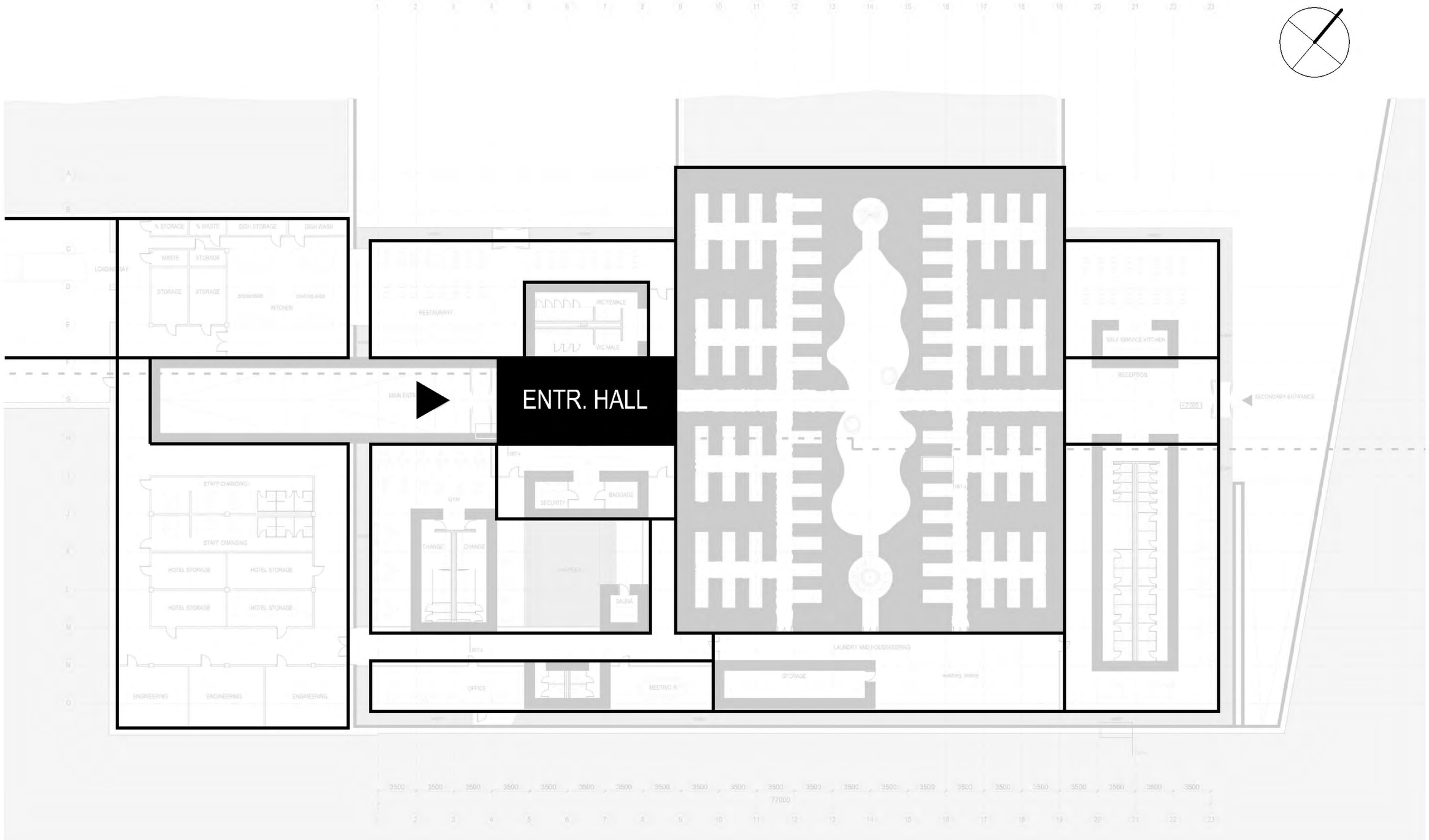
FINAL DESIGN



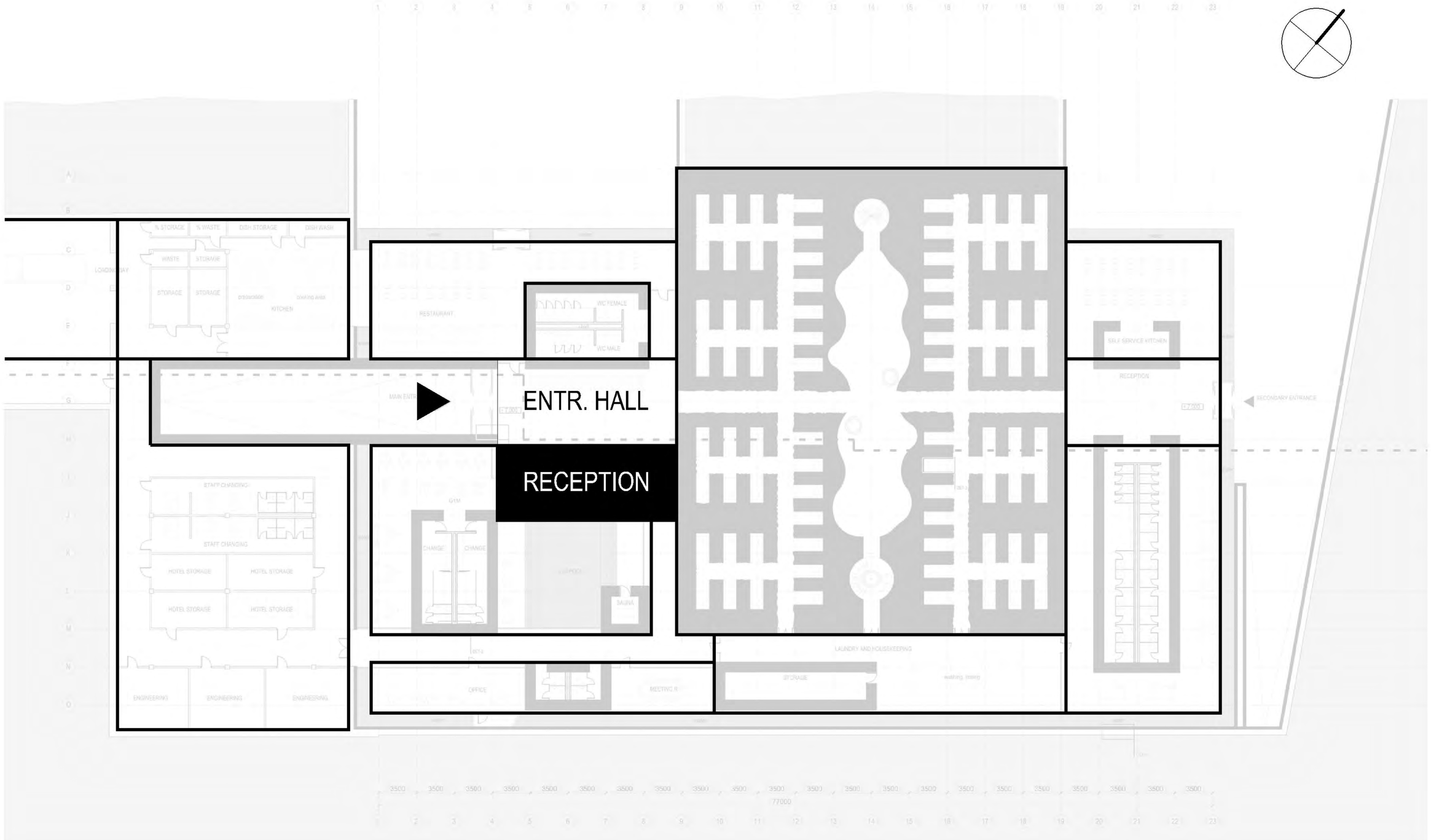
FUNCTIONAL ZONING



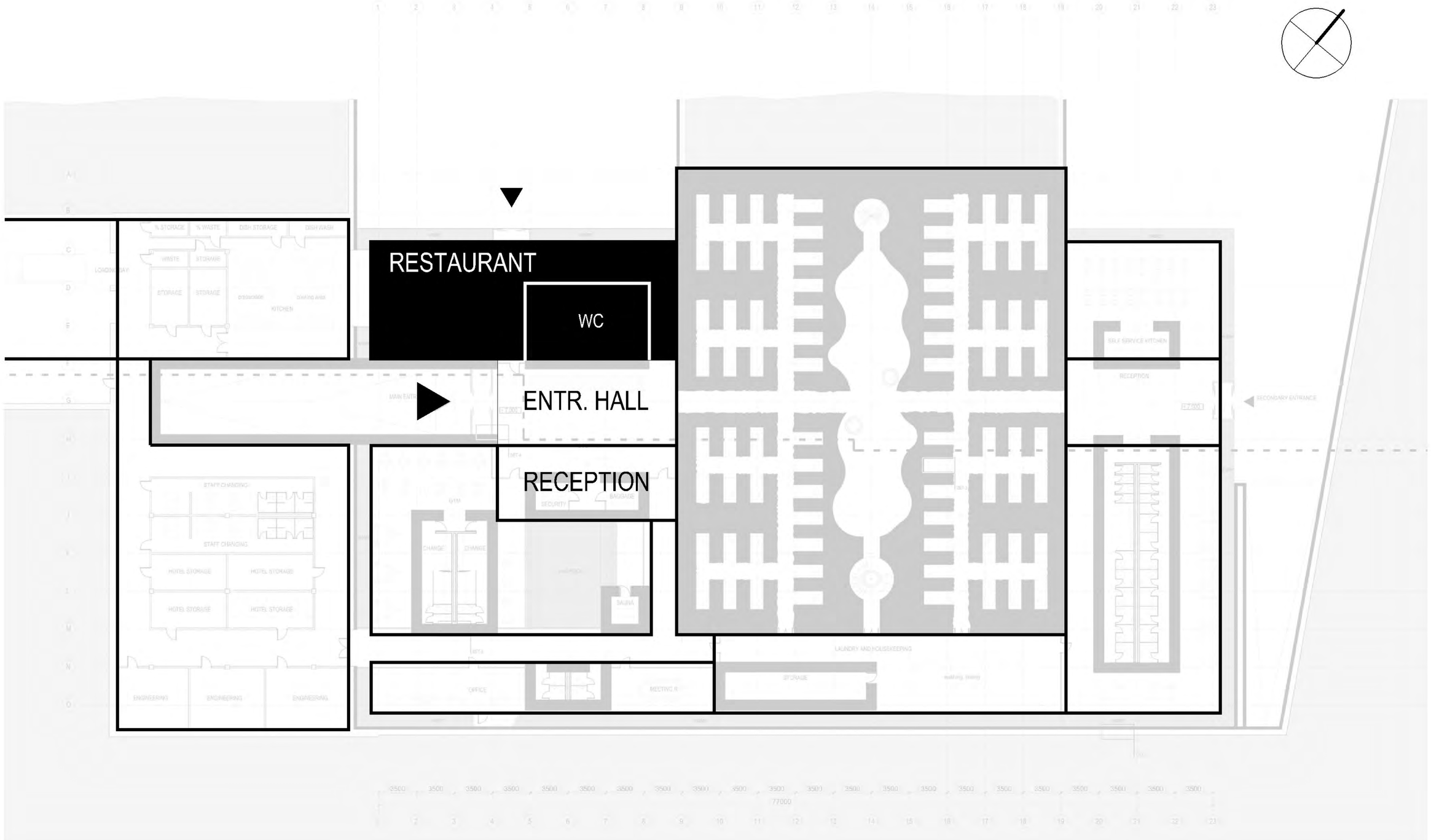
FUNCTIONAL ZONING



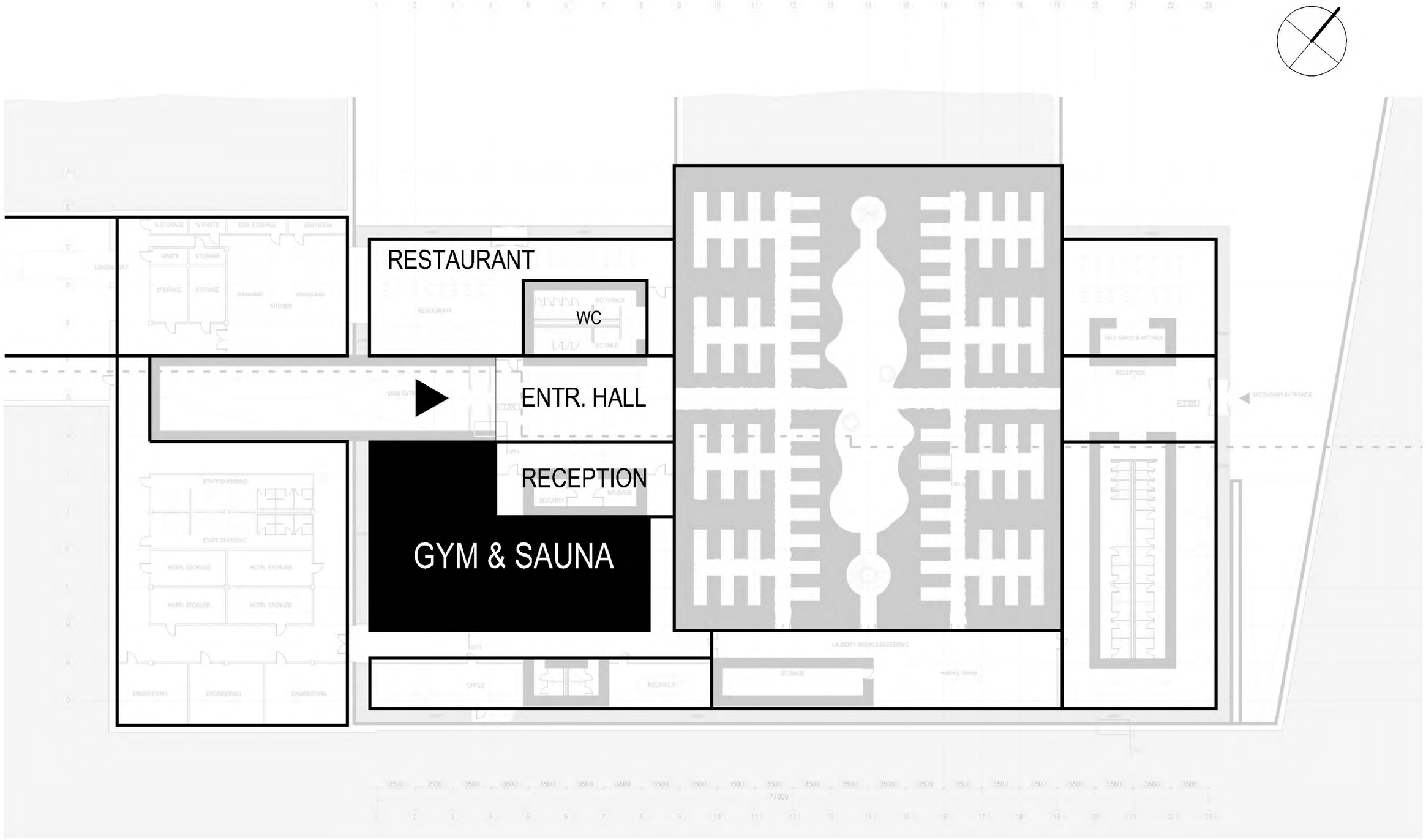
FUNCTIONAL ZONING



FUNCTIONAL ZONING



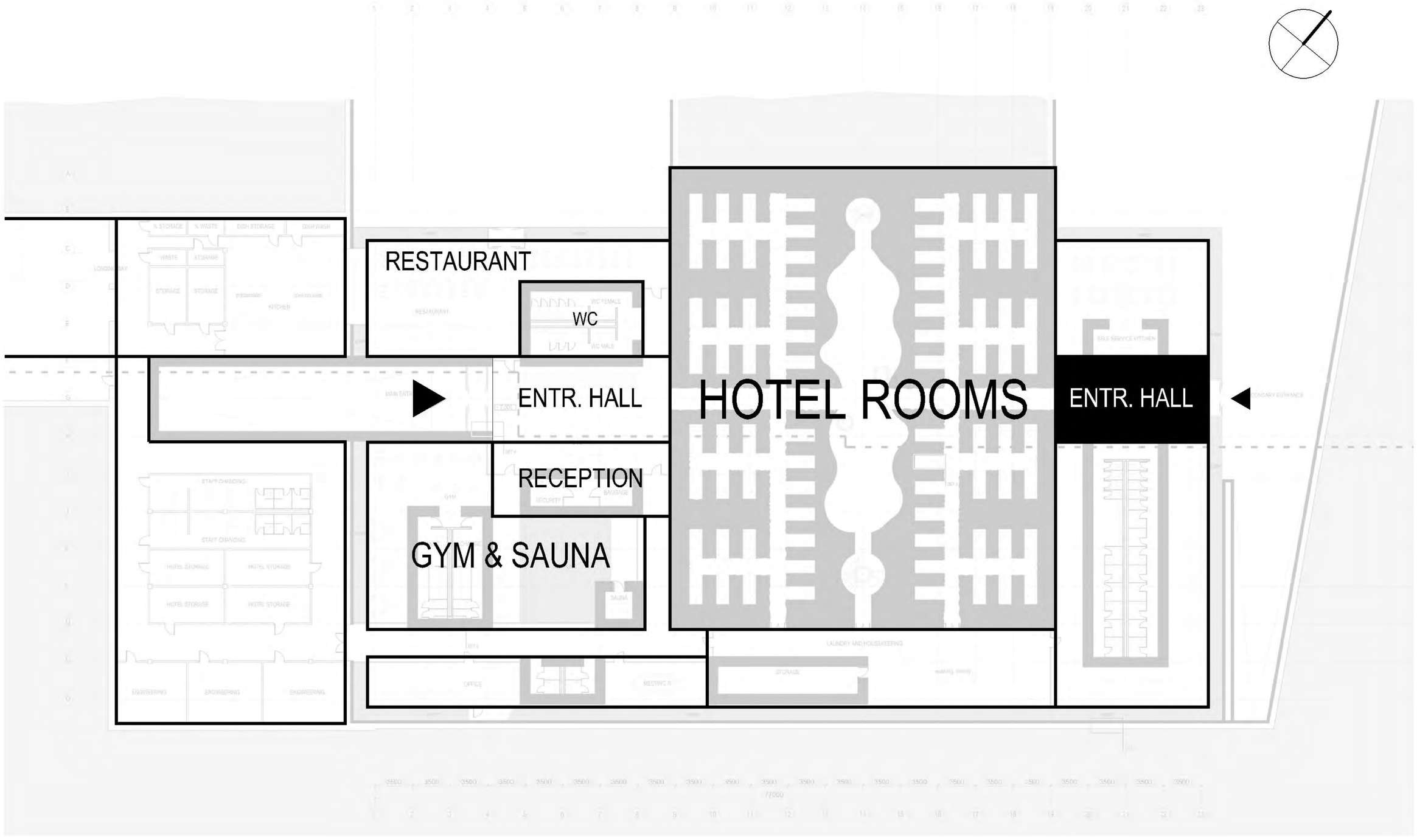
FUNCTIONAL ZONING



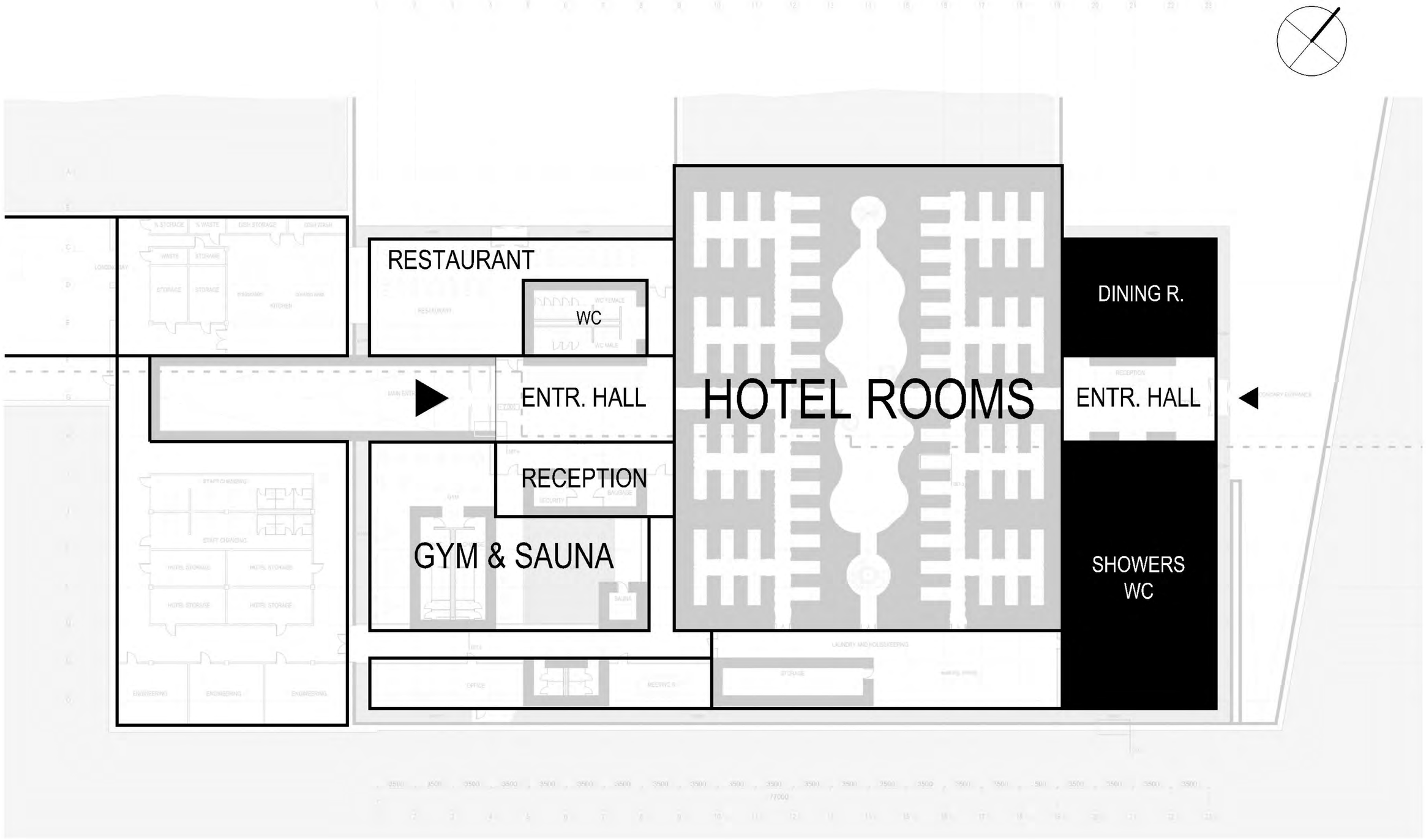
FUNCTIONAL ZONING



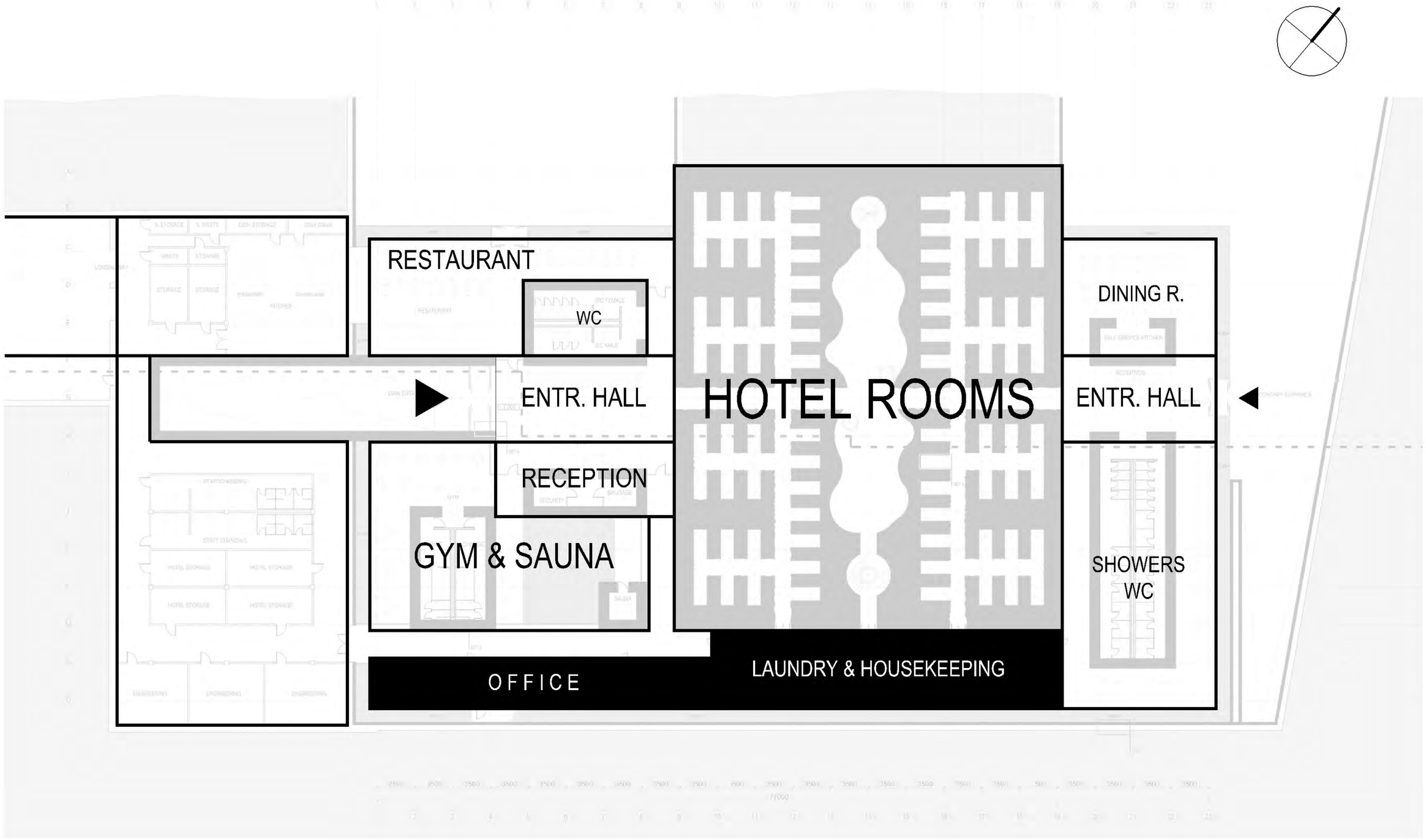
FUNCTIONAL ZONING



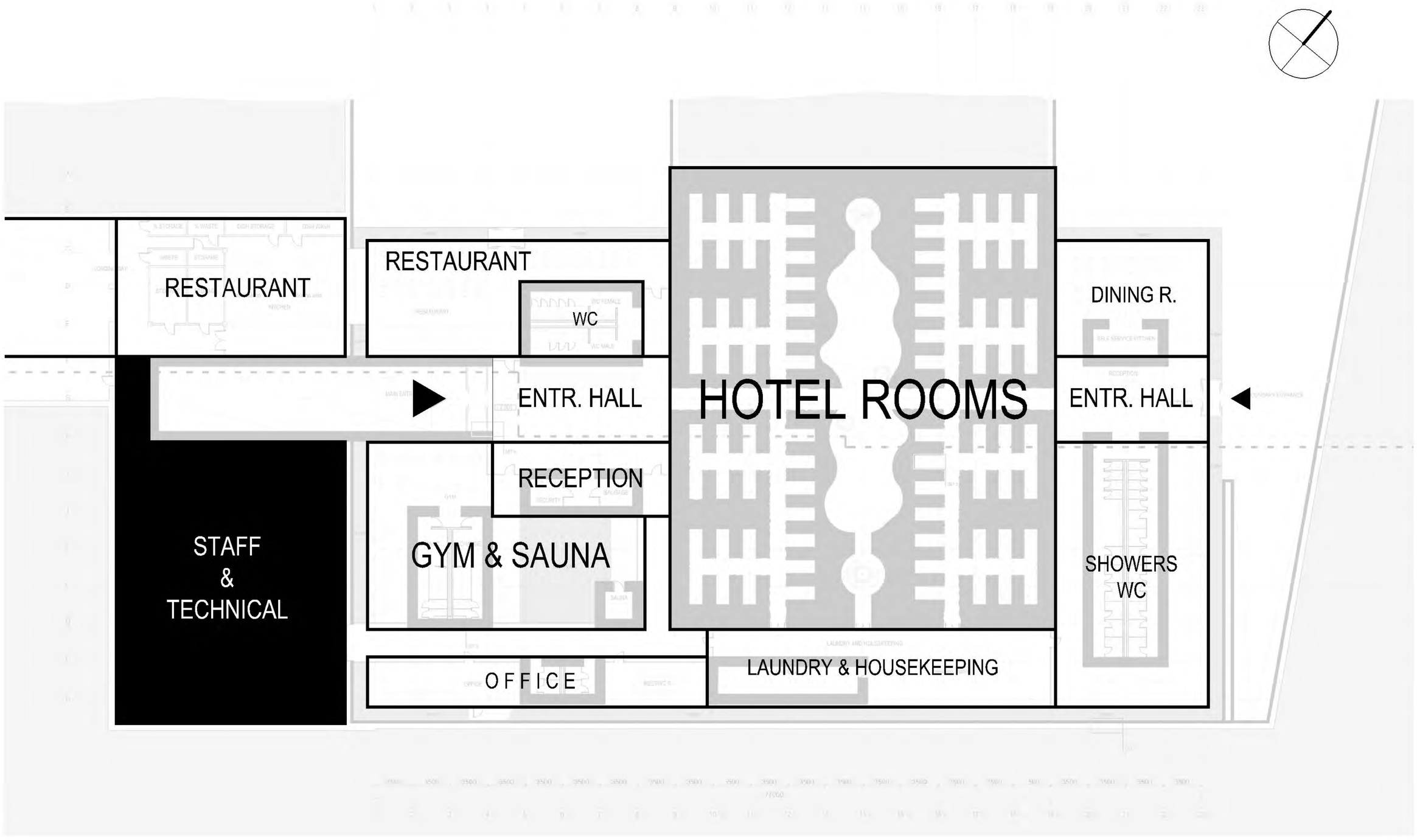
FUNCTIONAL ZONING



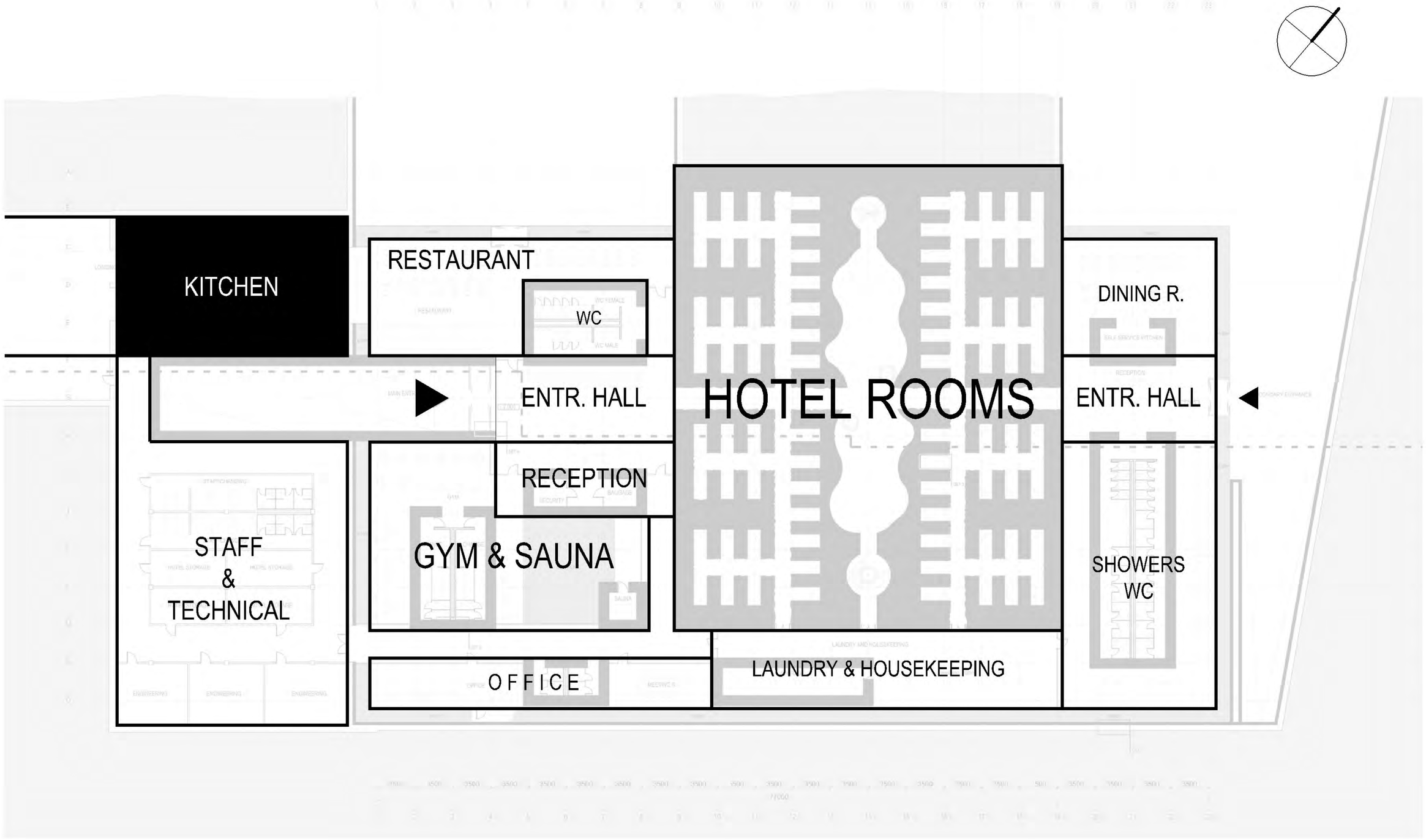
FUNCTIONAL ZONING



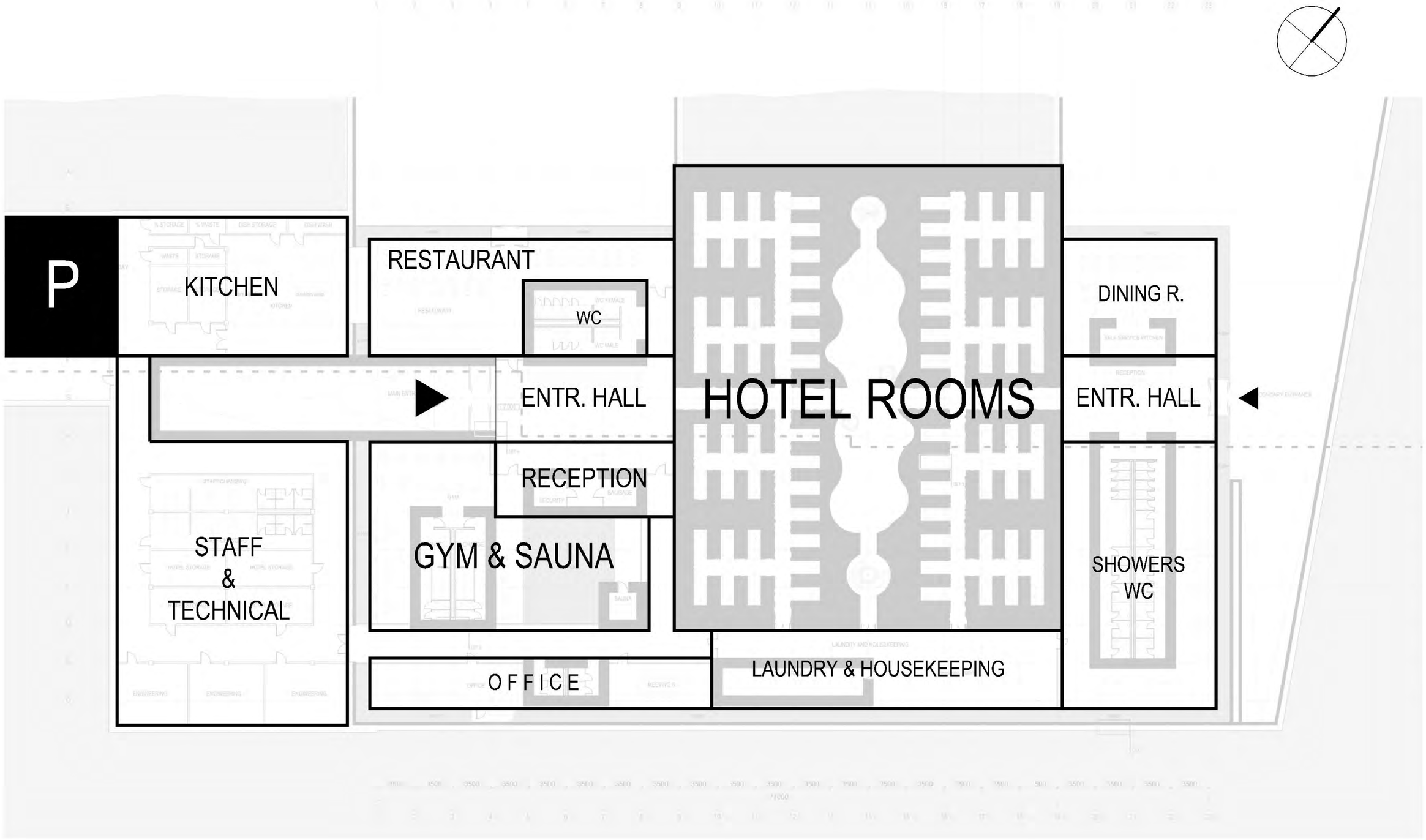
FUNCTIONAL ZONING



FUNCTIONAL ZONING



FUNCTIONAL ZONING



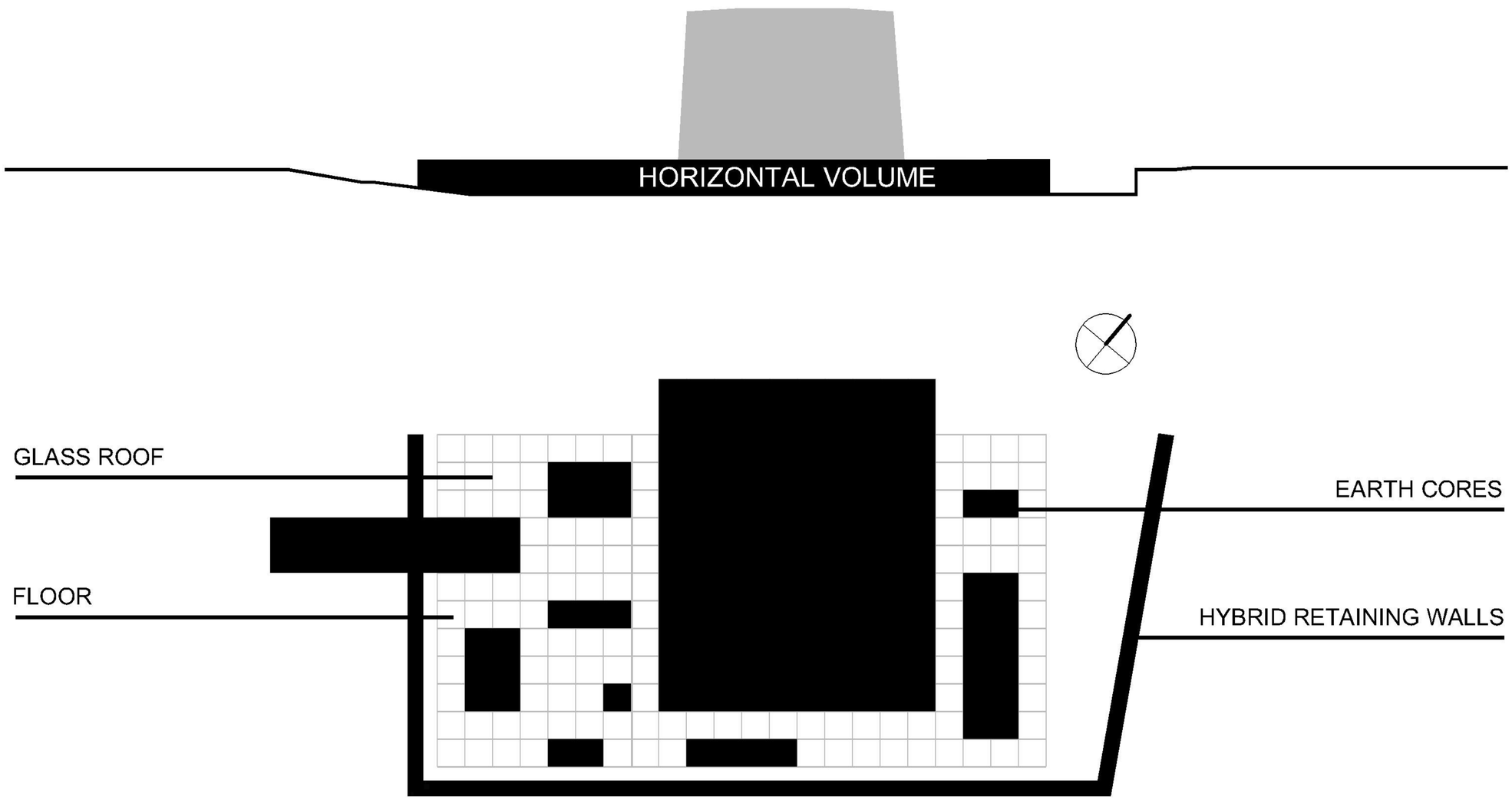
BUILDING
IN DETAIL

horizontal volume

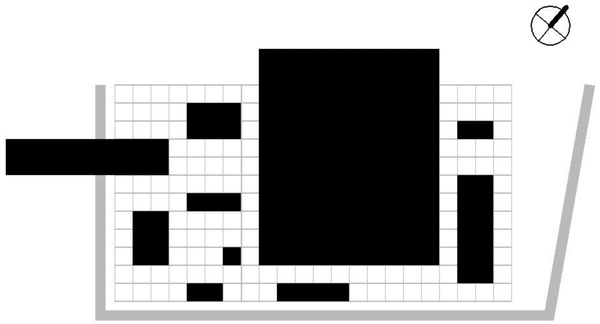
vertical volume

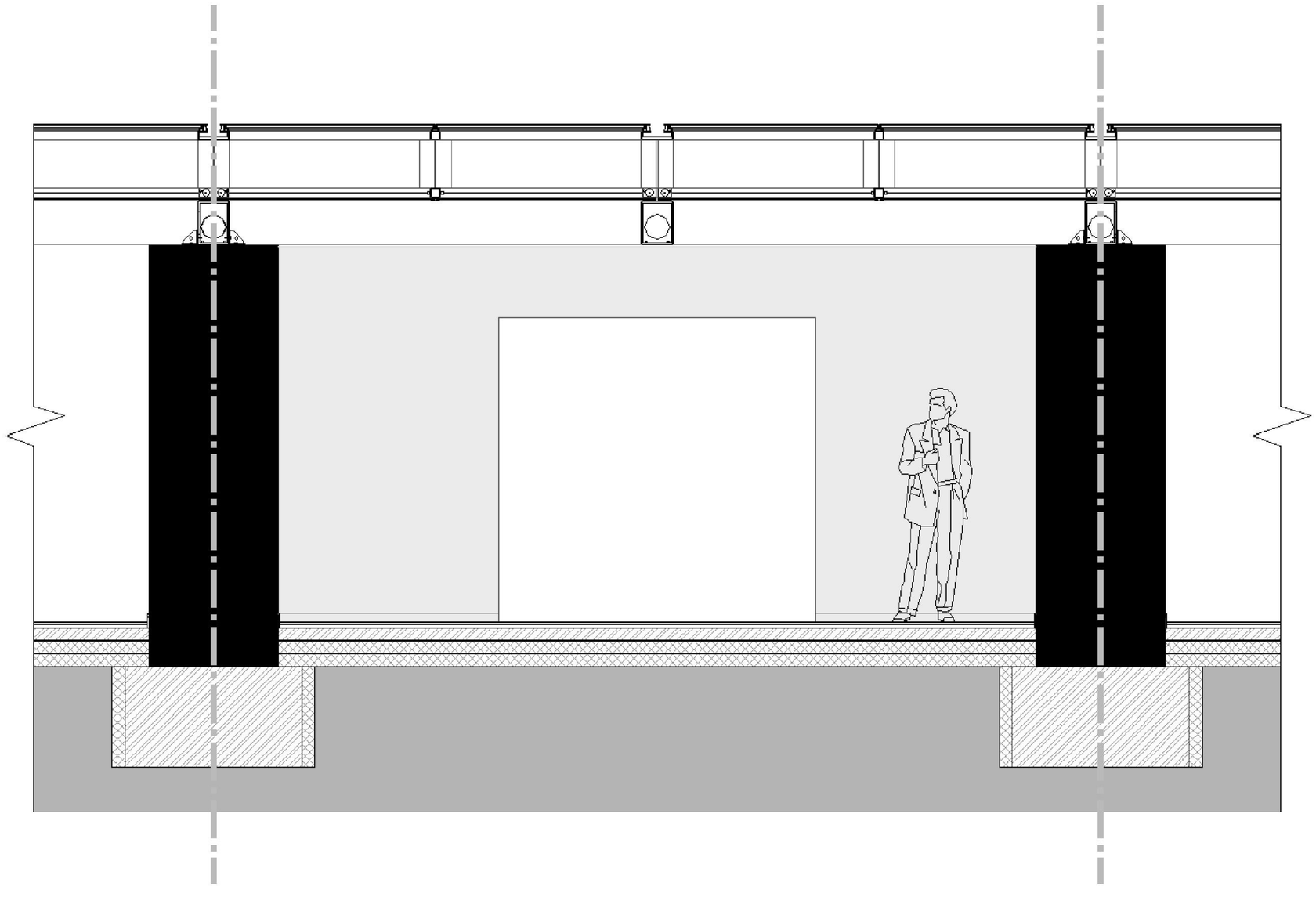
general

HORIZONTAL VOLUME



EARTH CORES

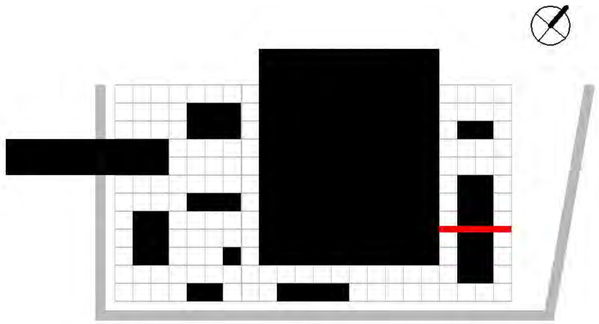


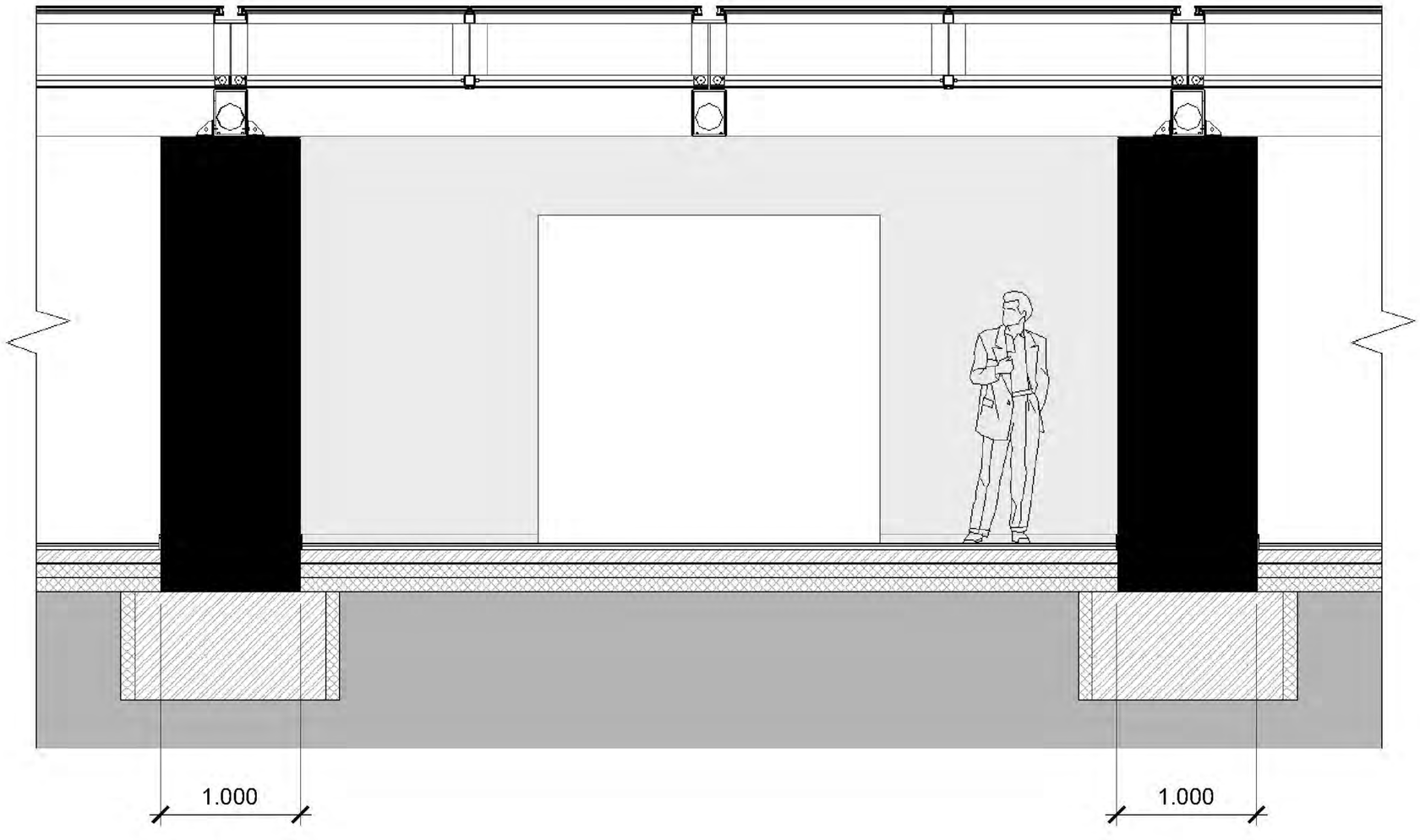


UNSTABILIZED EARTH:

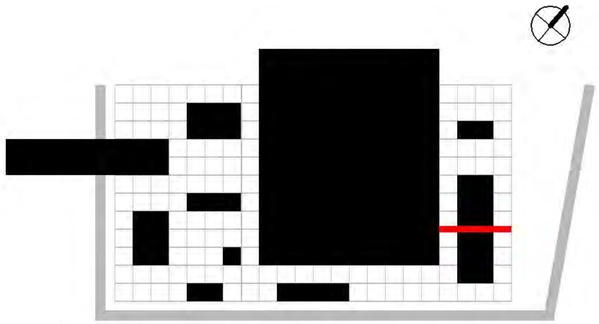
- 23% gravel
- 45% sand
- 20% silt
- 12 % clay

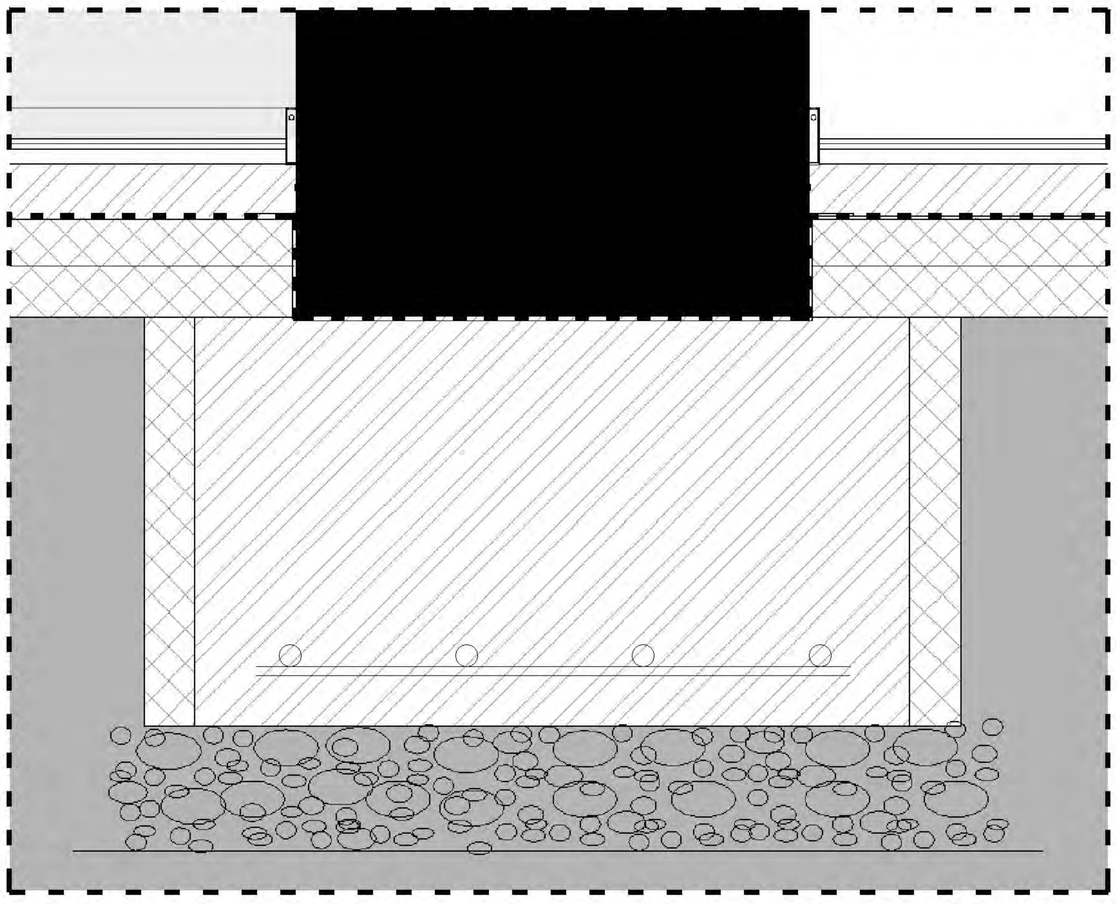
EARTH CORES

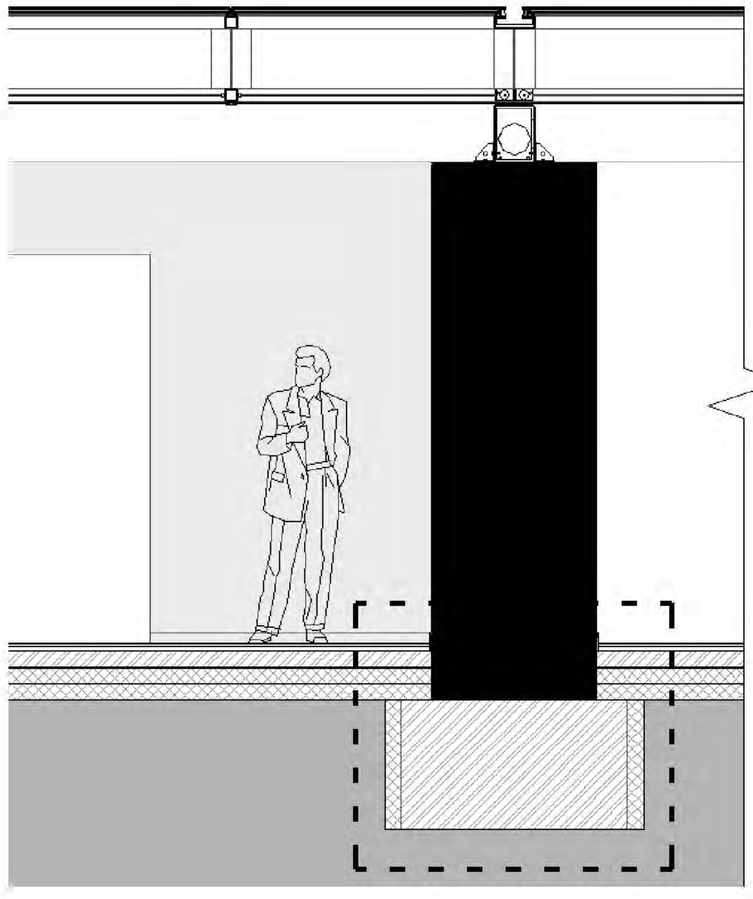




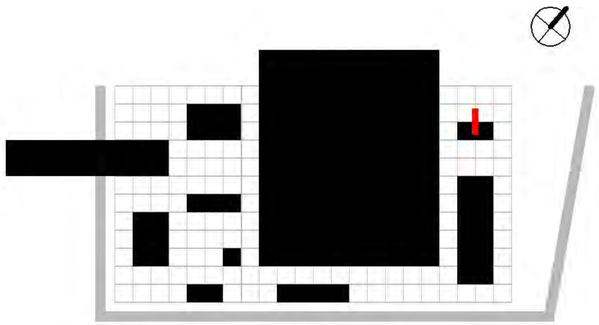
EARTH CORES



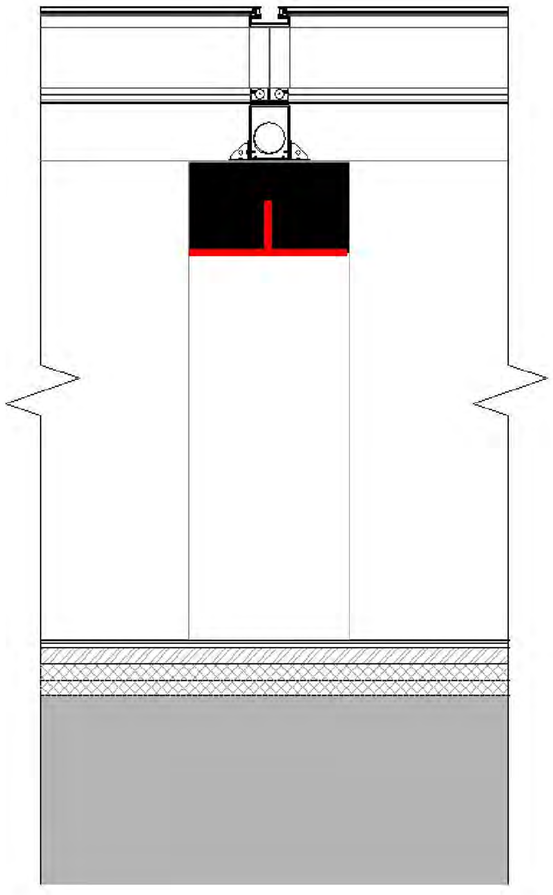


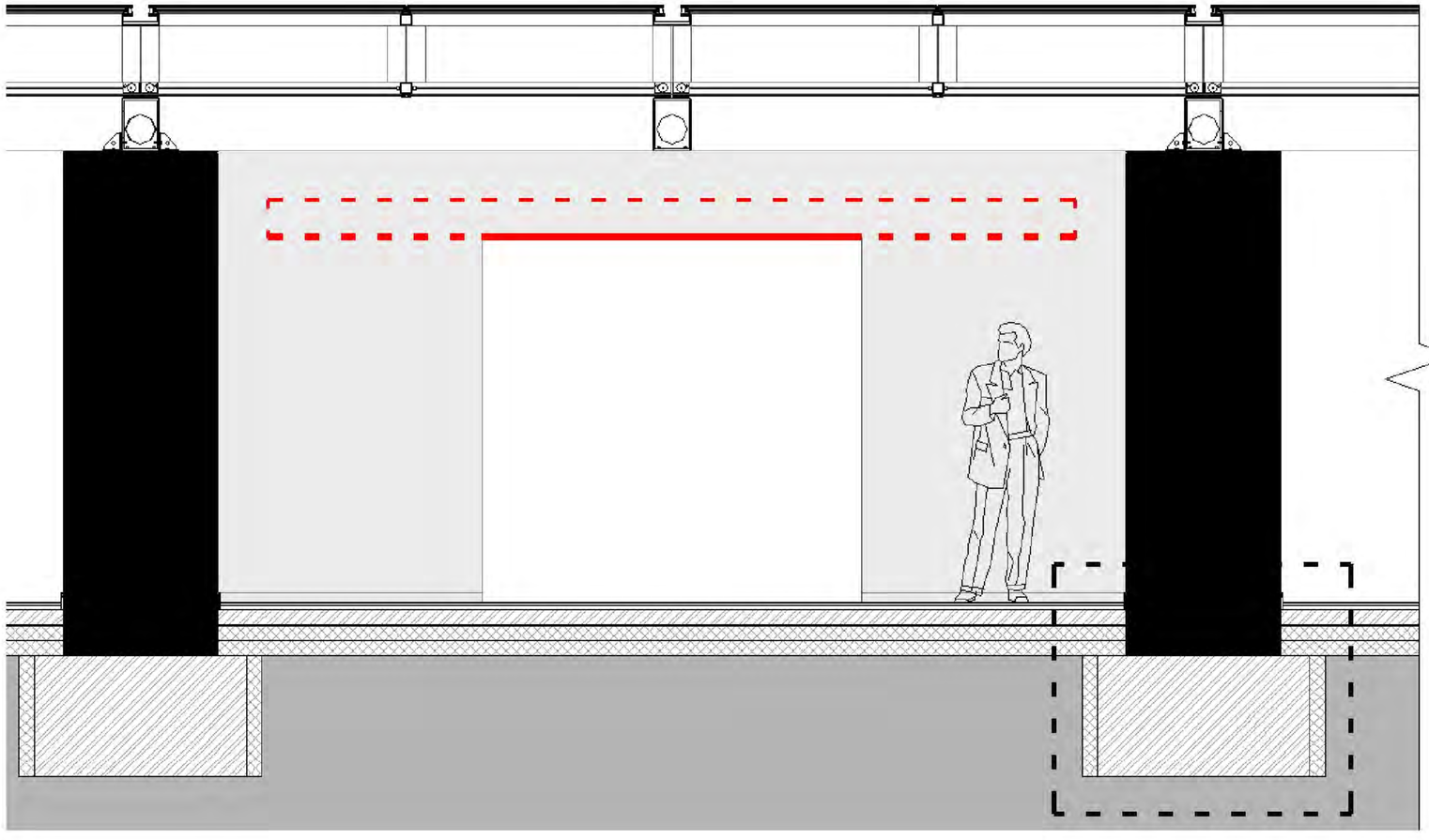


EARTH CORES

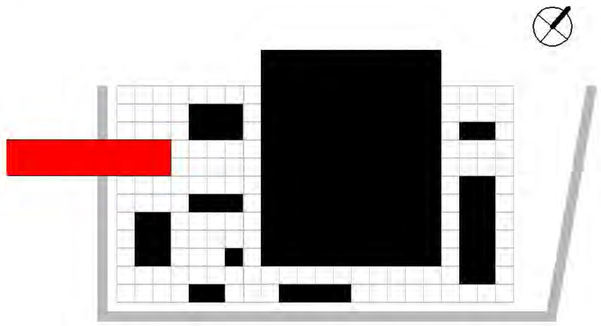


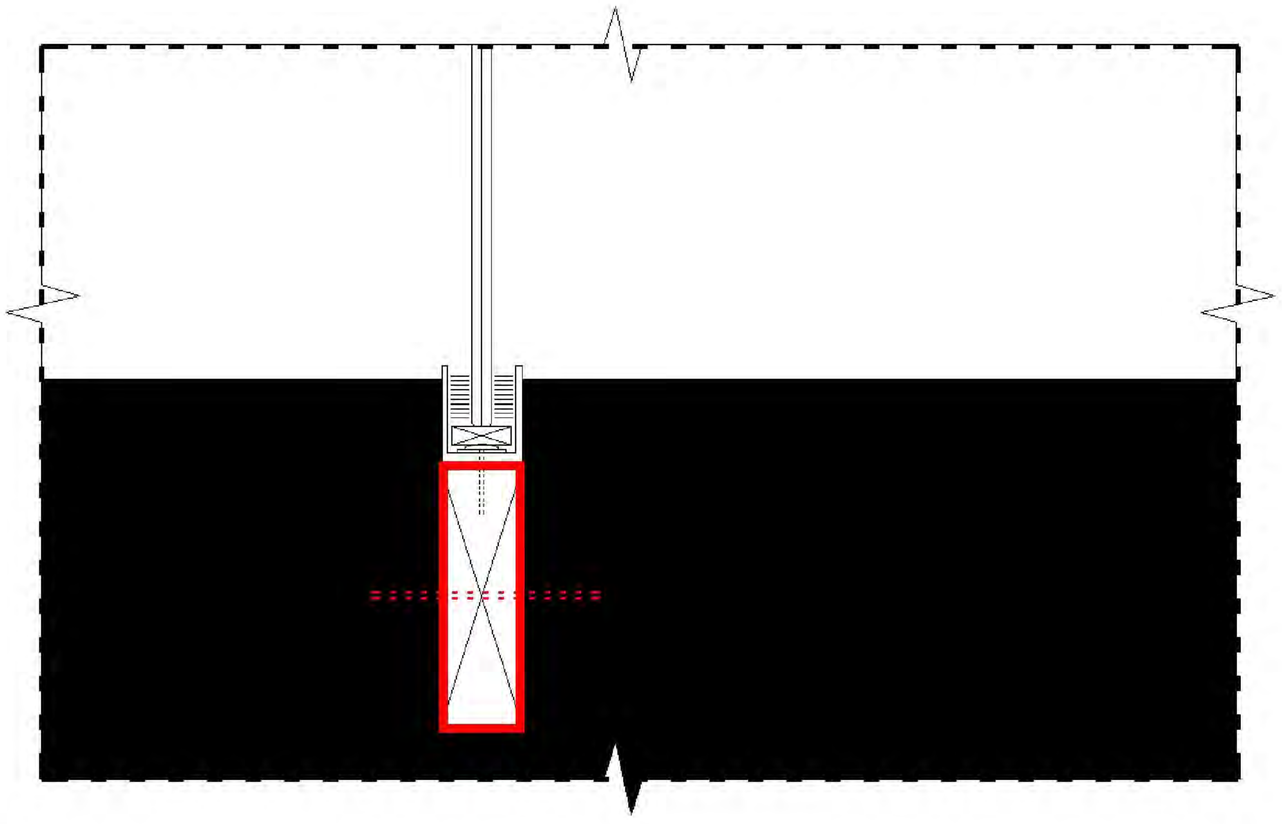




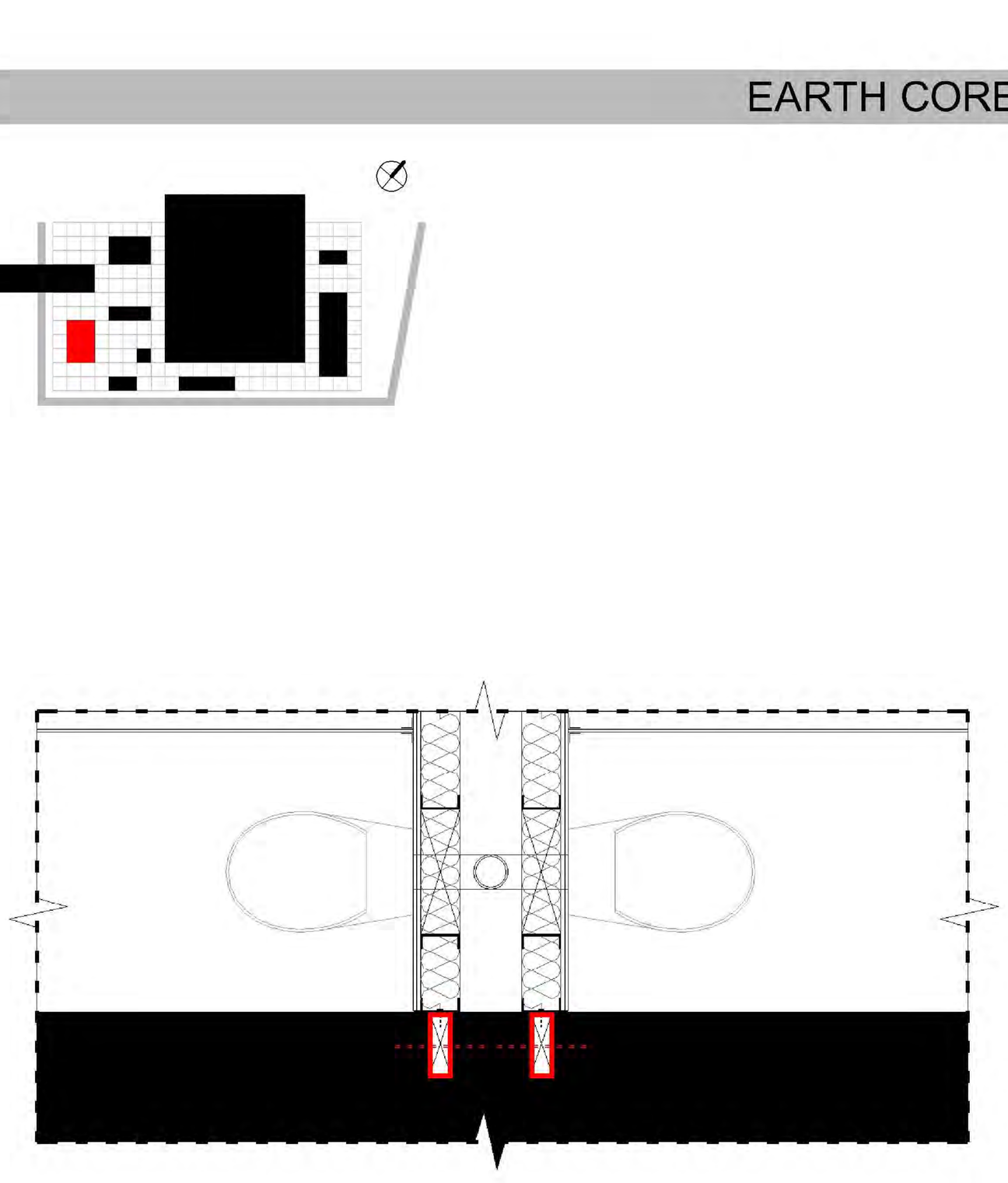


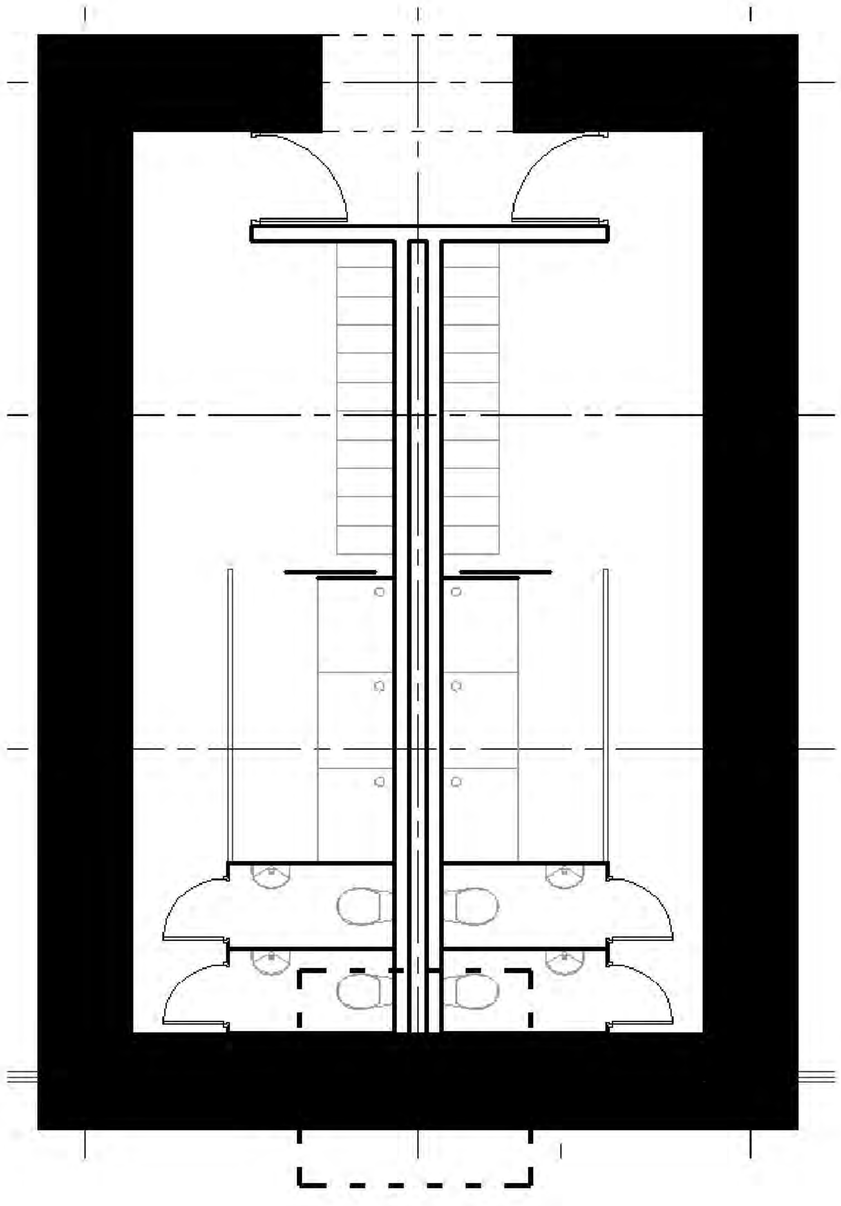
EARTH CORES



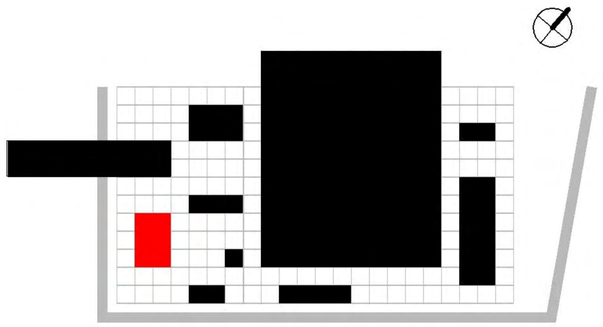


EARTH CORES



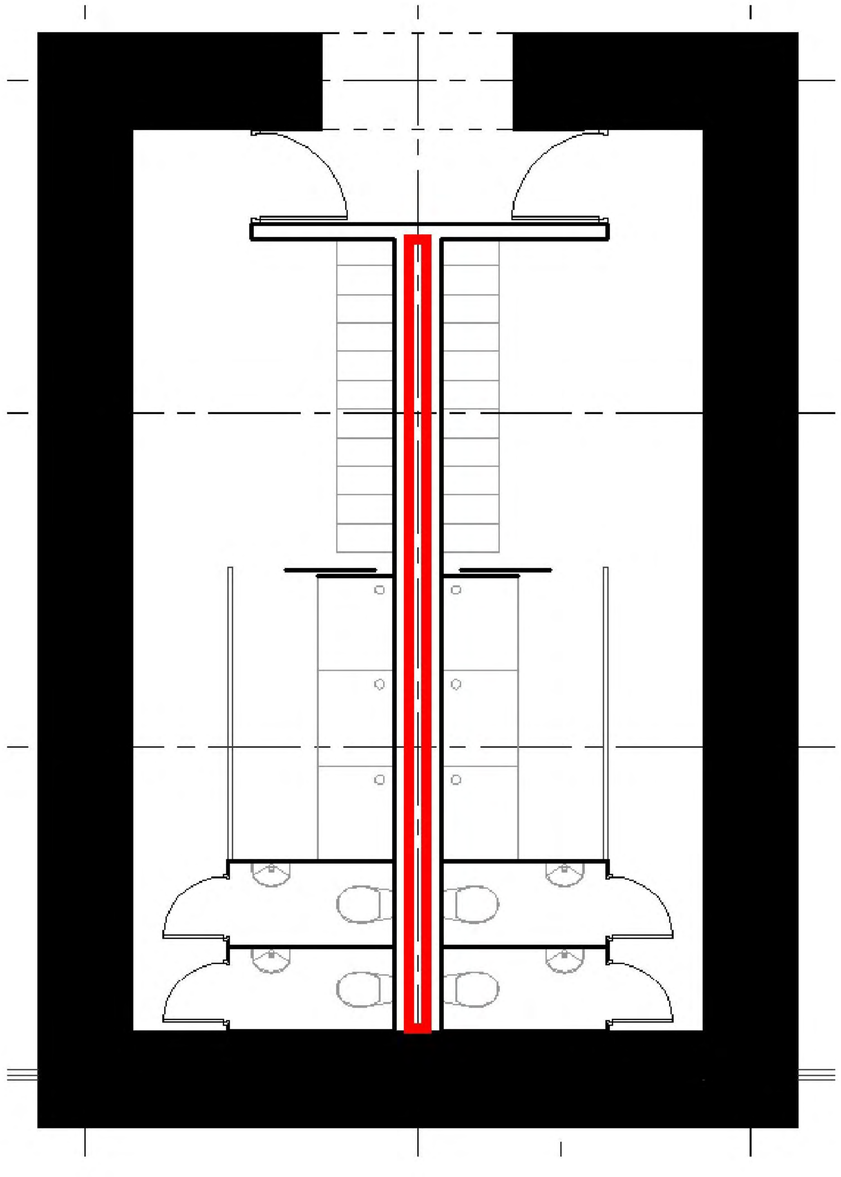


EARTH CORES

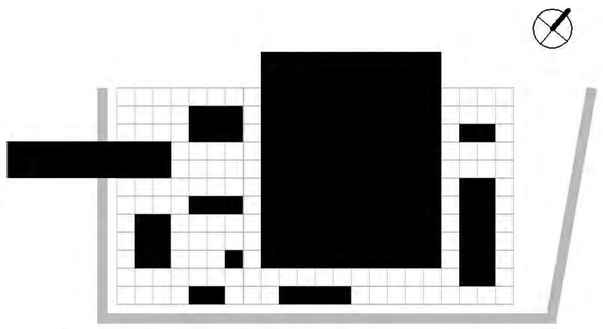


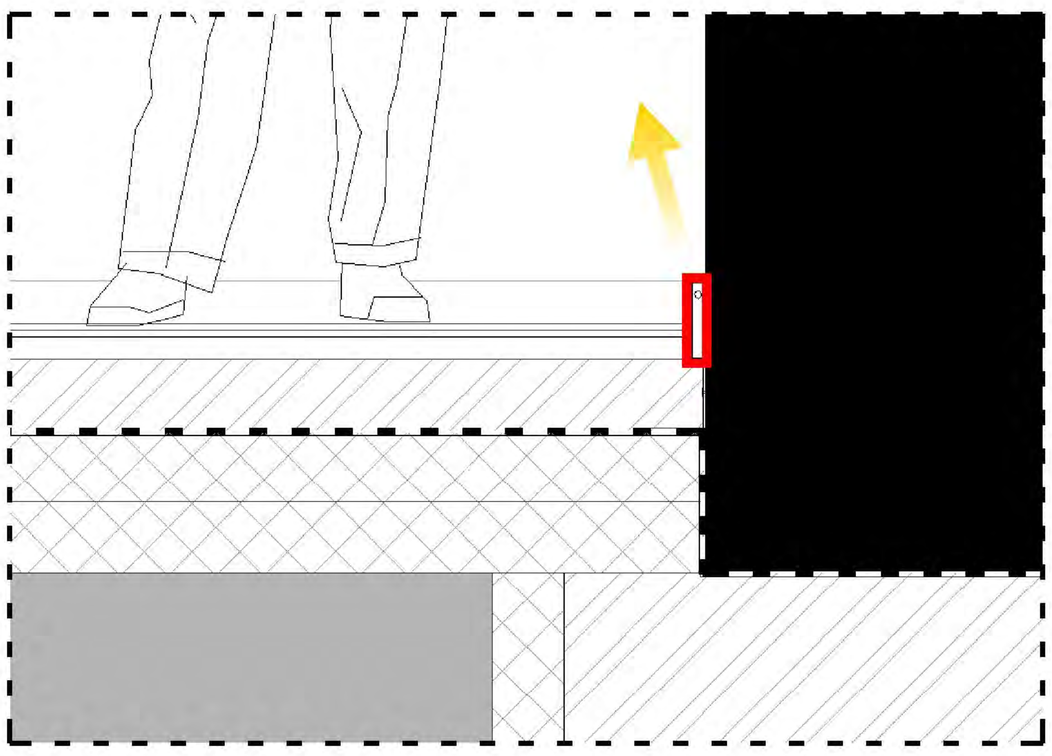


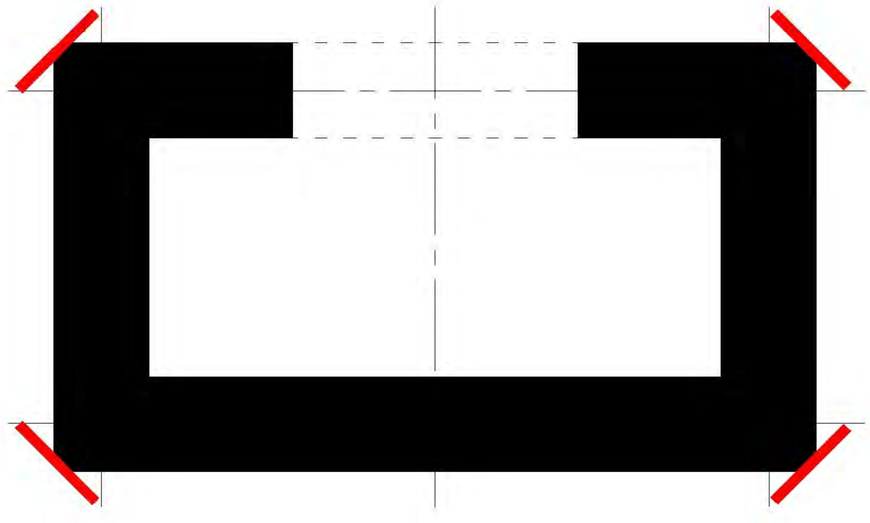




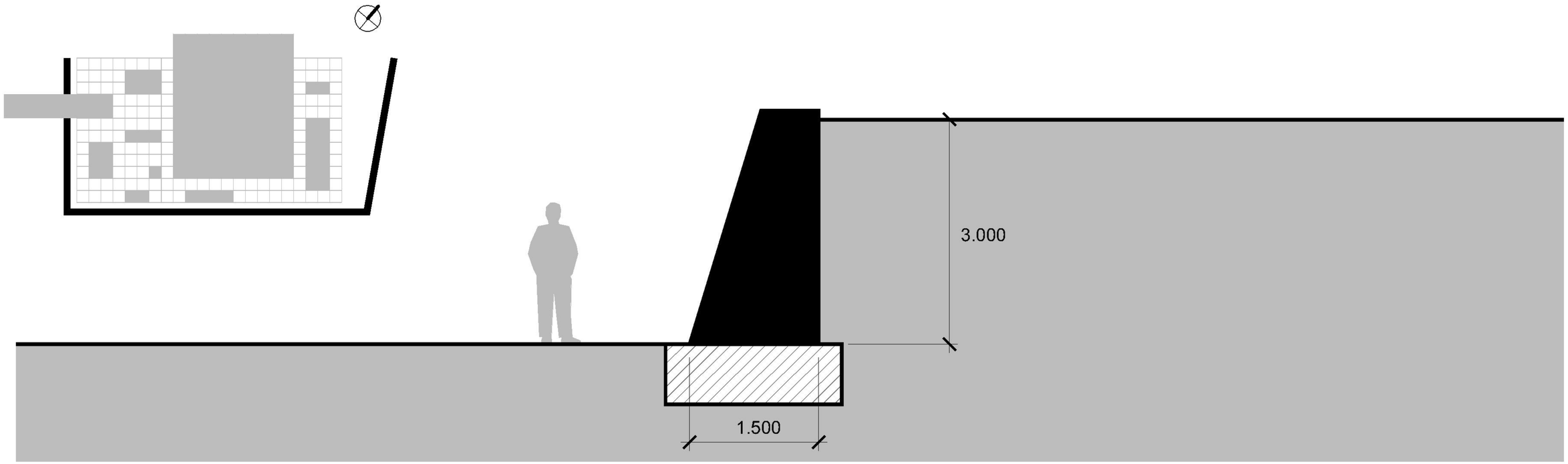
EARTH CORES



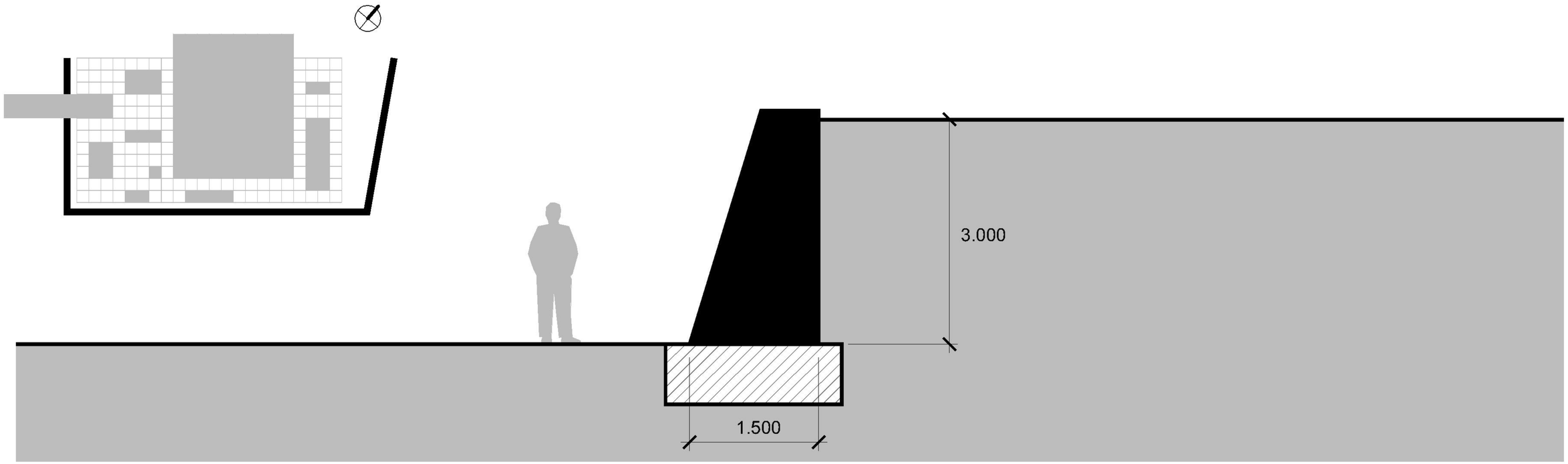


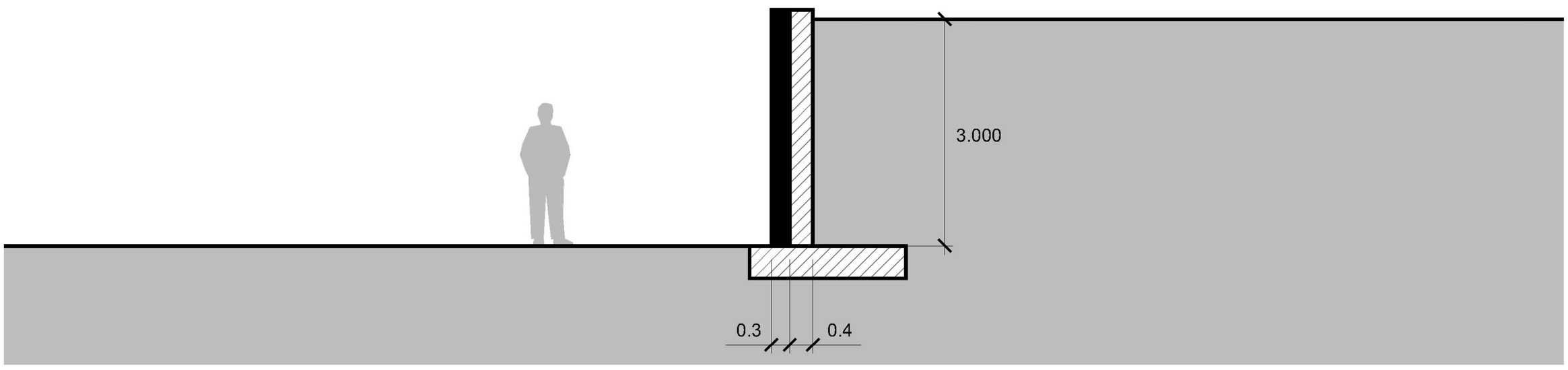


RETAINING WALL

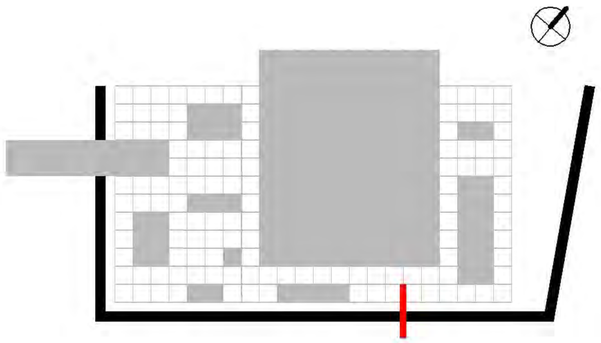


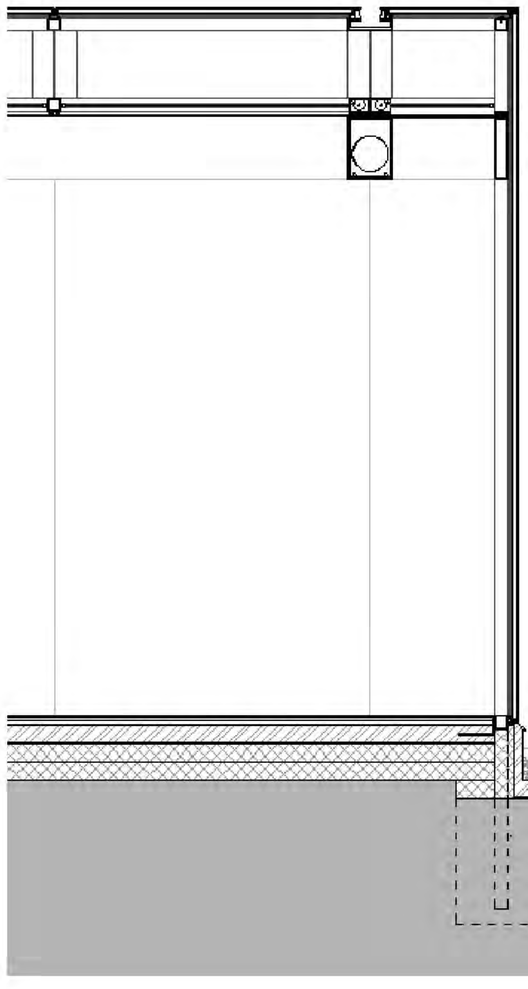
RETAINING WALL

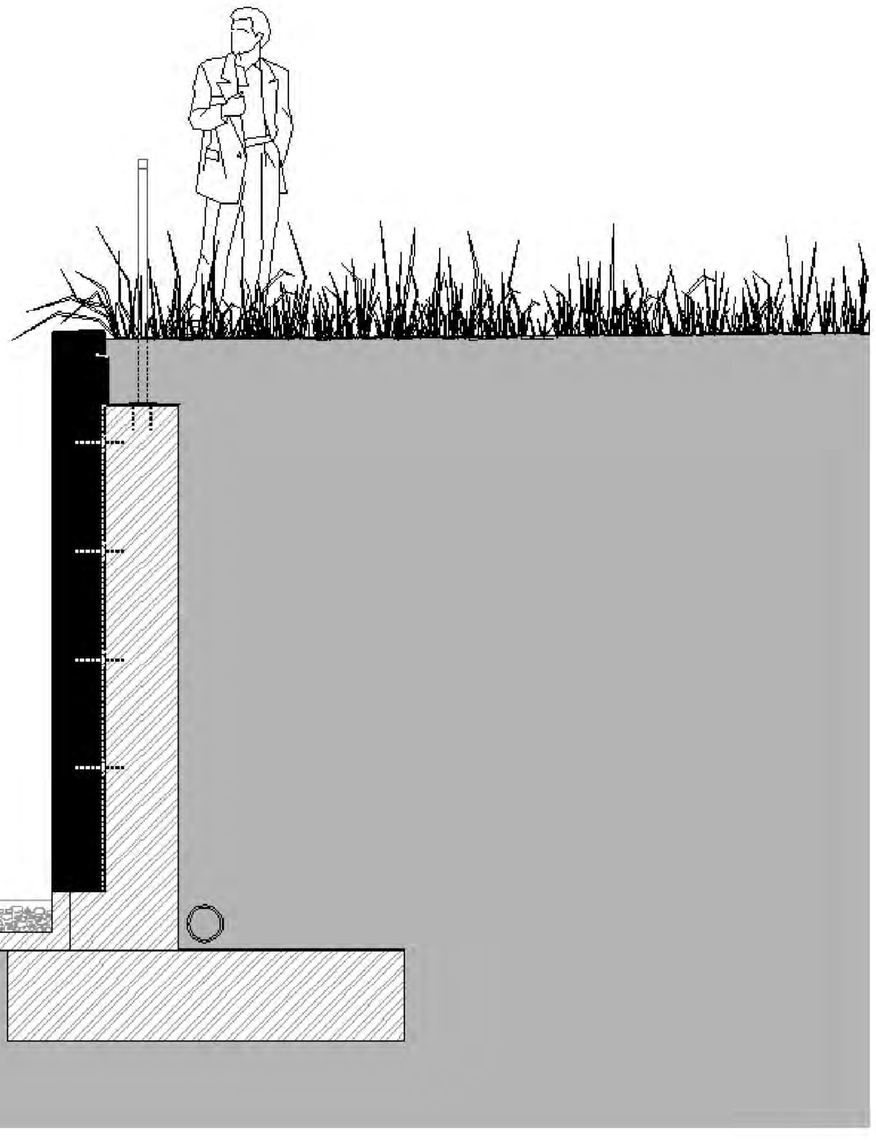




RETAINING WALL

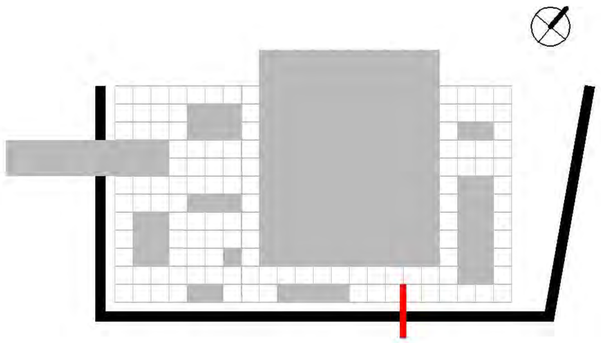


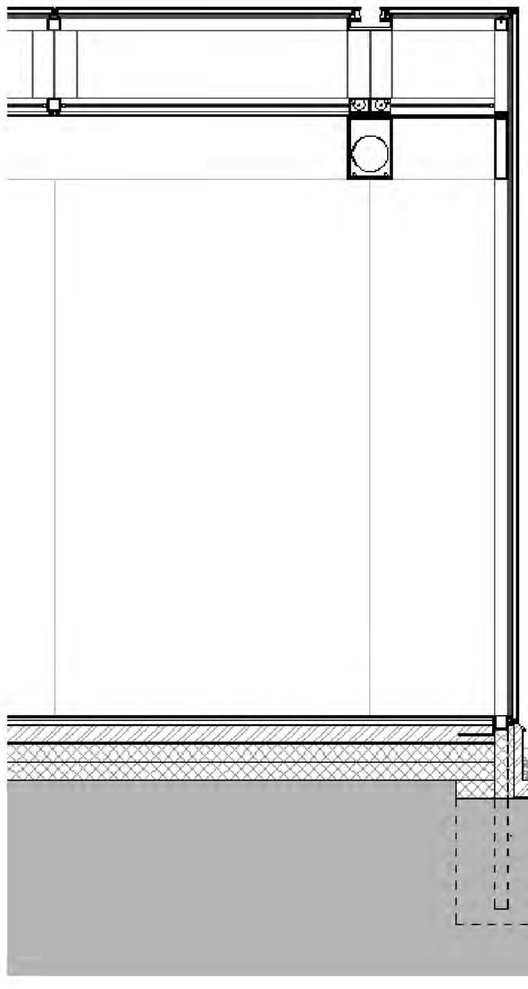


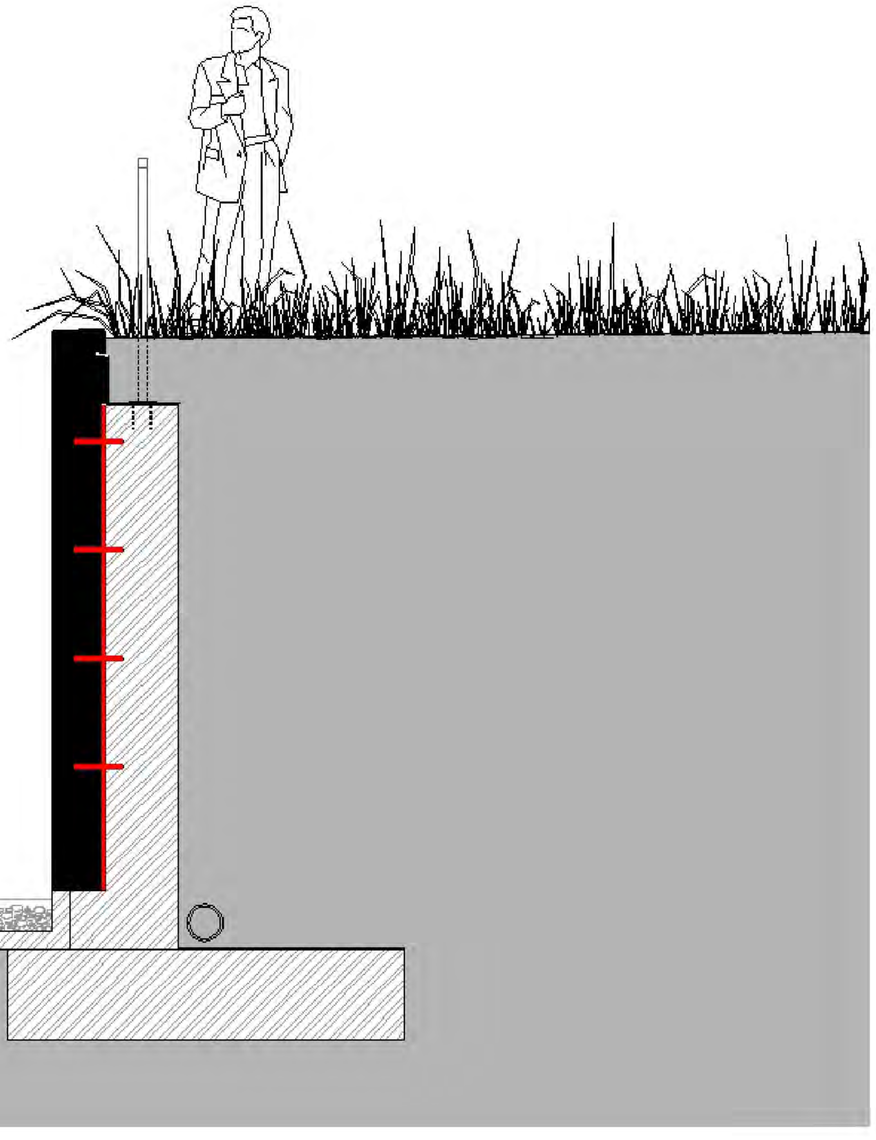


STABILIZED EARTH:
- 23% gravel
- 45% sand
- 20% silt
- 7 % clay
- 5% cement

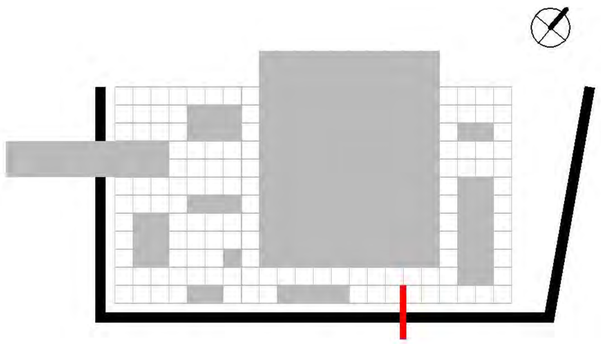
RETAINING WALL

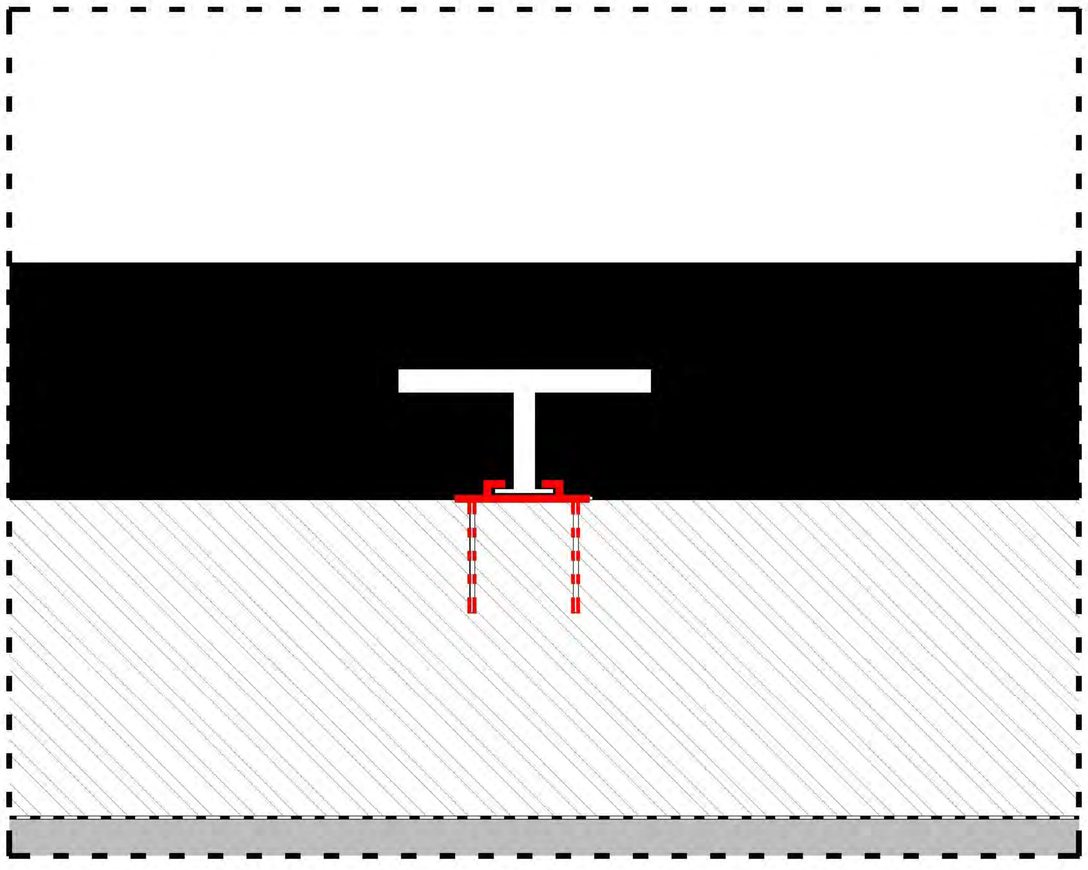


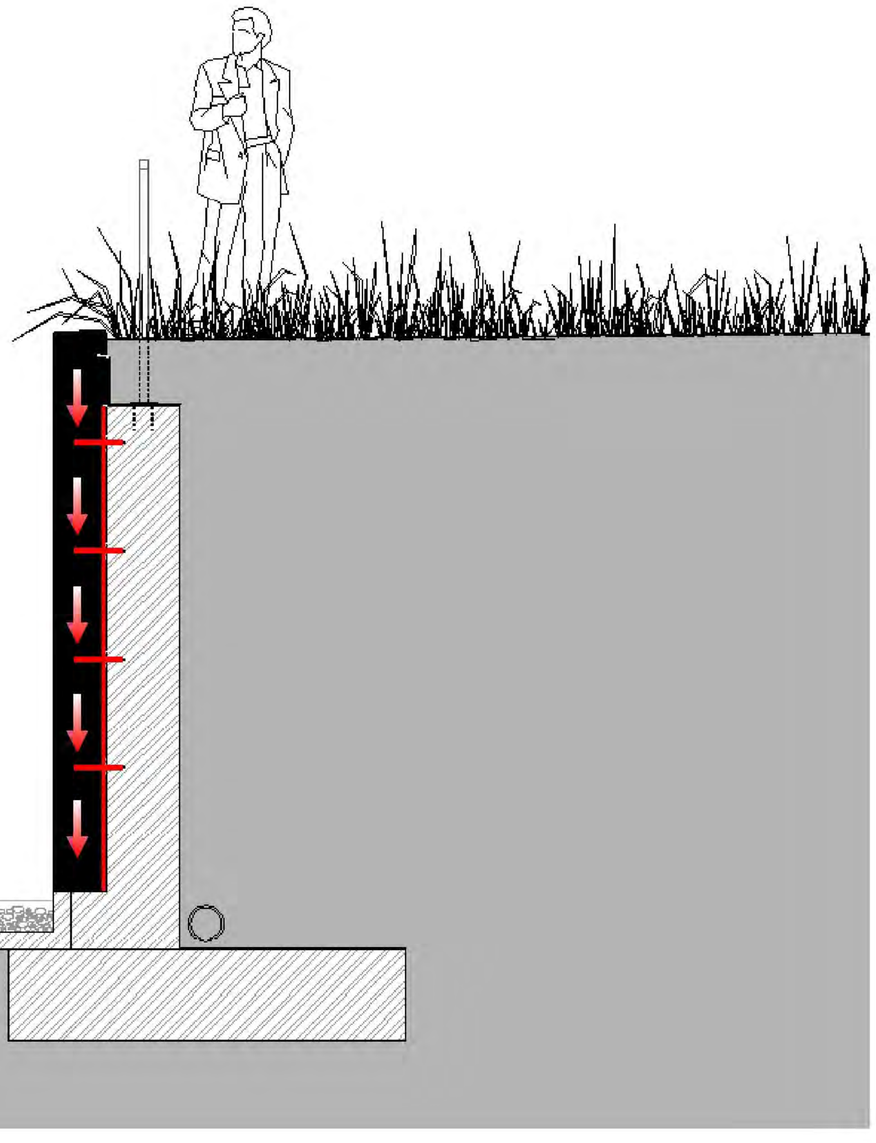




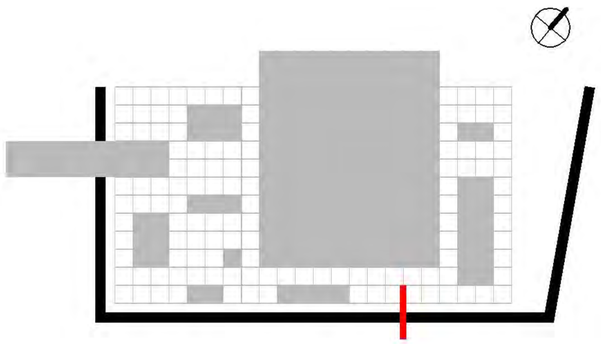
RETAINING WALL

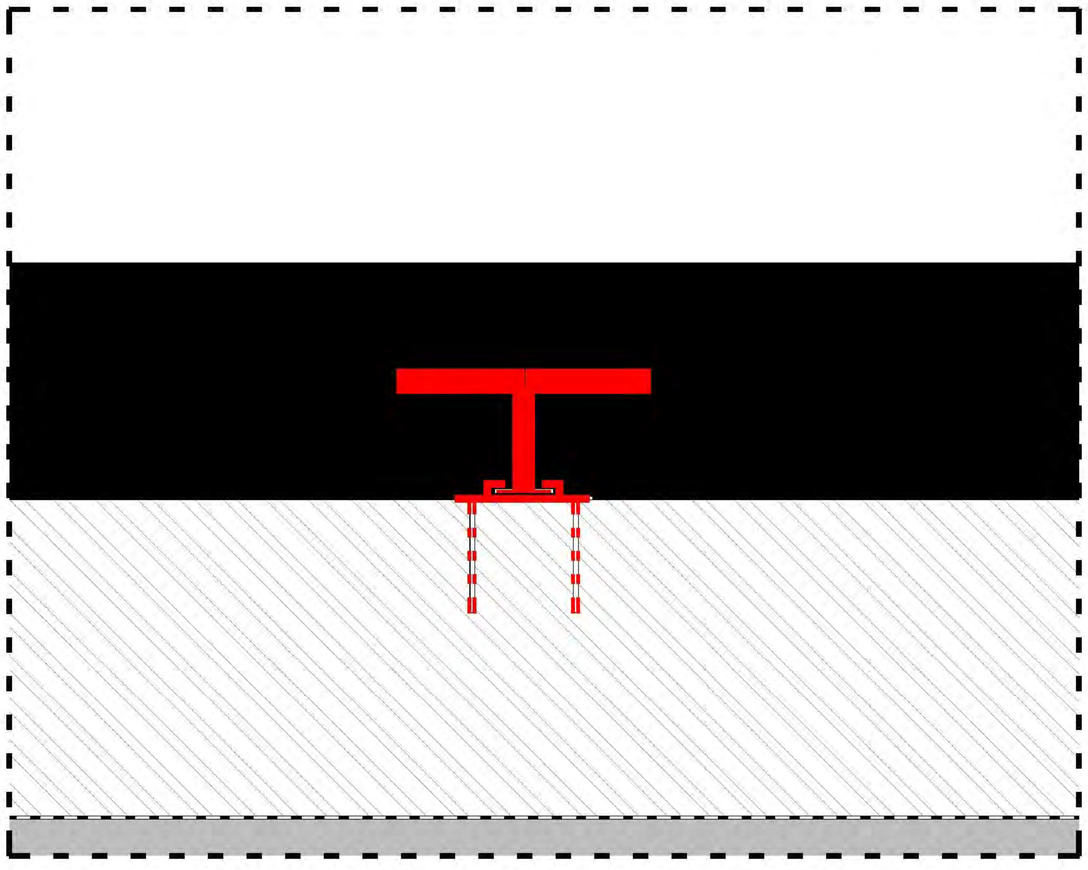


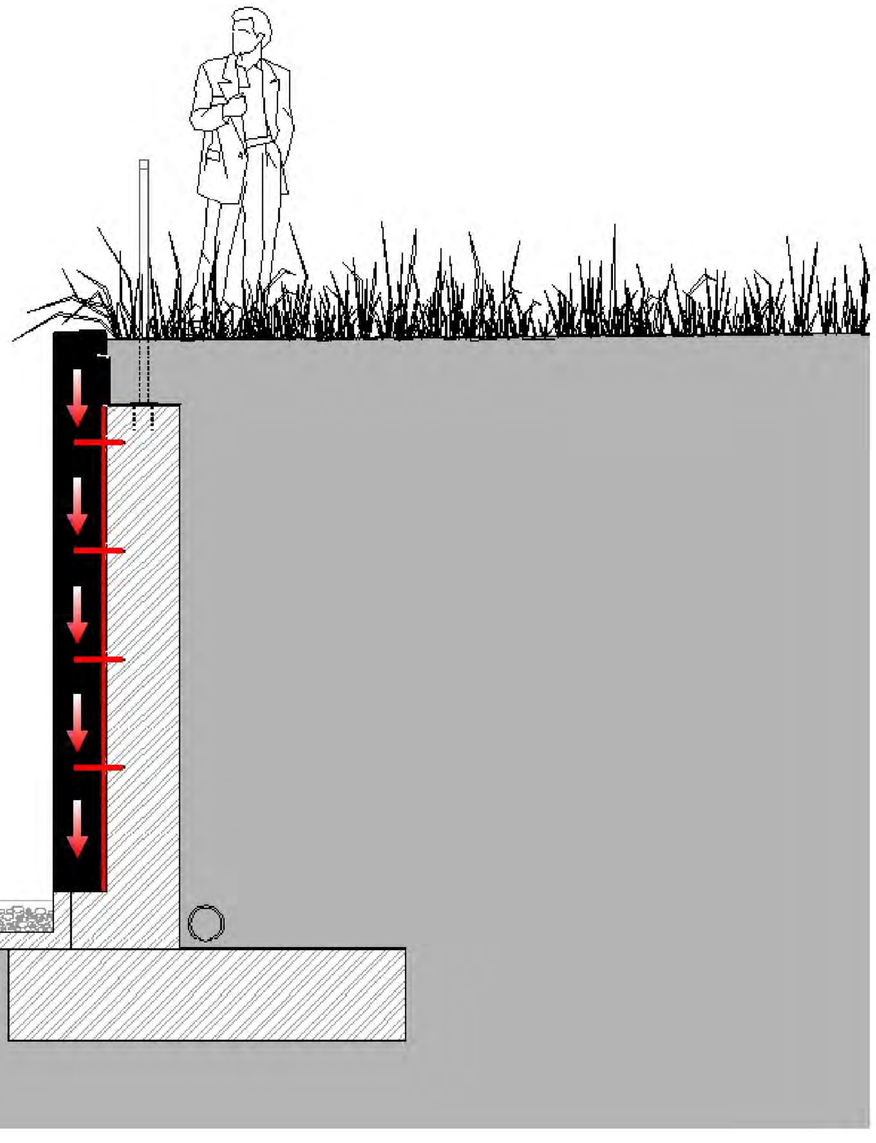




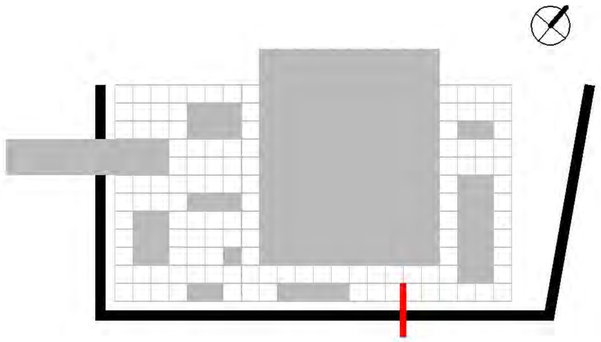
RETAINING WALL

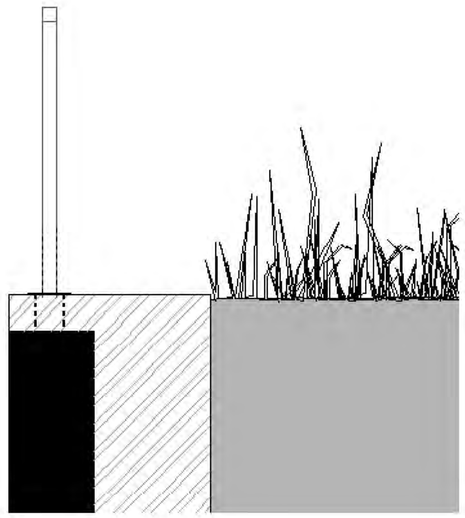


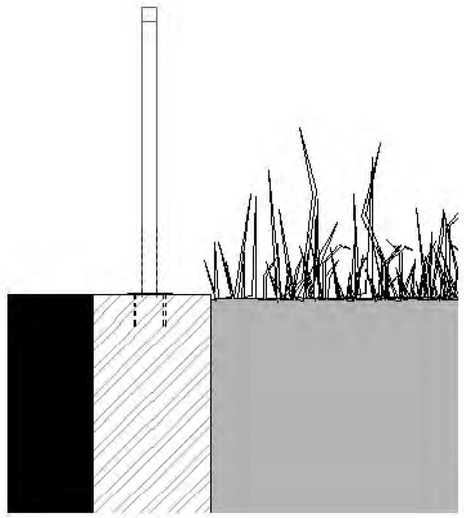


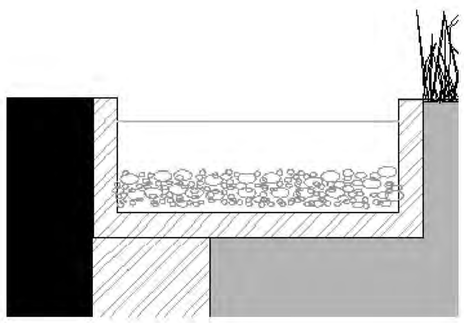


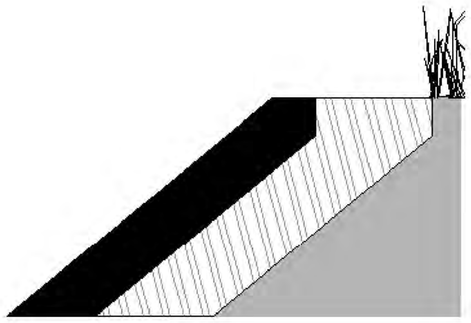
RETAINING WALL

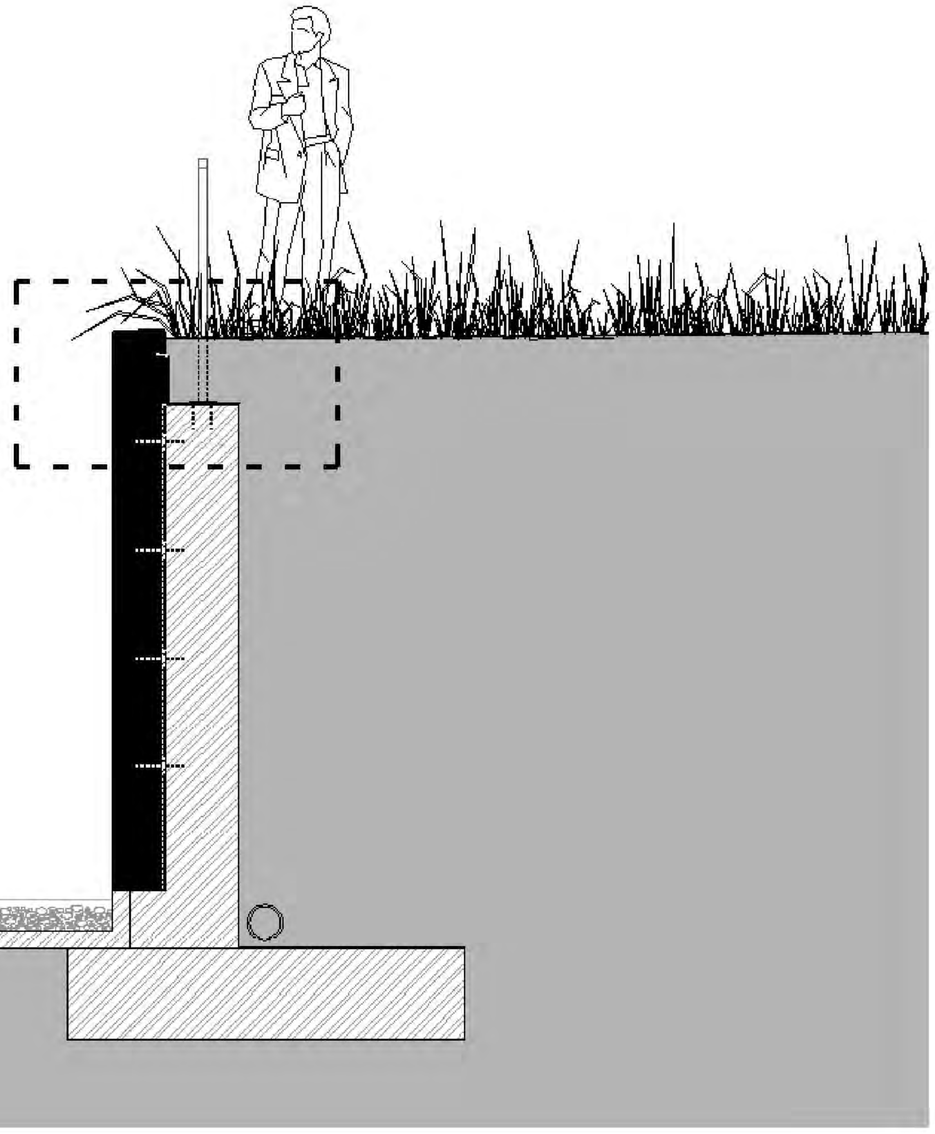




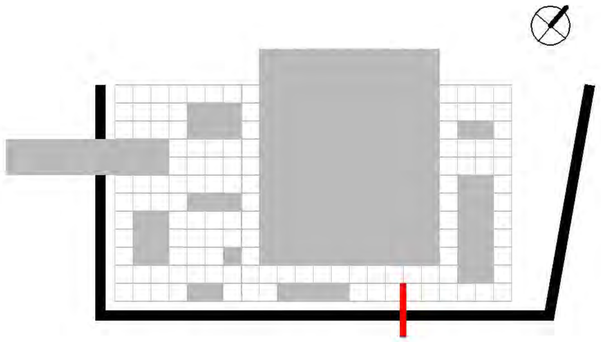


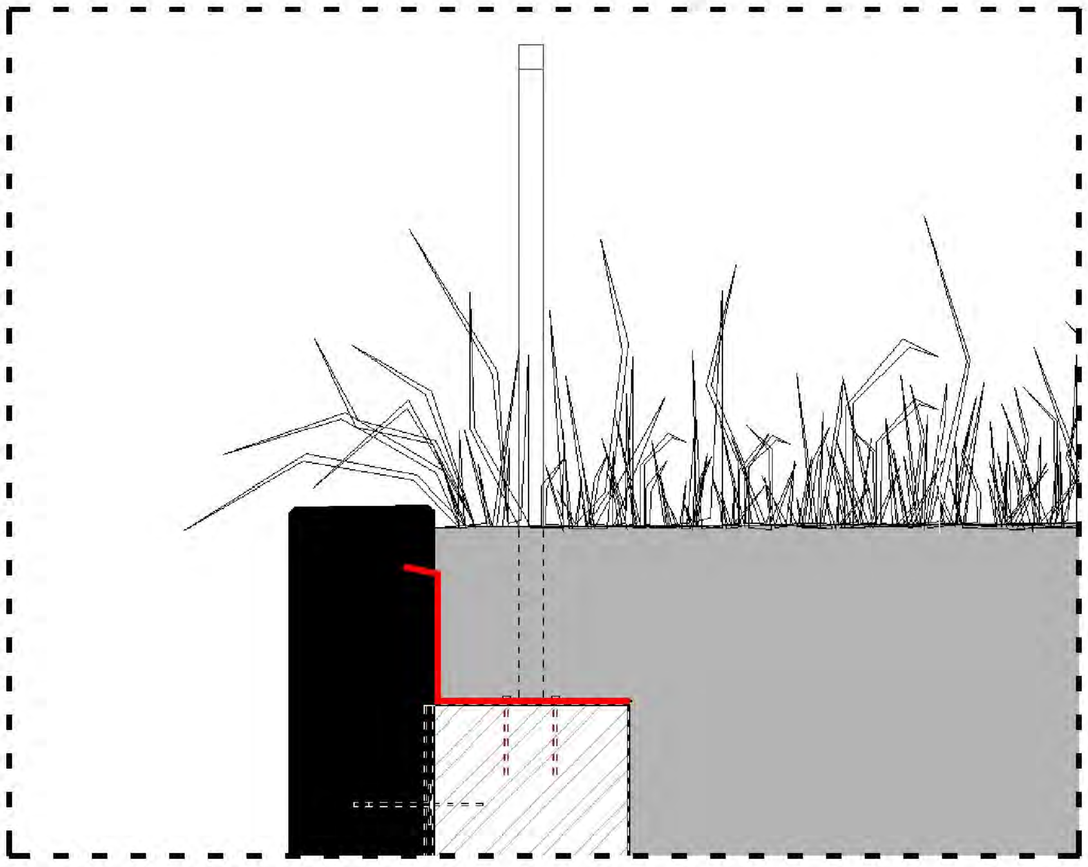


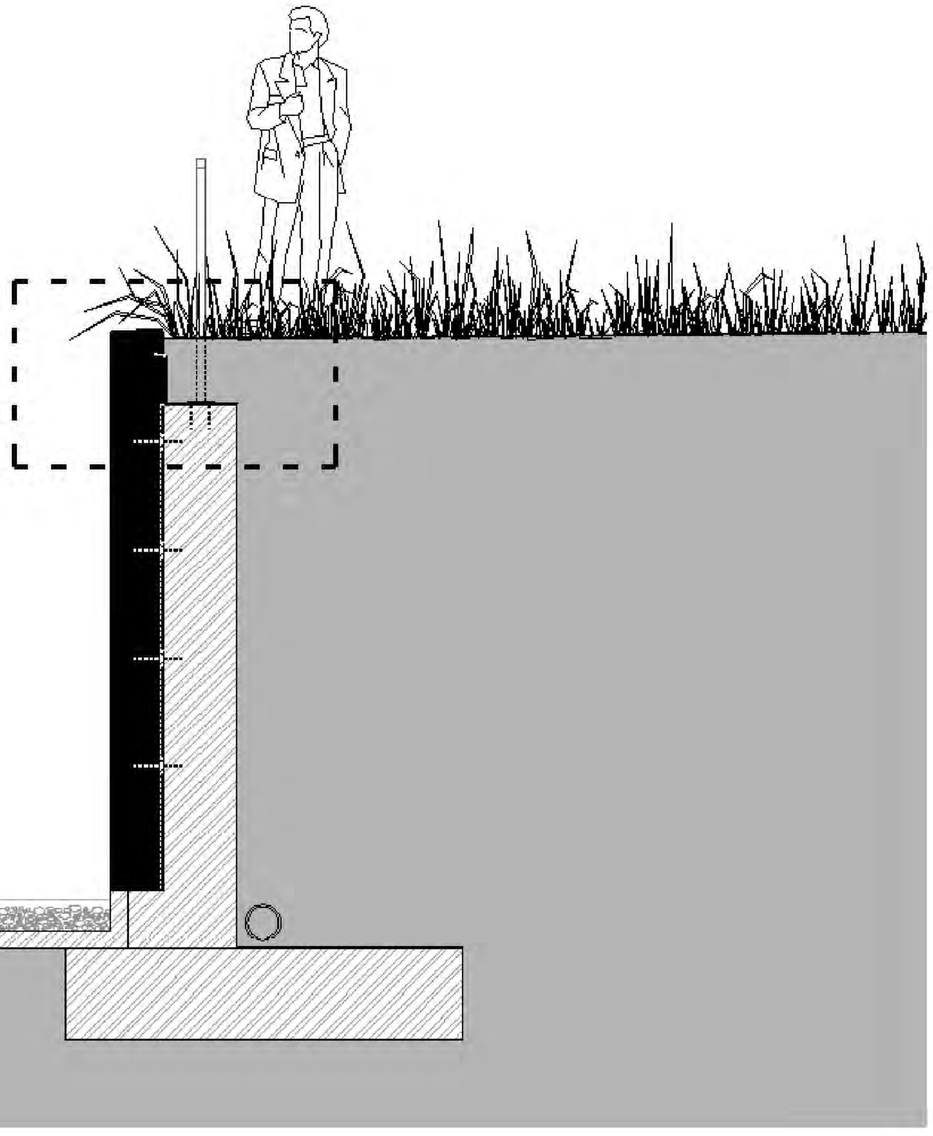




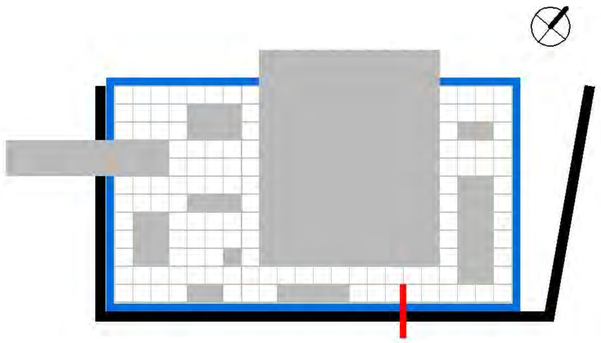
RETAINING WALL

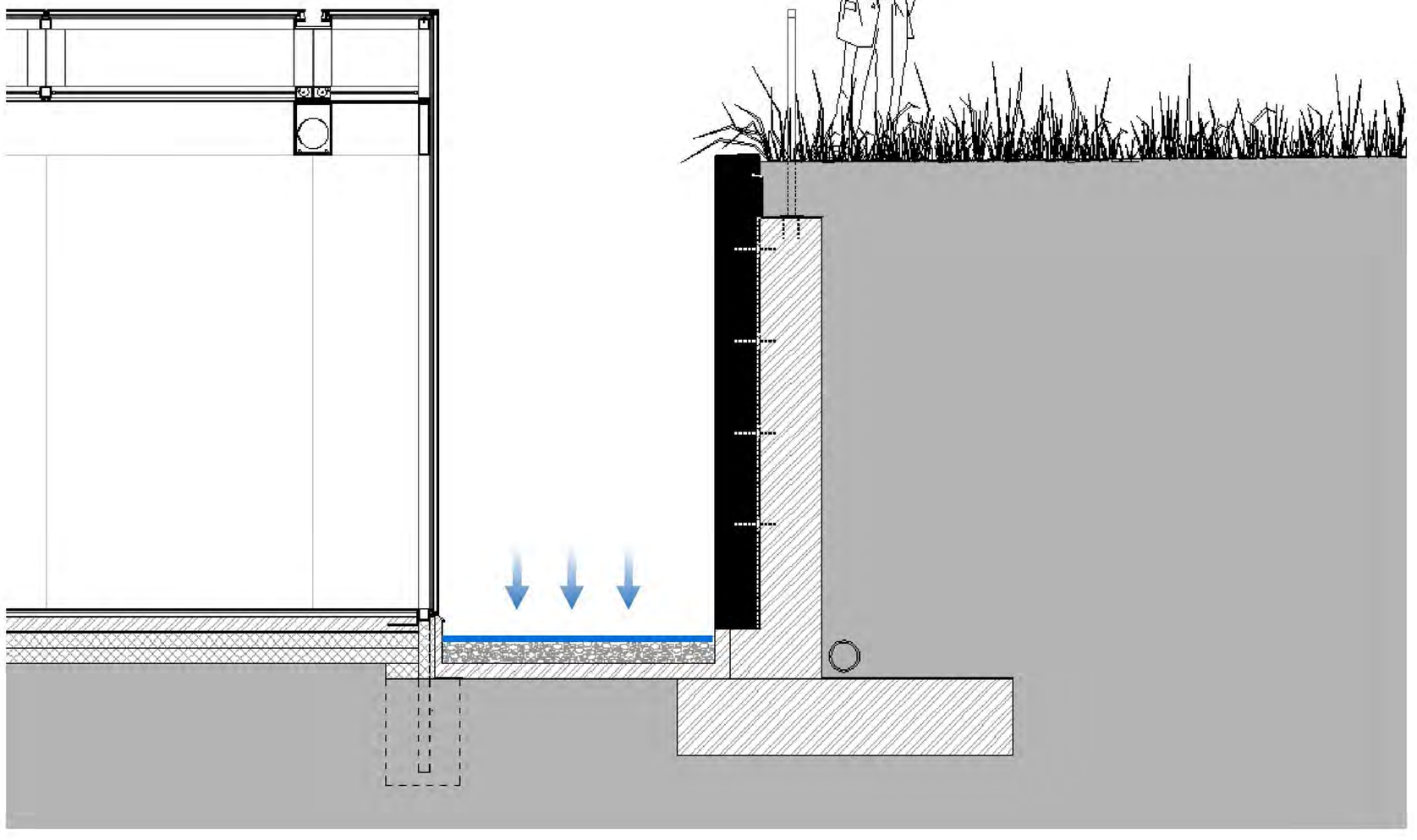




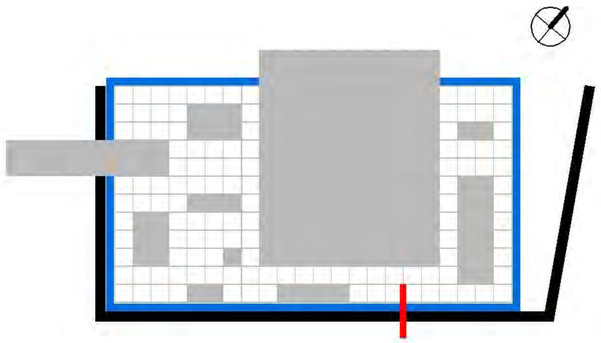


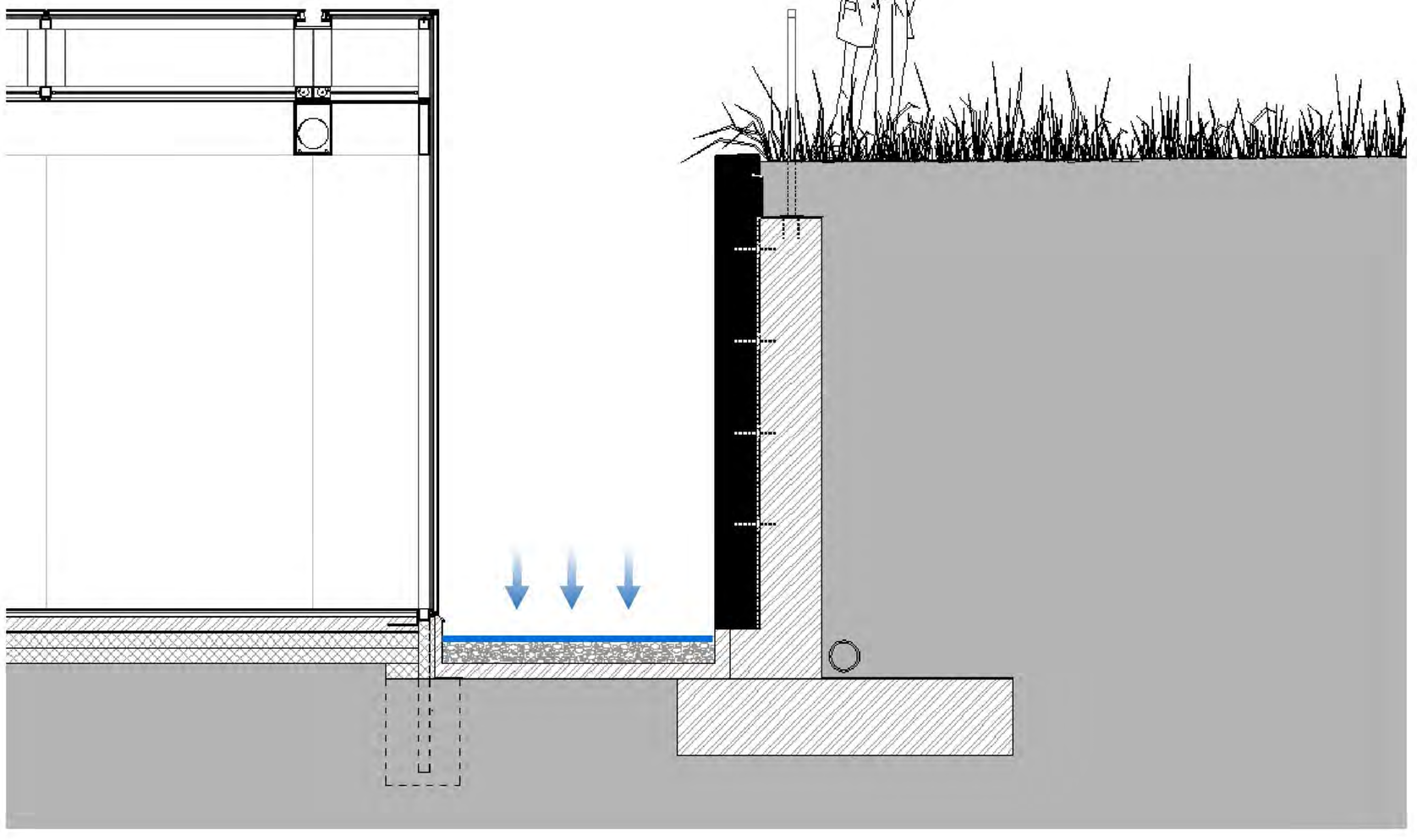
RETAINING WALL



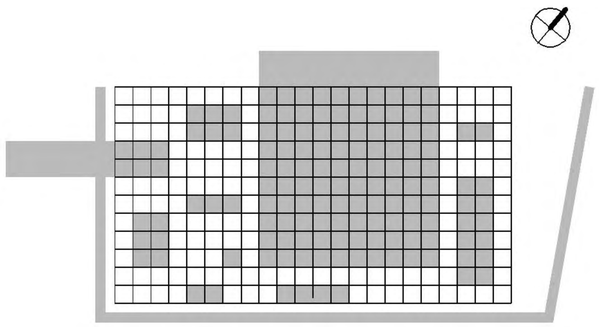


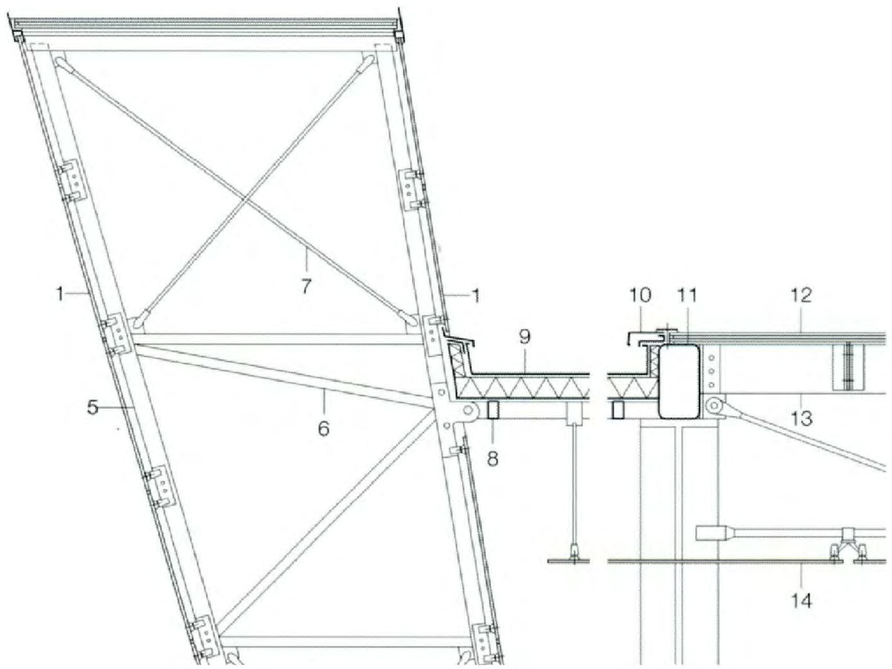
RETAINING WALL





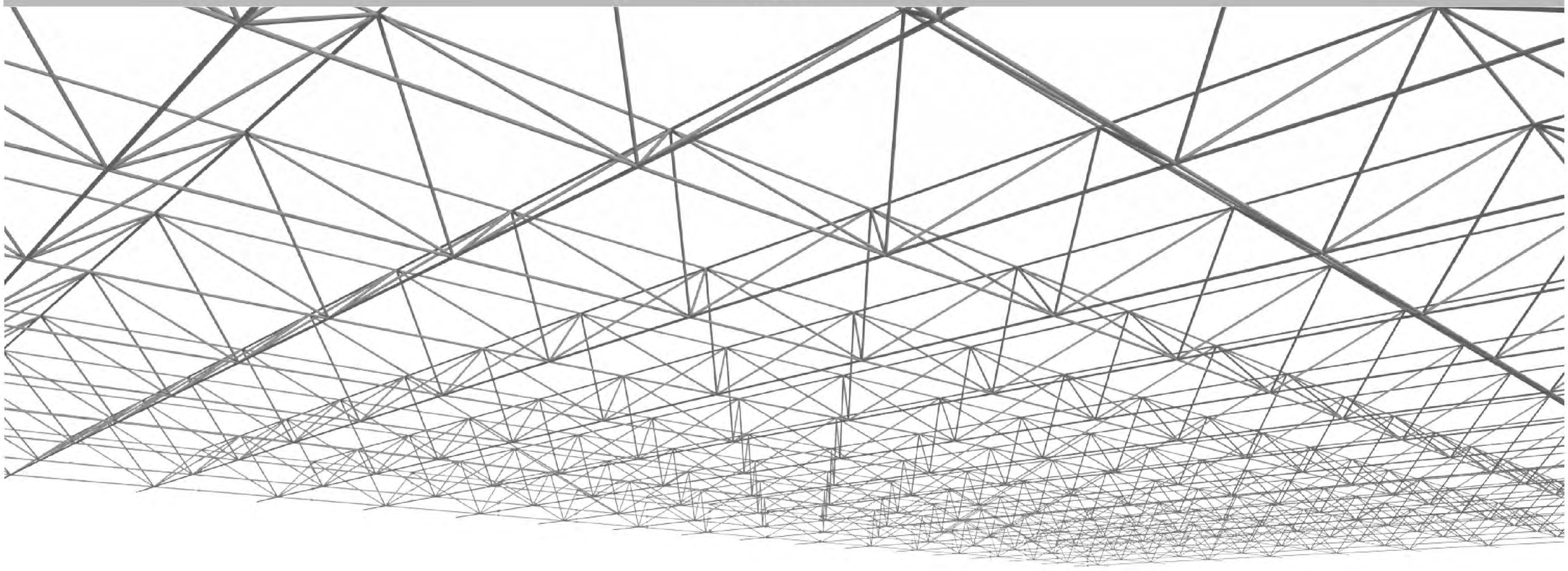
ROOF

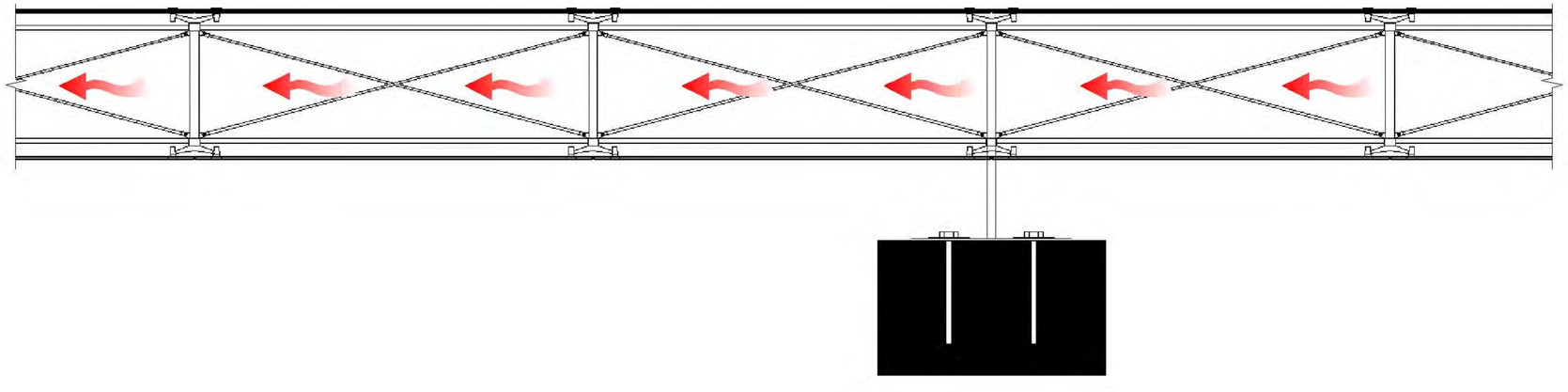




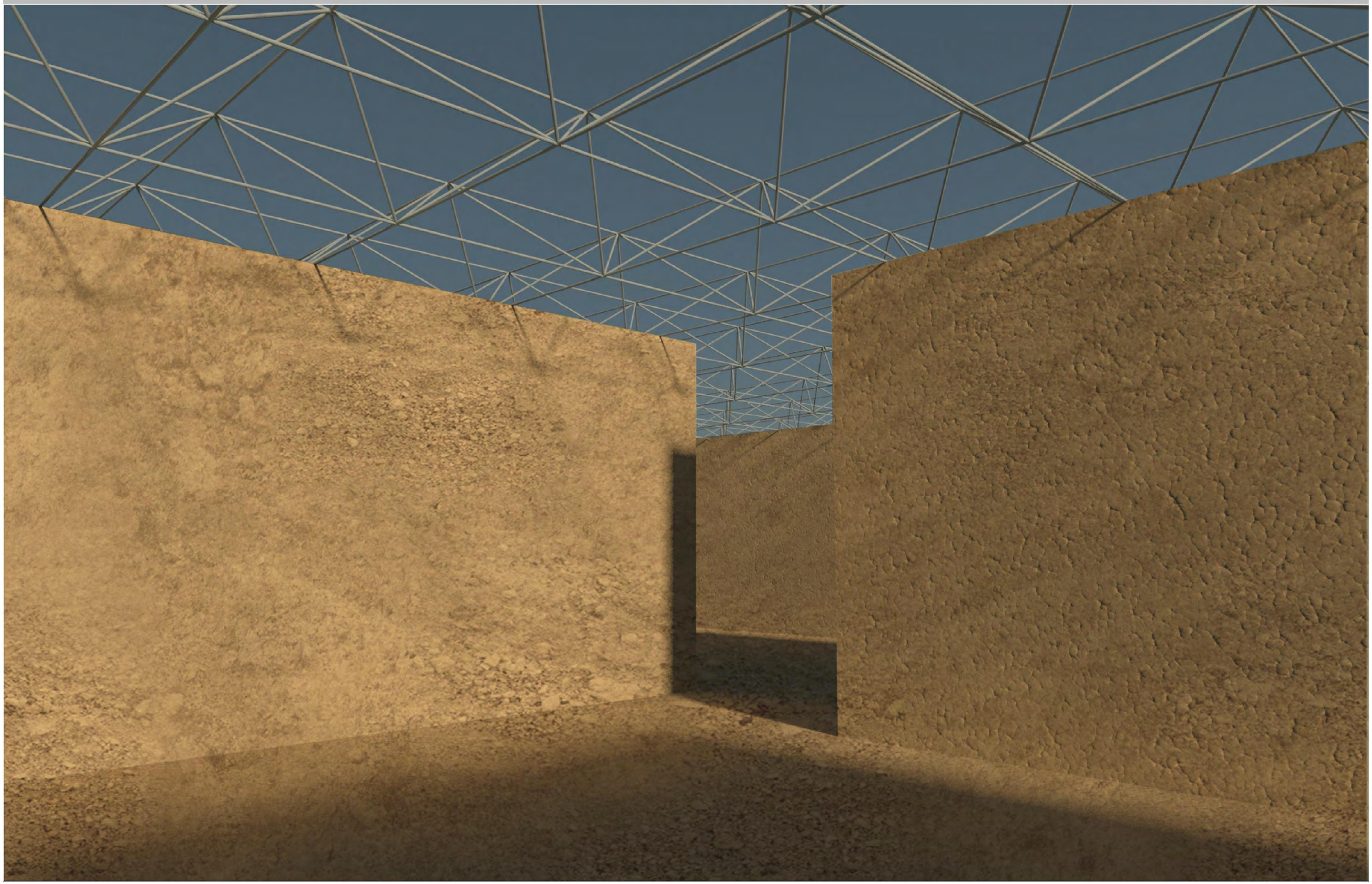

RODIN MUSEUM IN SEOUL(KPF)

ROOF

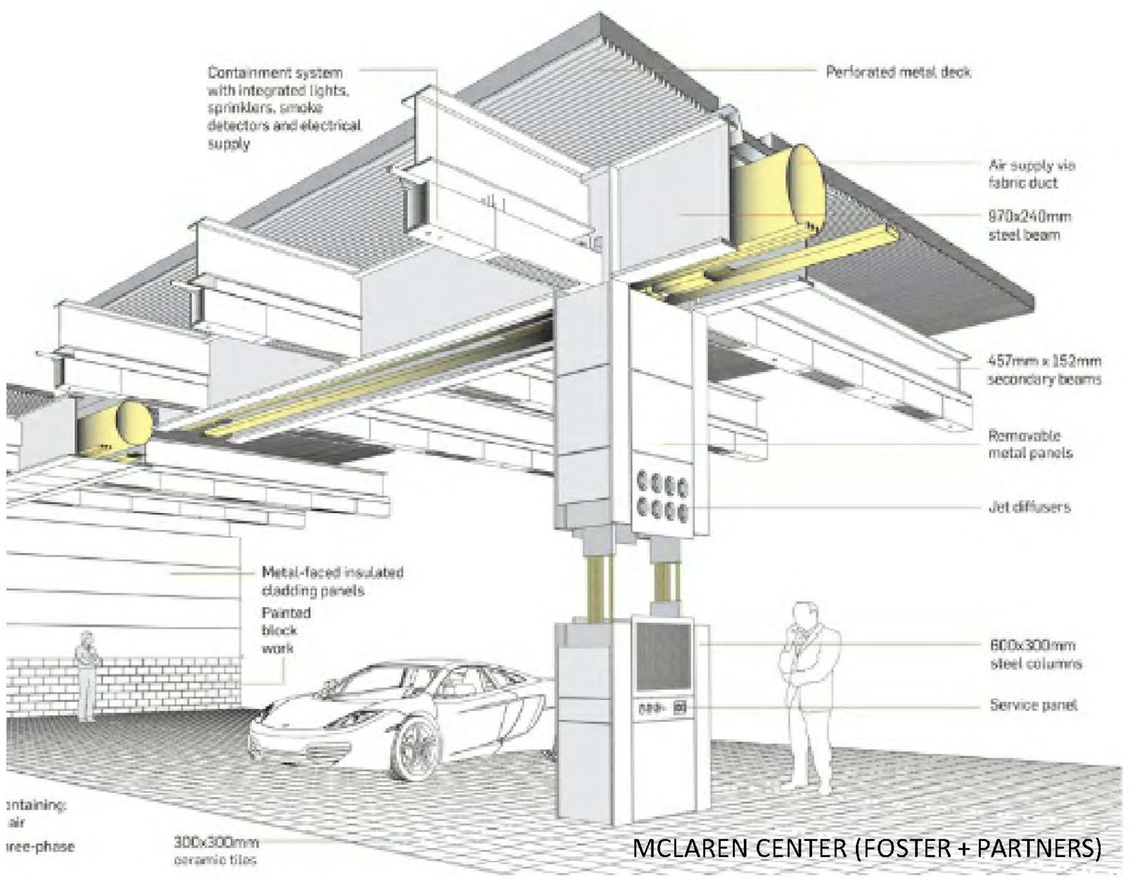




ROOF



ROOF



MCLAREN CENTER (FOSTER + PARTNERS)



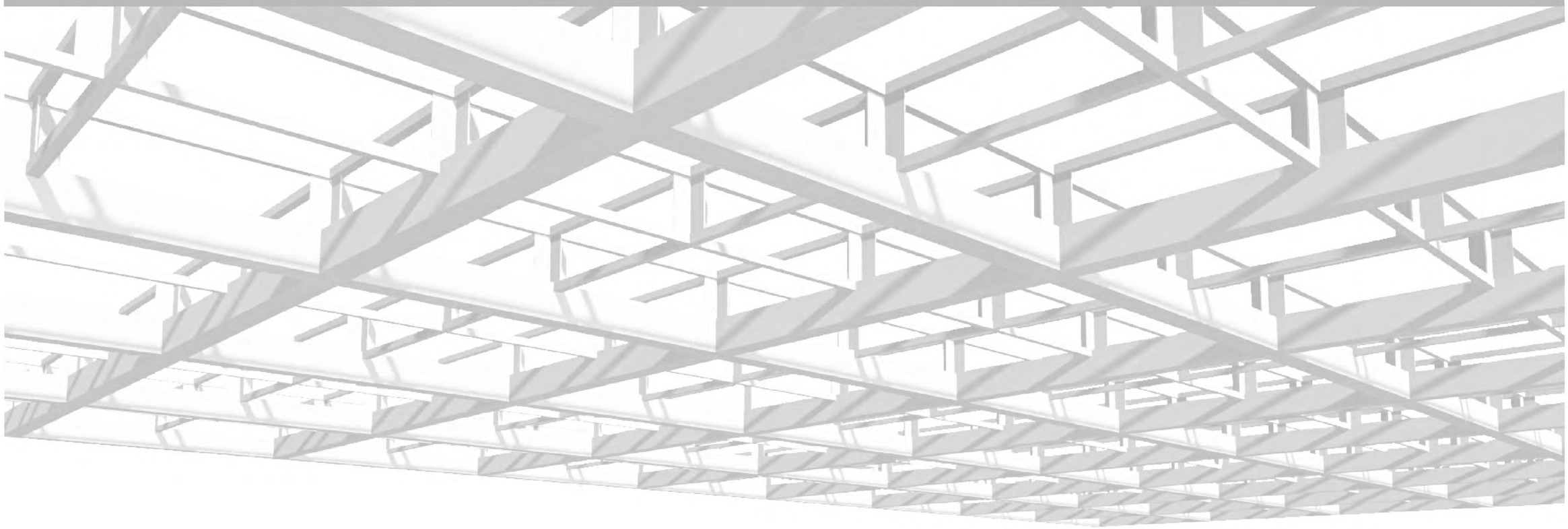
OFFICE IN STUTTGART (LICHT KUNST LICHT)

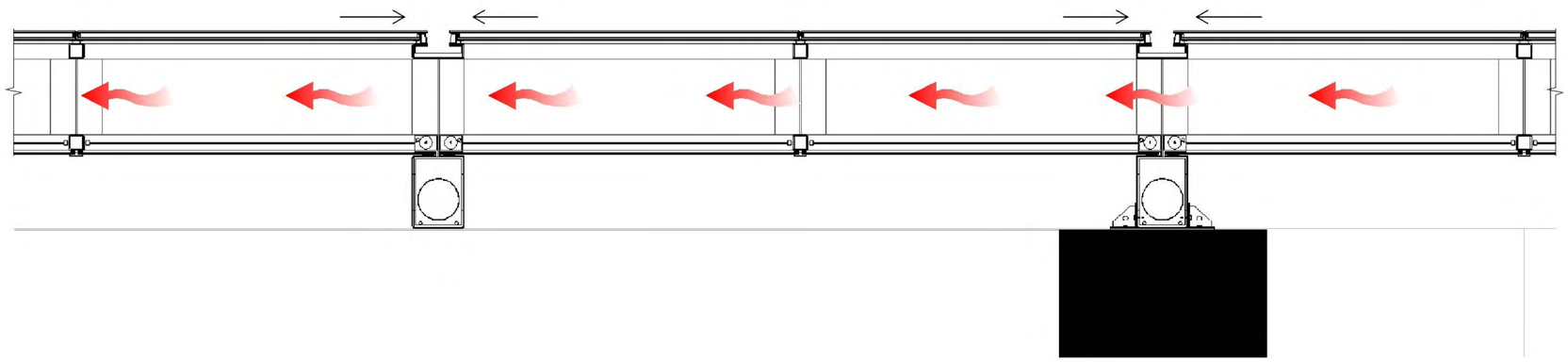
ROOF



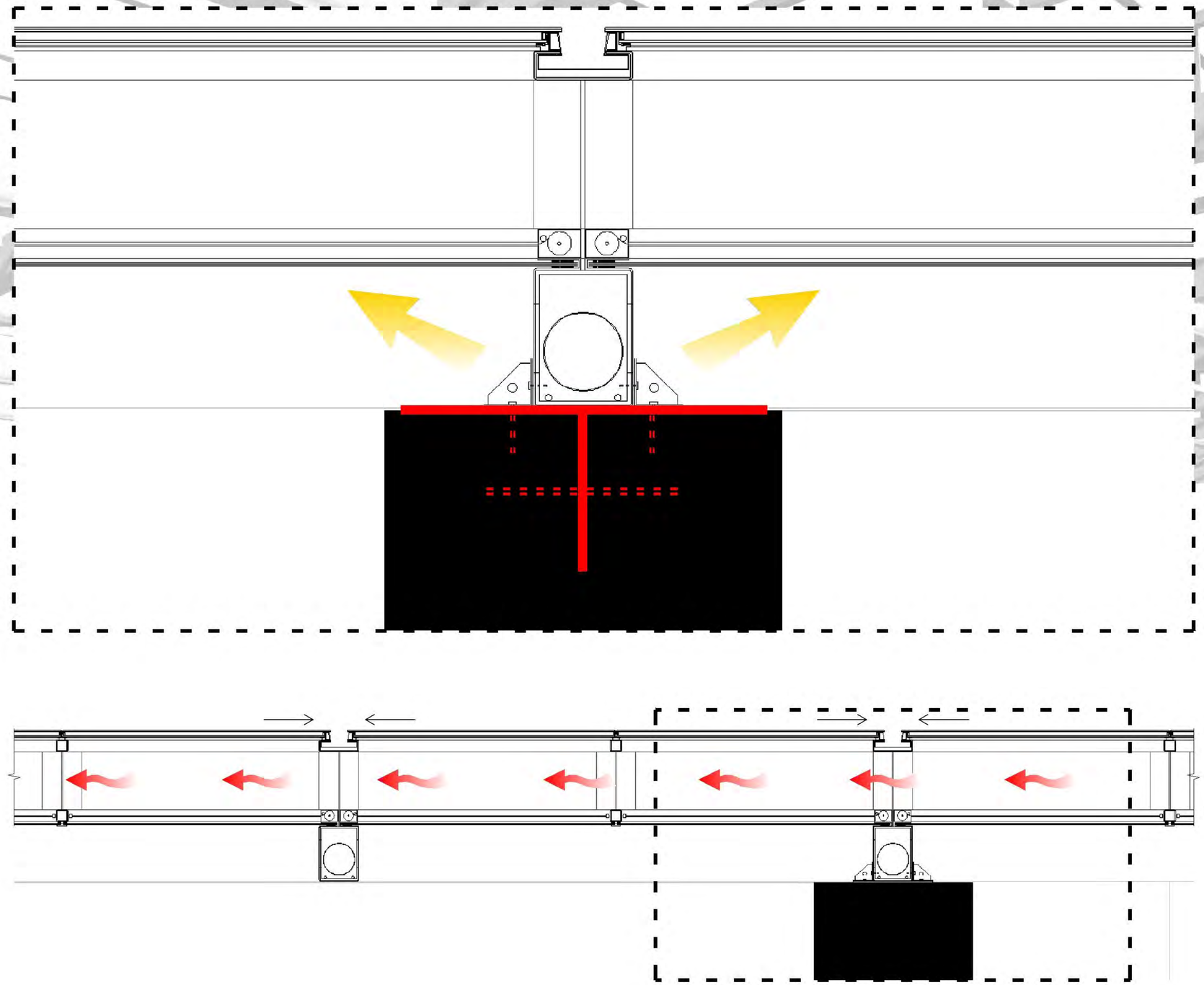


ROOF



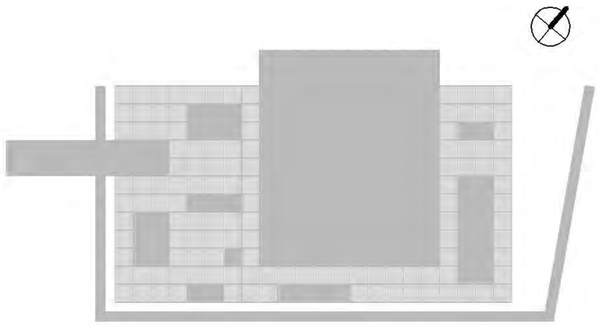


ROOF

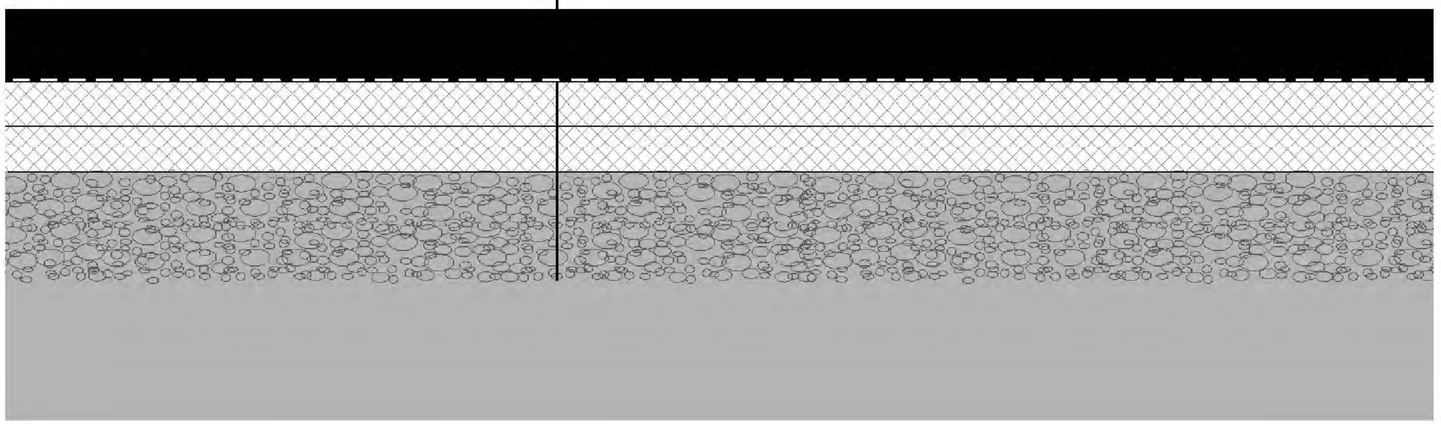




FLOOR



STABILIZED EARTH WITH PROTECTIVE OIL COVER
HYDRO INSULATION
THERMAL INSULATION
RAMMED GRAVEL

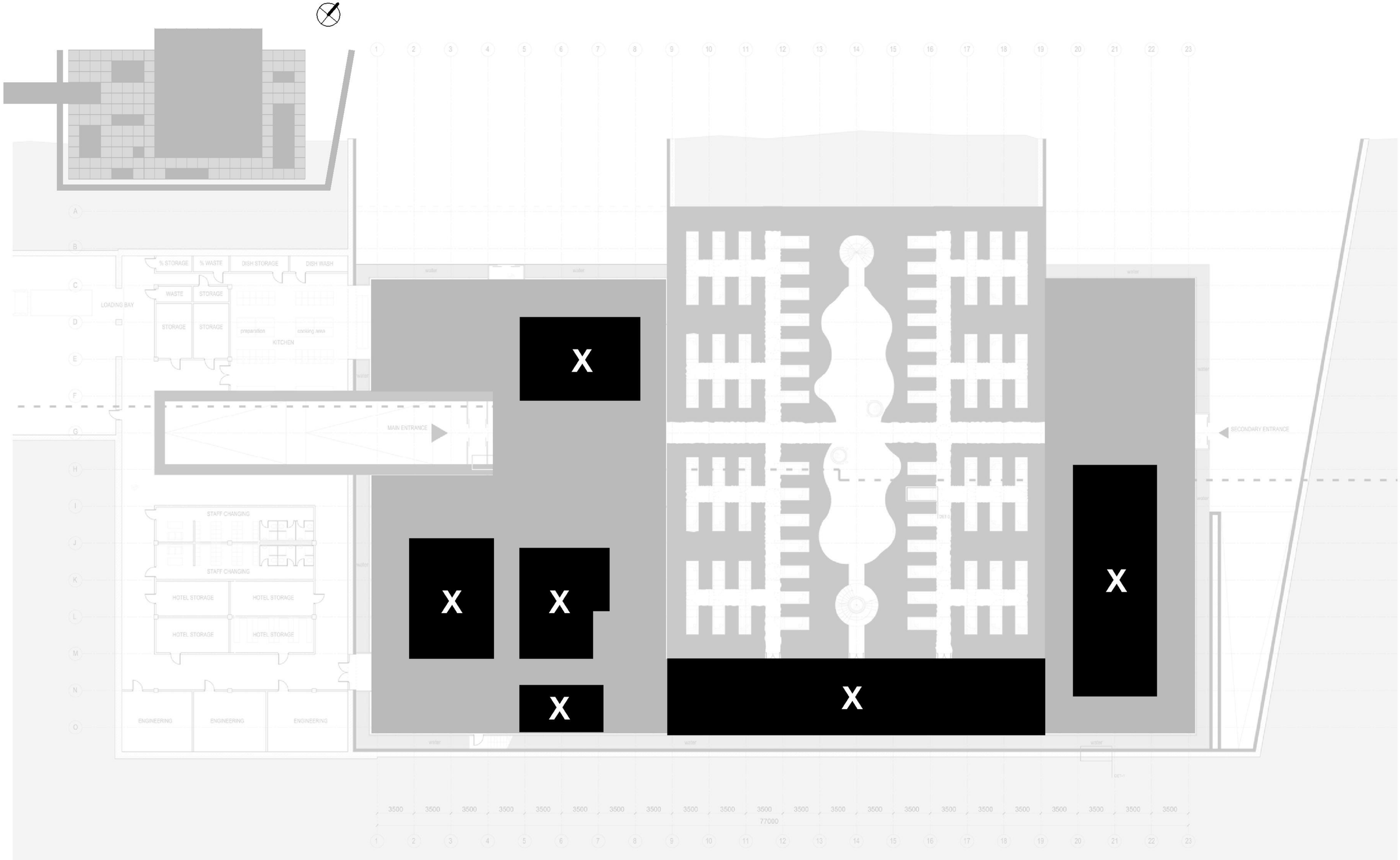




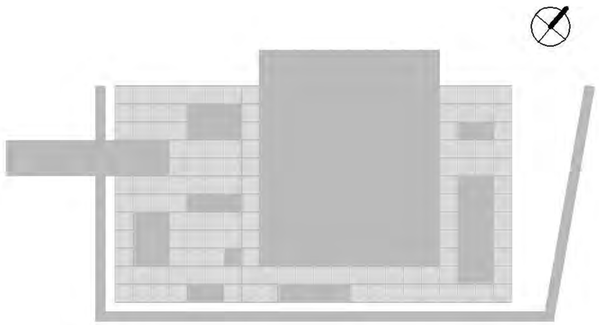


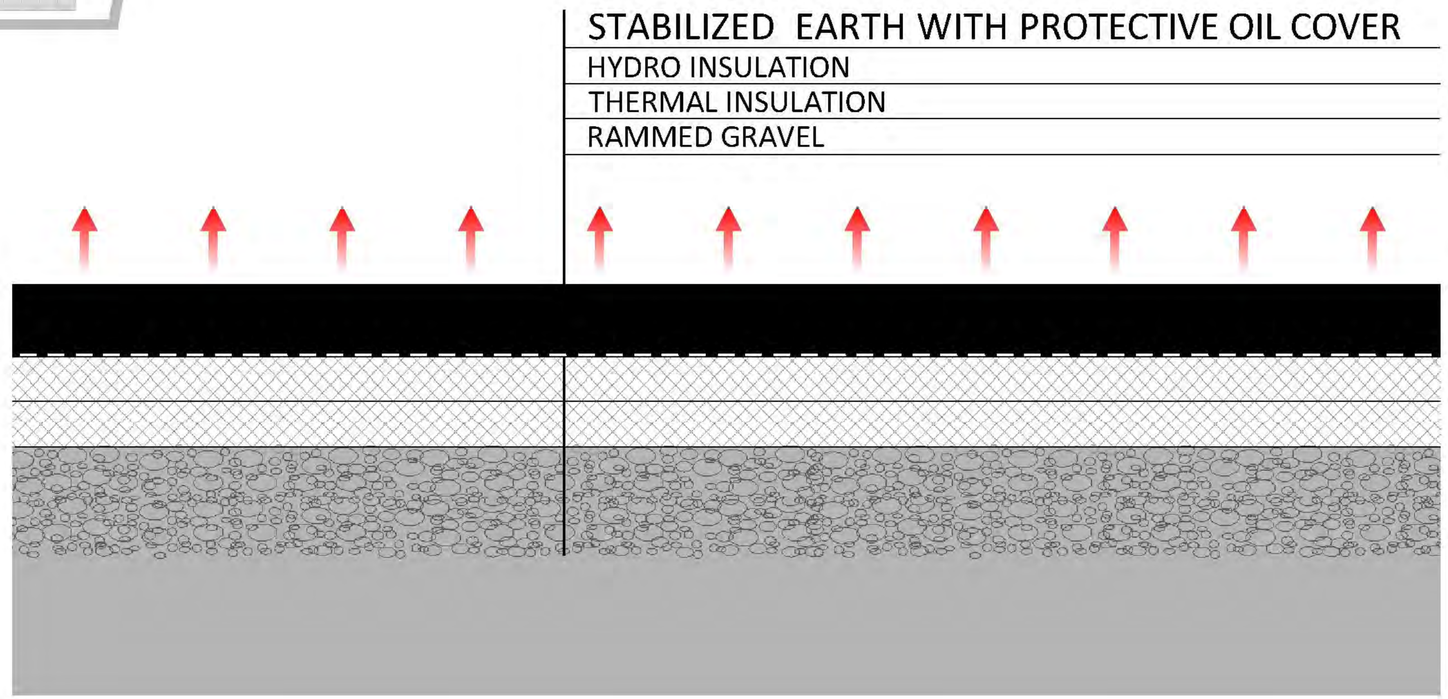


FLOOR


% STORAGE
% WASTE
DISH STORAGE
DISH WASH
WASTE
STORAGE
LOADING BAY
STORAGE
STORAGE
preparation
cooking area
KITCHEN
MAIN ENTRANCE
SECONDARY ENTRANCE
STAFF CHANGING
STAFF CHANGING
HOTEL STORAGE
HOTEL STORAGE
HOTEL STORAGE
HOTEL STORAGE
ENGINEERING
ENGINEERING
ENGINEERING
X
X
X
X
X
X
3500
77000

FLOOR





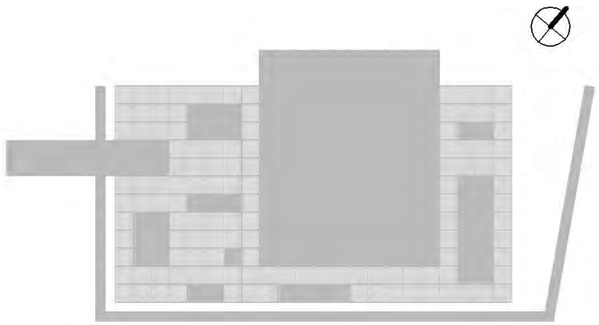
ELECTRIC HEATING CABLE

- MAY GET DAMAGED DURING CONSTRUCTION
- SLOW RESPONSE TIME

WATER TUBES

- MAY HARM THE FLOOR IN CASE OF LEAKAGE
- SLOW RESPONSE TIME

FLOOR

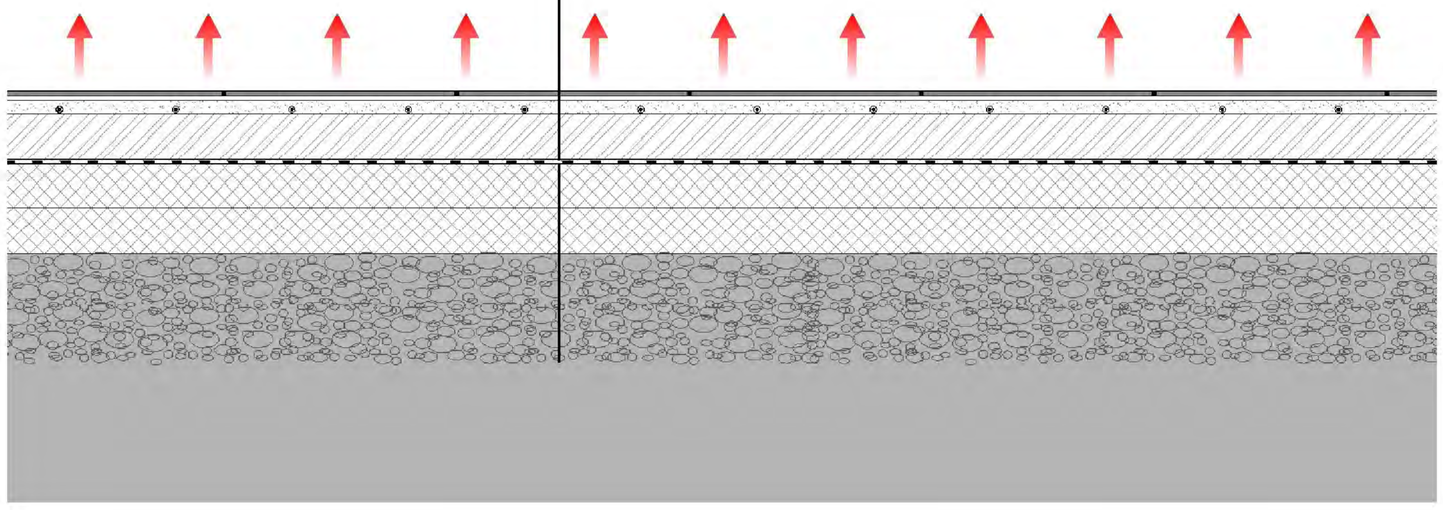


TILE FLOOR WITH HEATING CABLE

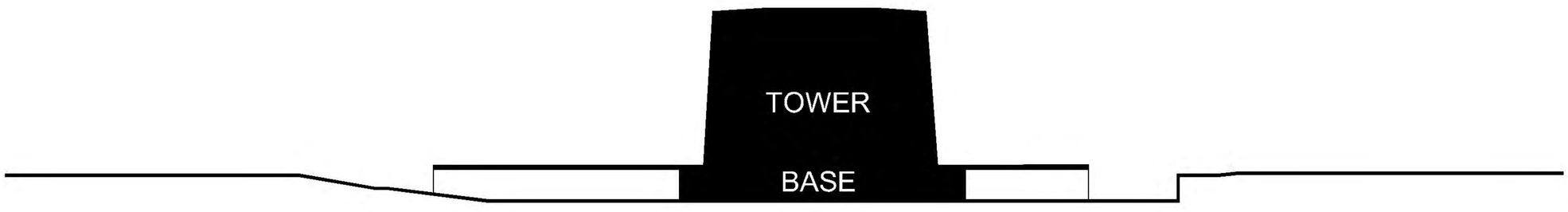
REINFORCED CONCRETE

FOAM INSULATION

RAMMED GRAVEL

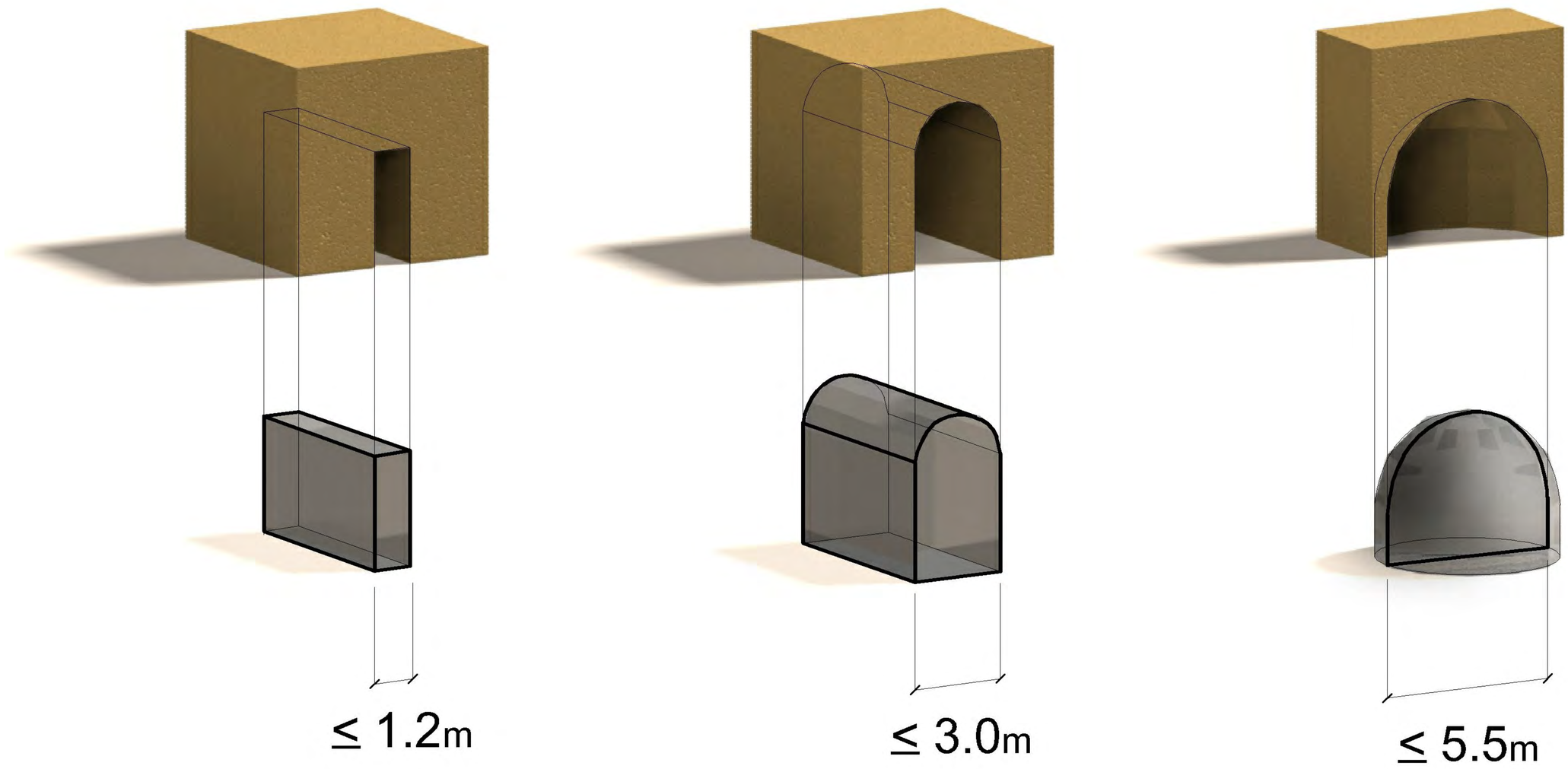


VERTICAL VOLUME

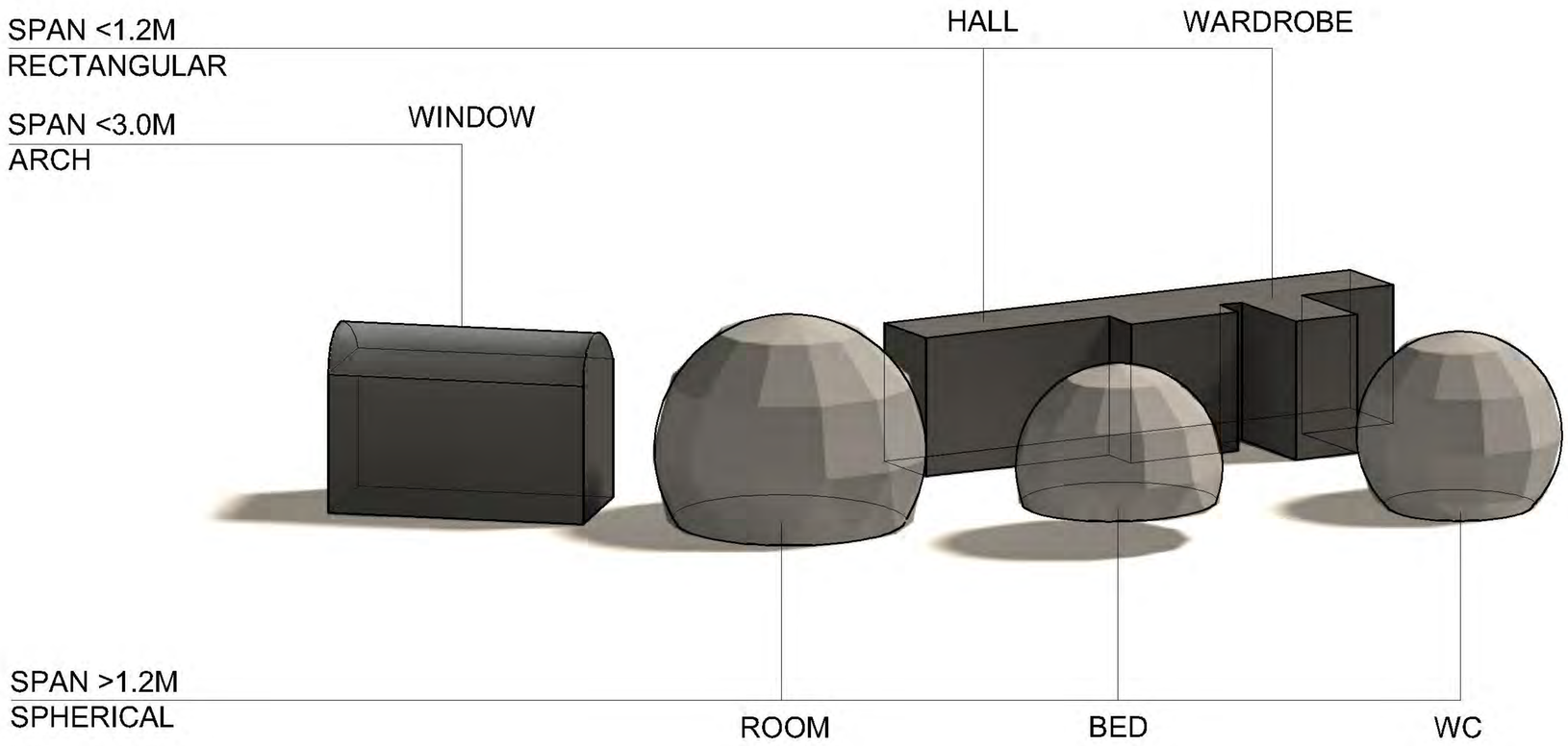




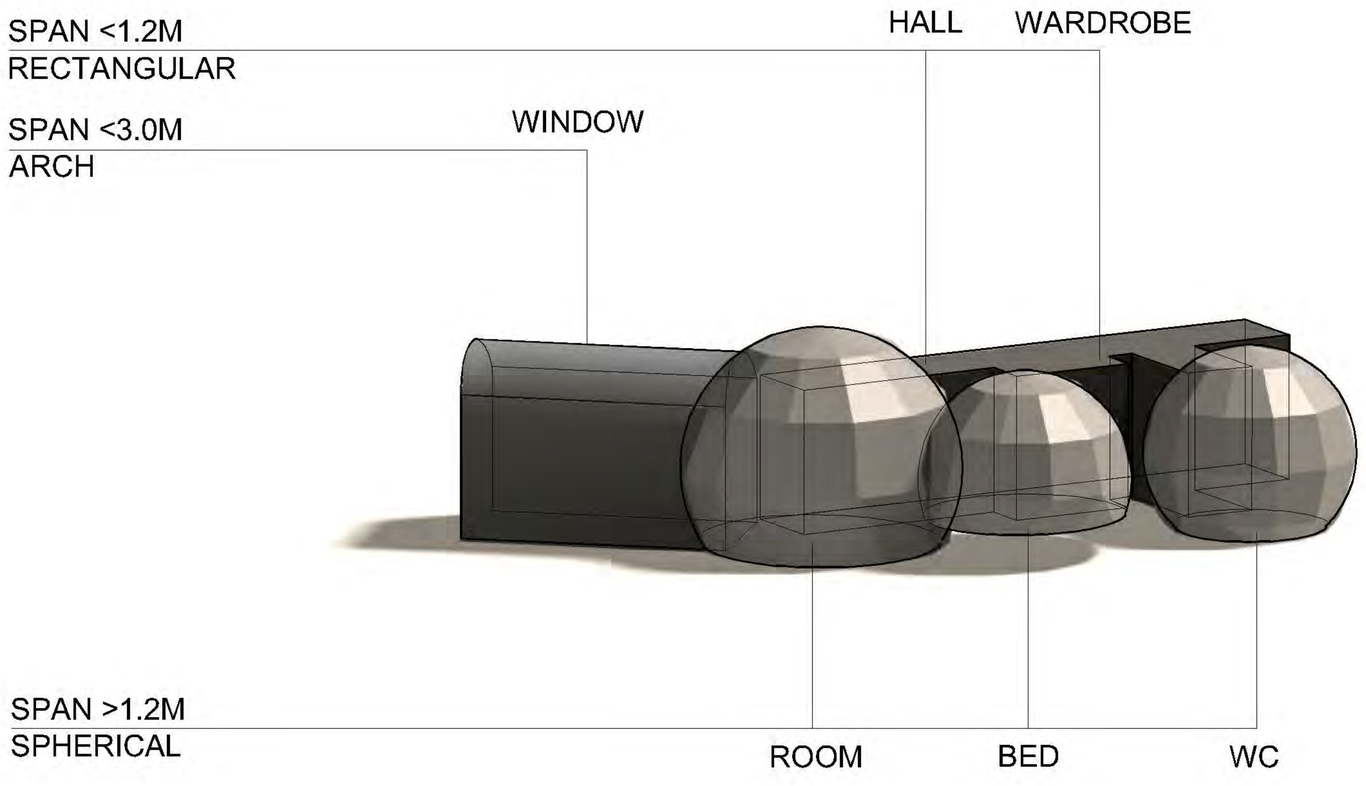
HOTEL ROOMS



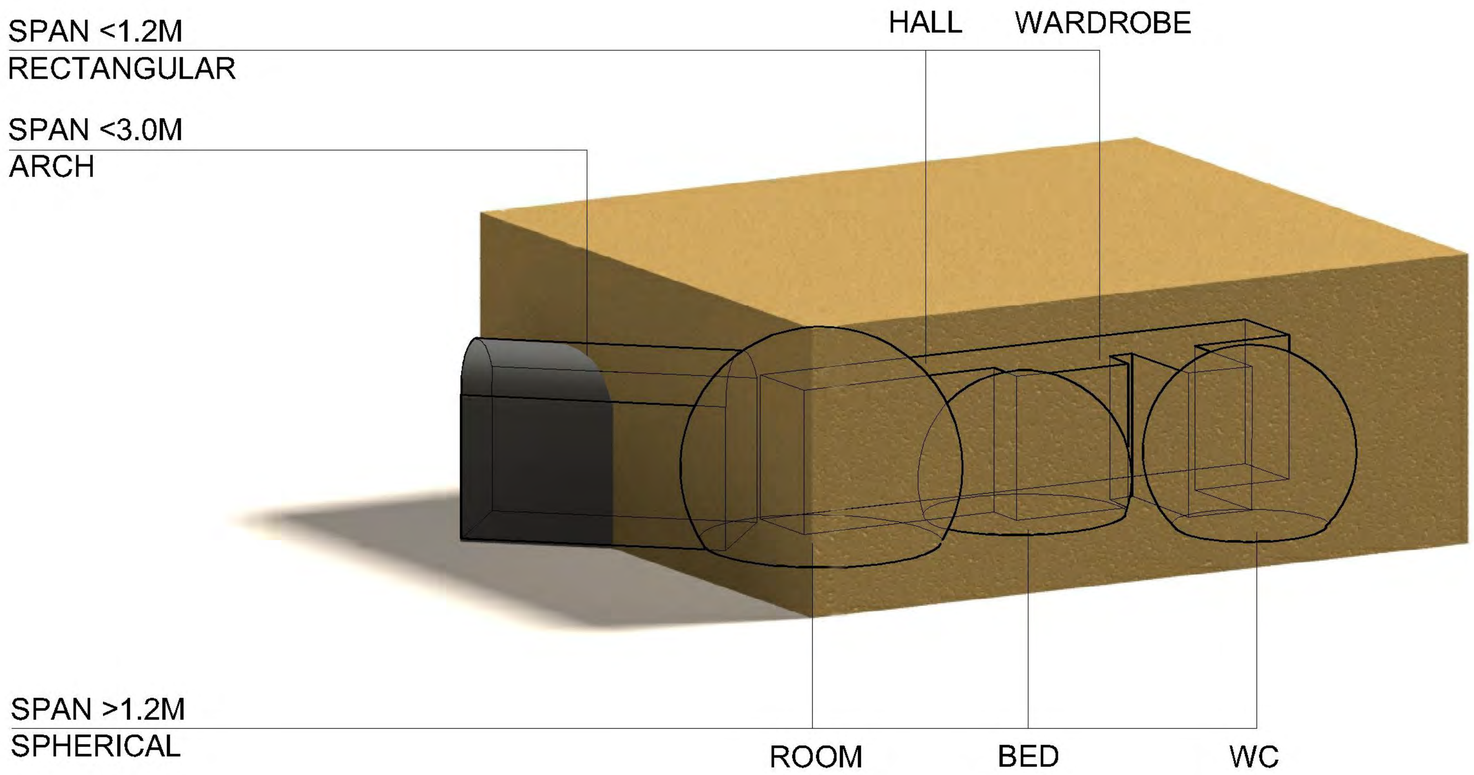
HOTEL ROOMS


SPAN <1.2M
RECTANGULAR
SPAN <3.0M
ARCH
SPAN >1.2M
SPHERICAL
WINDOW
HALL
WARDROBE
ROOM
BED
WC

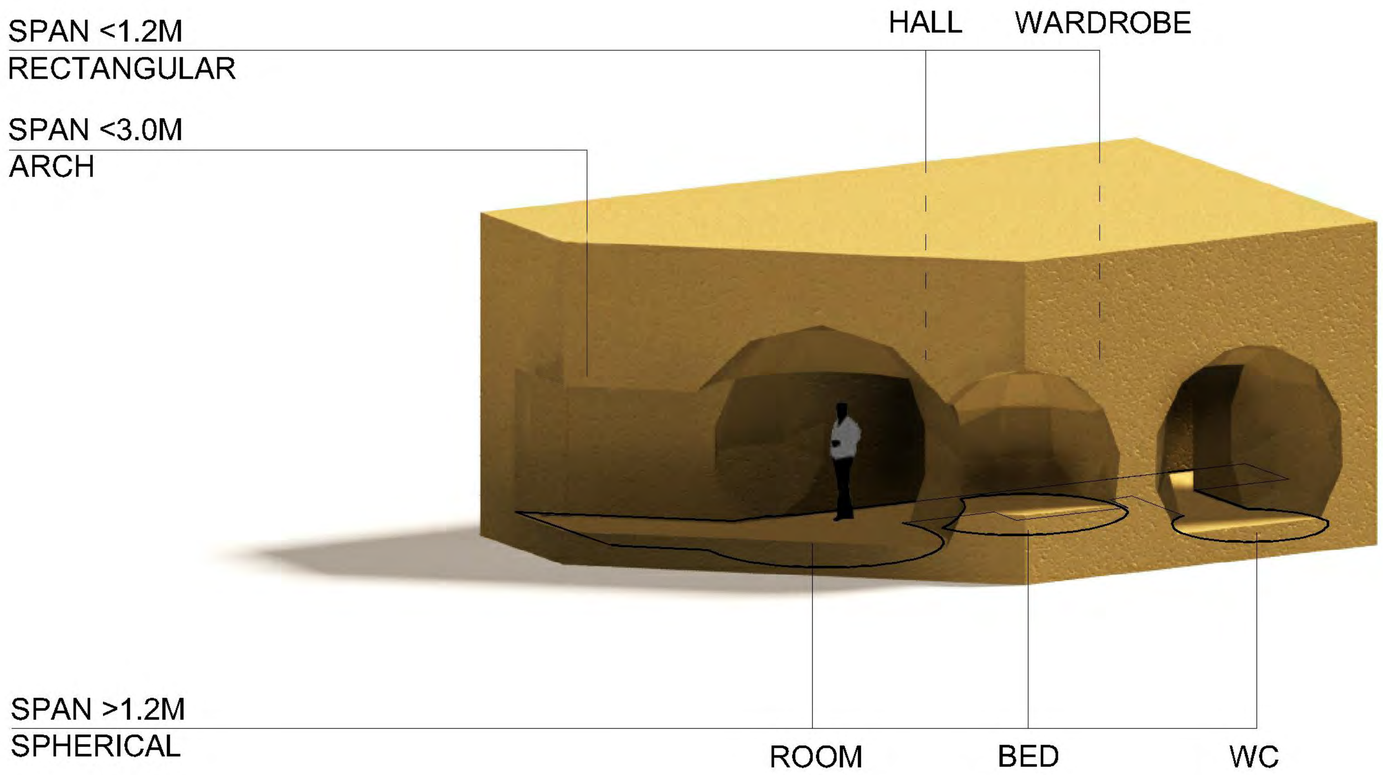
HOTEL ROOMS


SPAN <1.2M
RECTANGULAR
SPAN <3.0M
ARCH
SPAN >1.2M
SPHERICAL
HALL
WARDROBE
WINDOW
ROOM
BED
WC

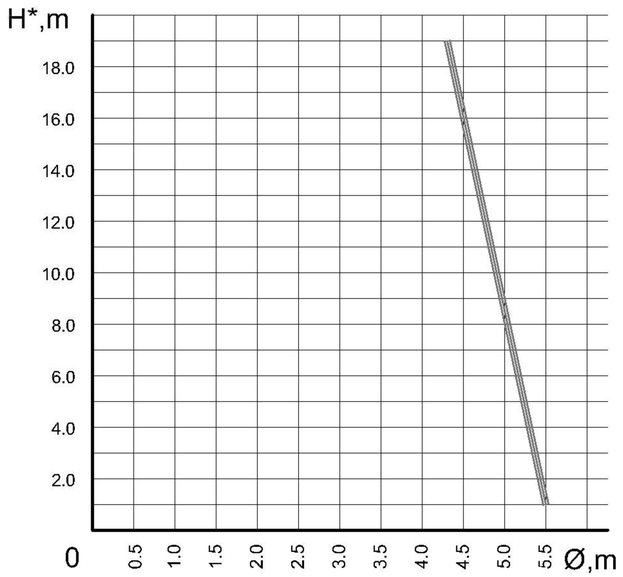
HOTEL ROOMS

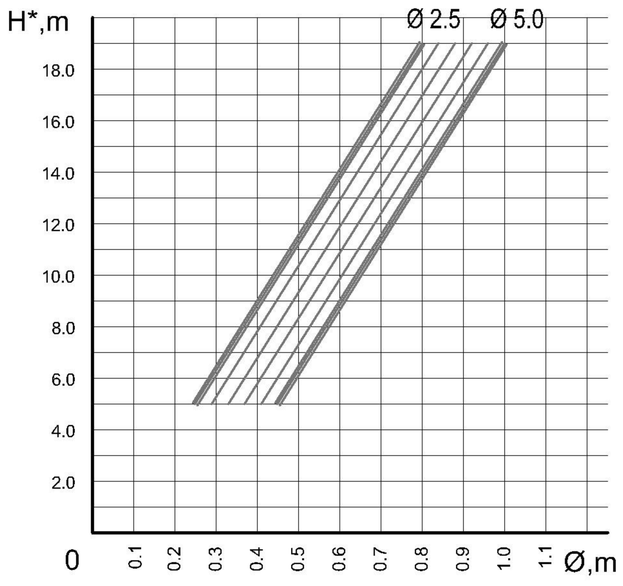

SPAN <1.2M
RECTANGULAR
SPAN <3.0M
ARCH
SPAN >1.2M
SPHERICAL
HALL
WARDROBE
ROOM
BED
WC

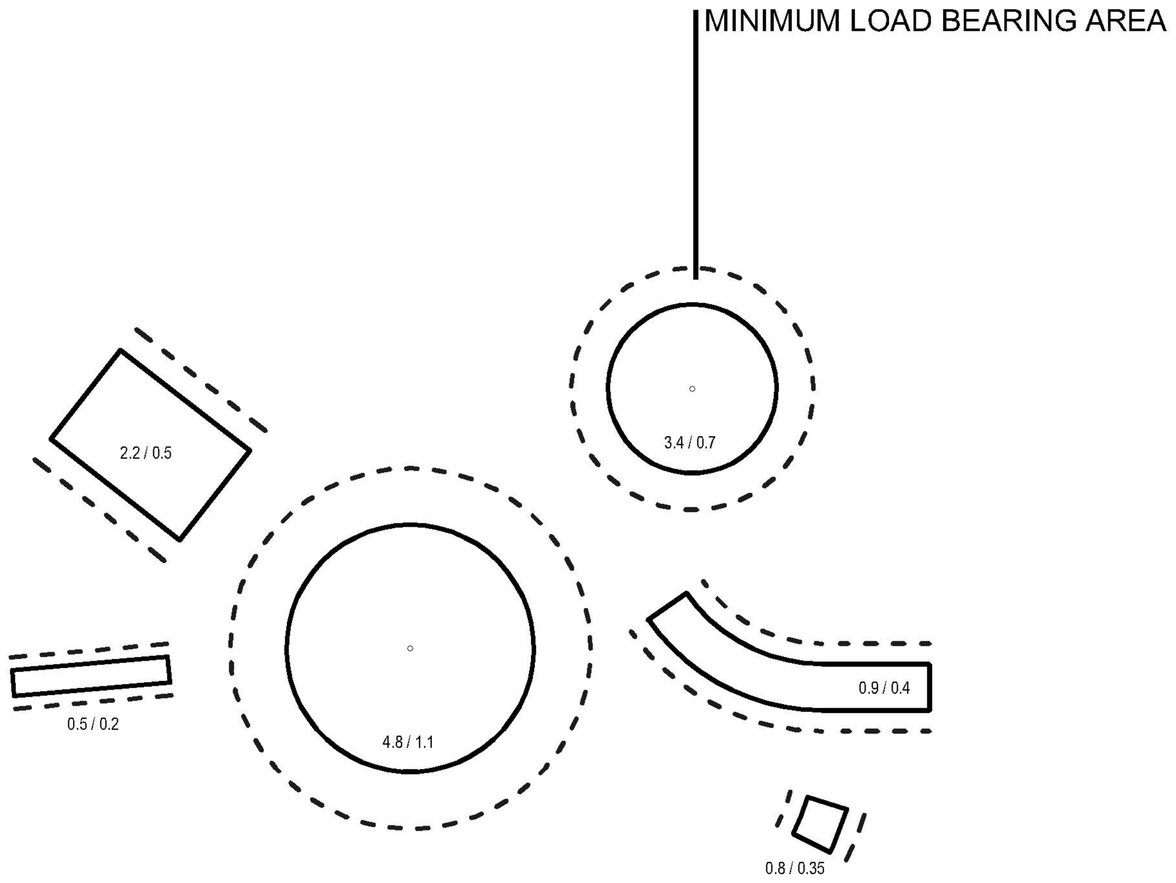
HOTEL ROOMS


SPAN <1.2M
RECTANGULAR
SPAN <3.0M
ARCH
SPAN >1.2M
SPHERICAL
HALL
WARDROBE
ROOM
BED
WC

HOTEL ROOMS

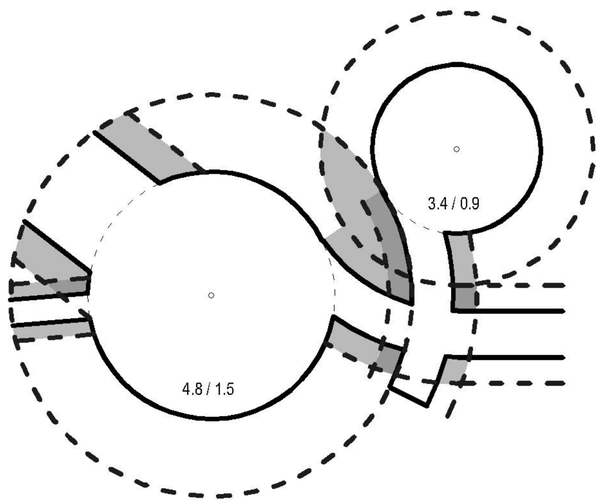






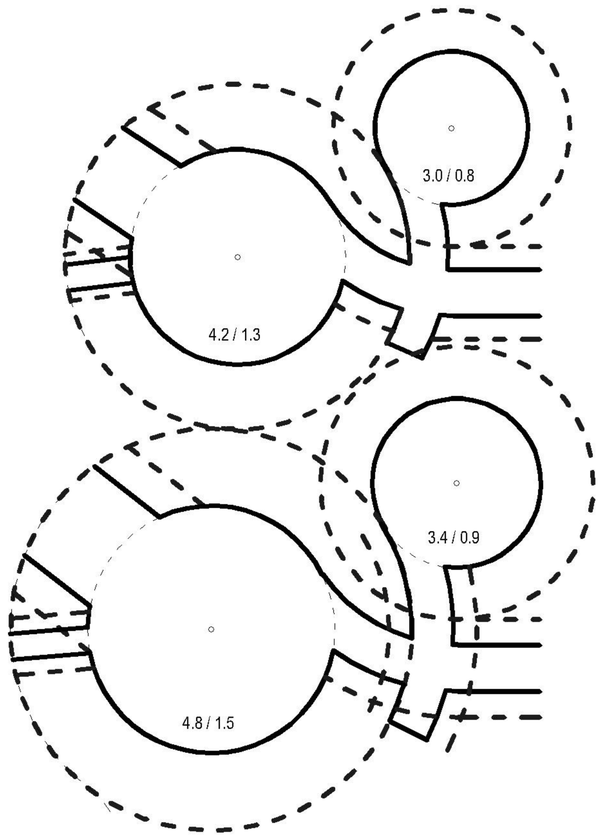
SIZE OF OPENING
LOAD ON TOP

HOTEL ROOMS

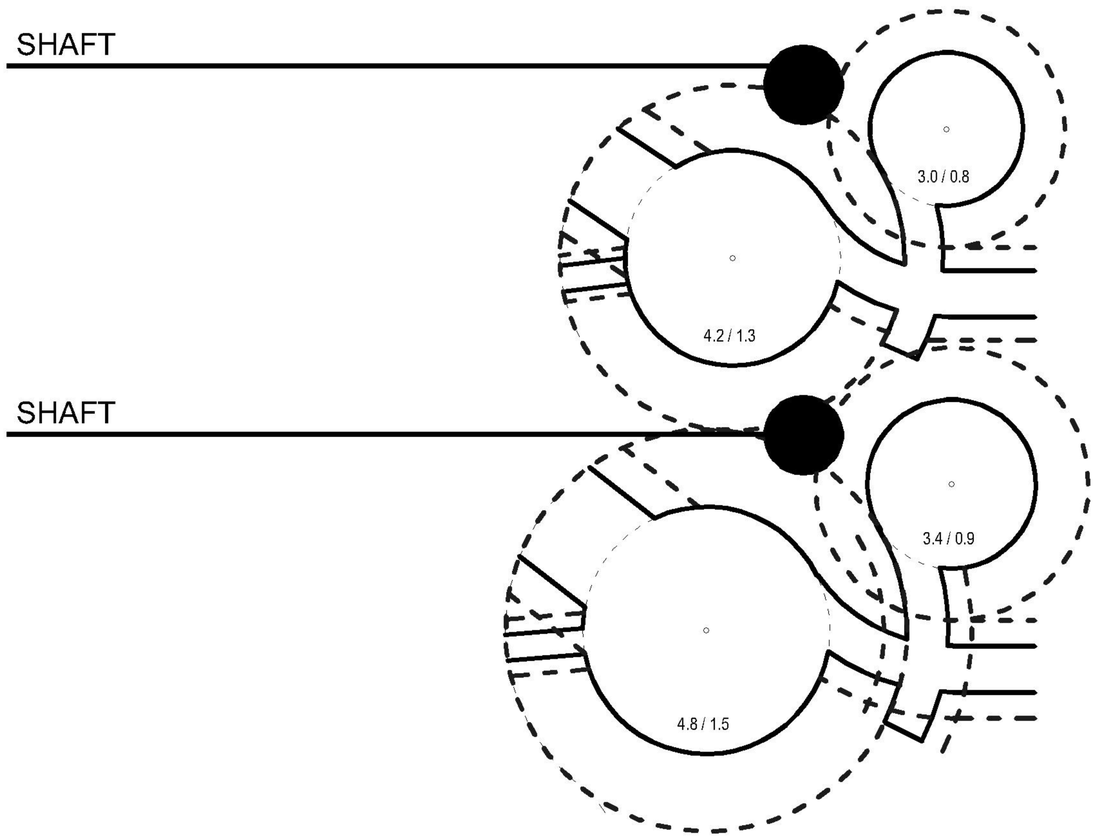


INCREASE BY % OF INTERFERED AREA
INCREASE BY % OF OPENINGS

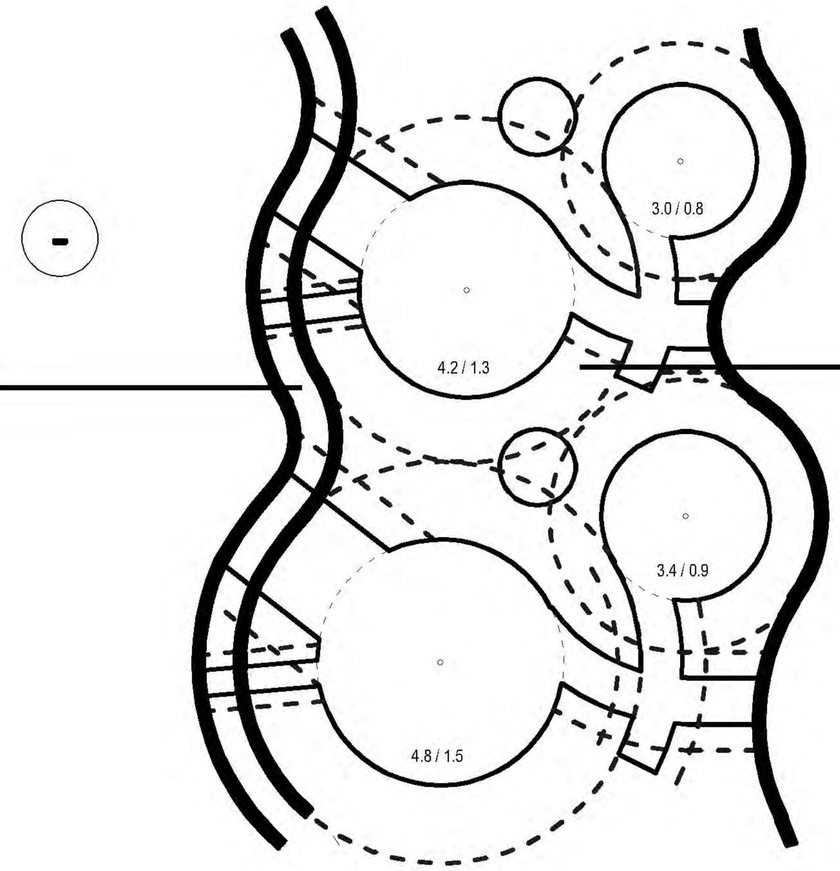
HOTEL ROOMS



HOTEL ROOMS



HOTEL ROOMS



INSULATED IMPREGNATED EARTH:

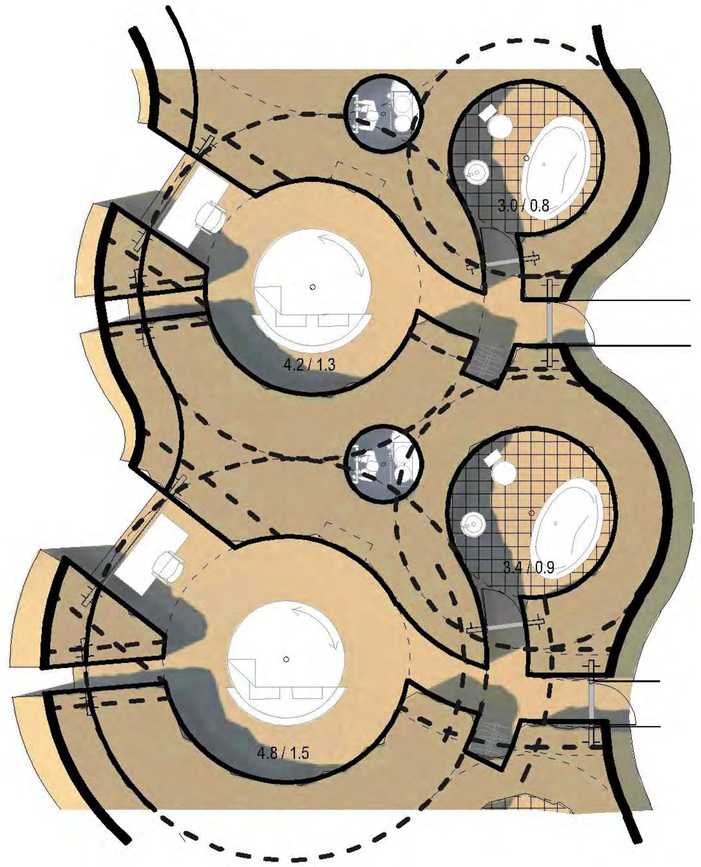
23% expanded glass
43% sand
20% silt
12 %clay
2% dissolved bitumen
(k-value ~0.11W/mK)



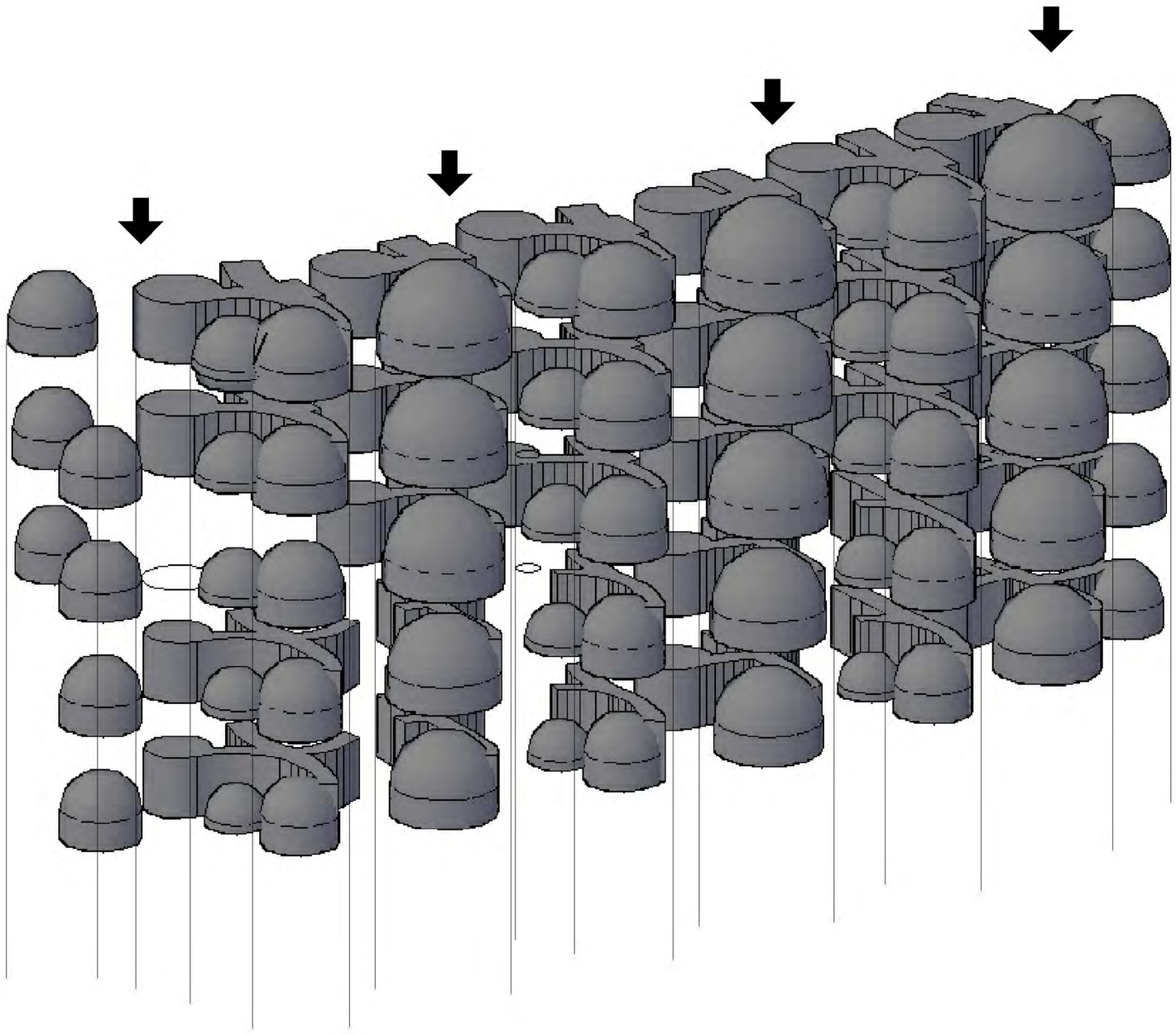
UNSTABILIZED EARTH:

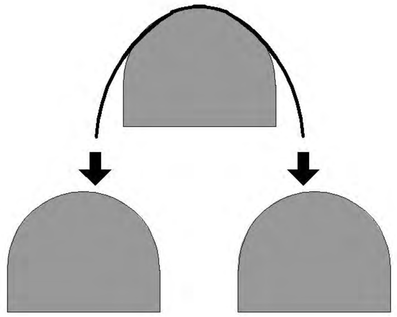
- 23% gravel
- 45% sand
- 20% silt
- 12 % clay

HOTEL ROOMS

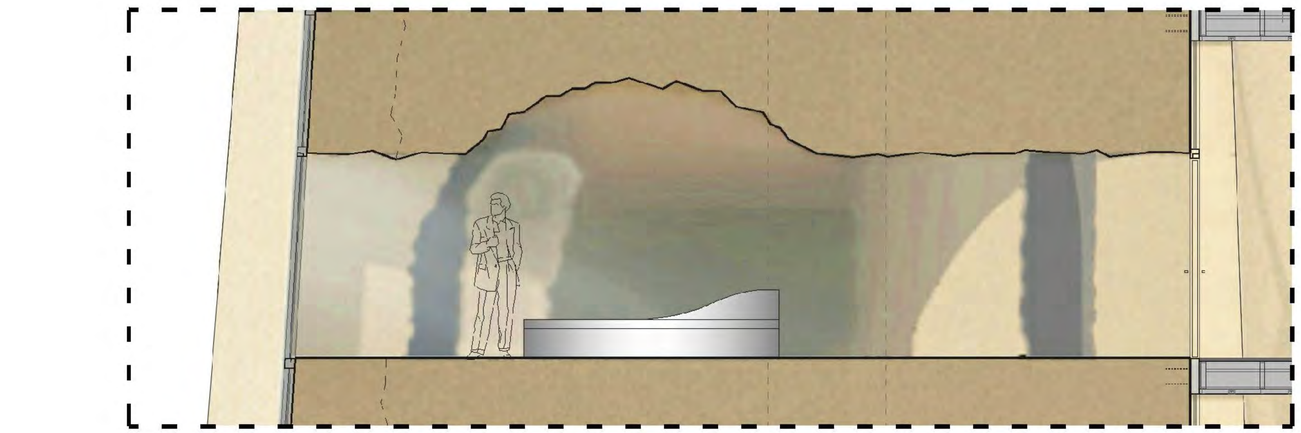


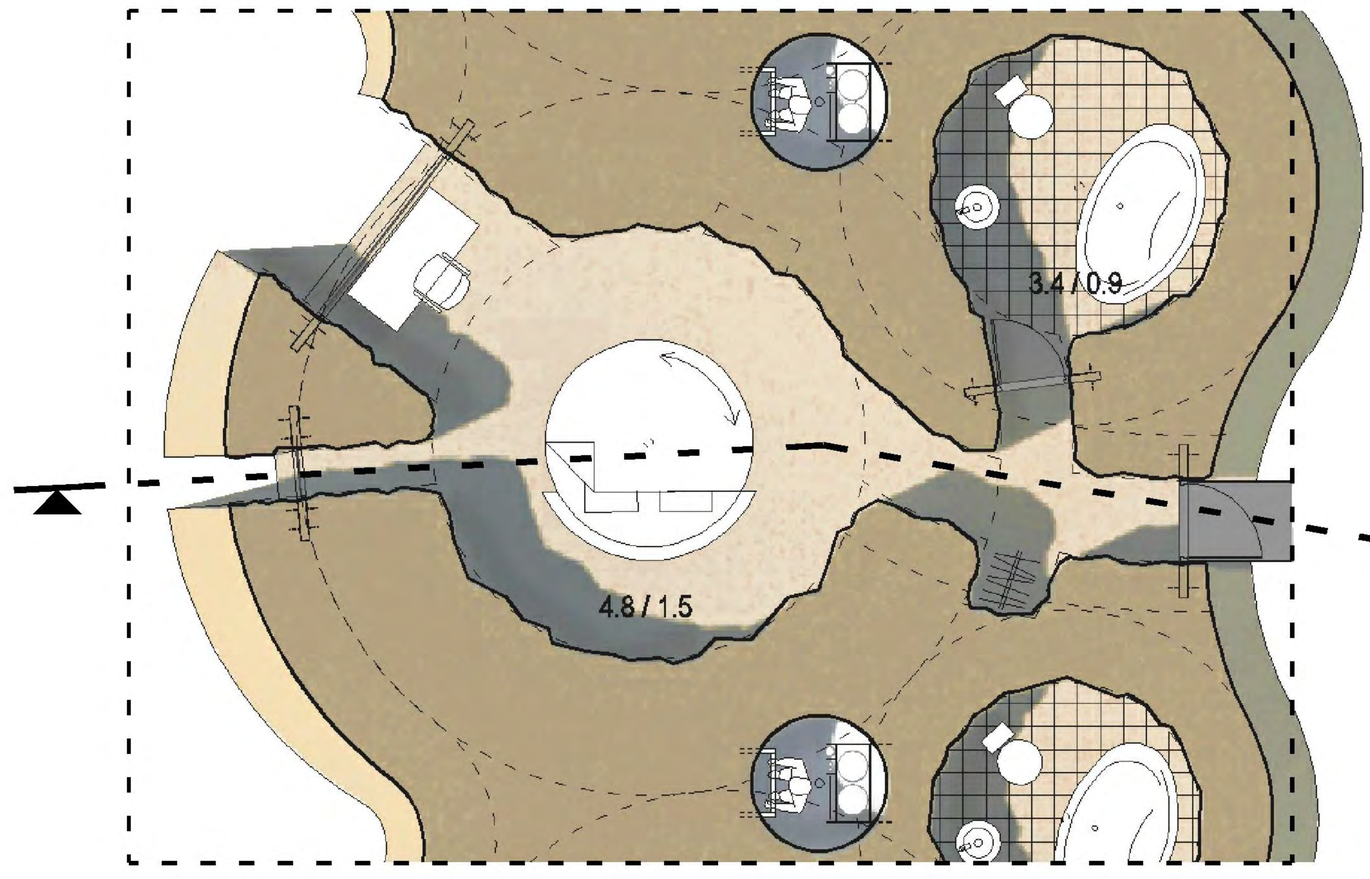
HOTEL ROOMS





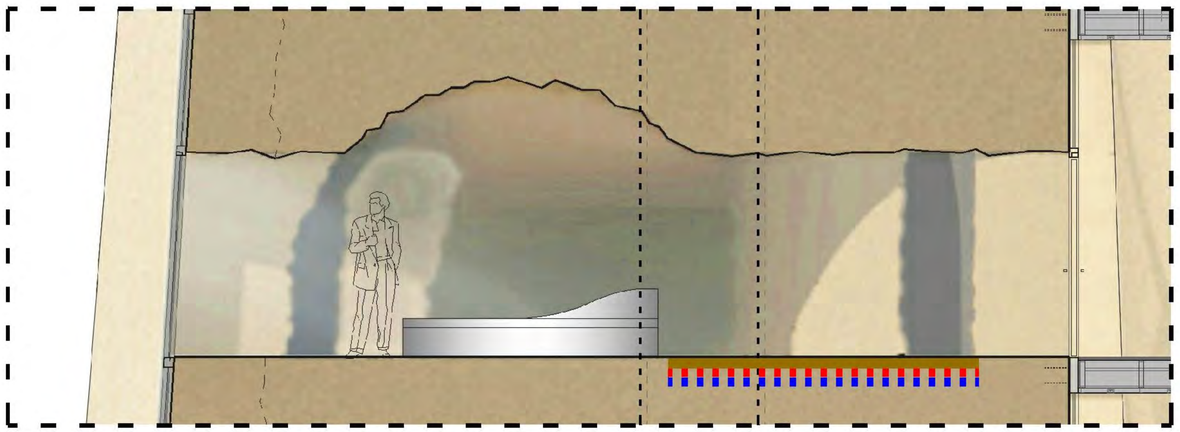
HOTEL ROOMS

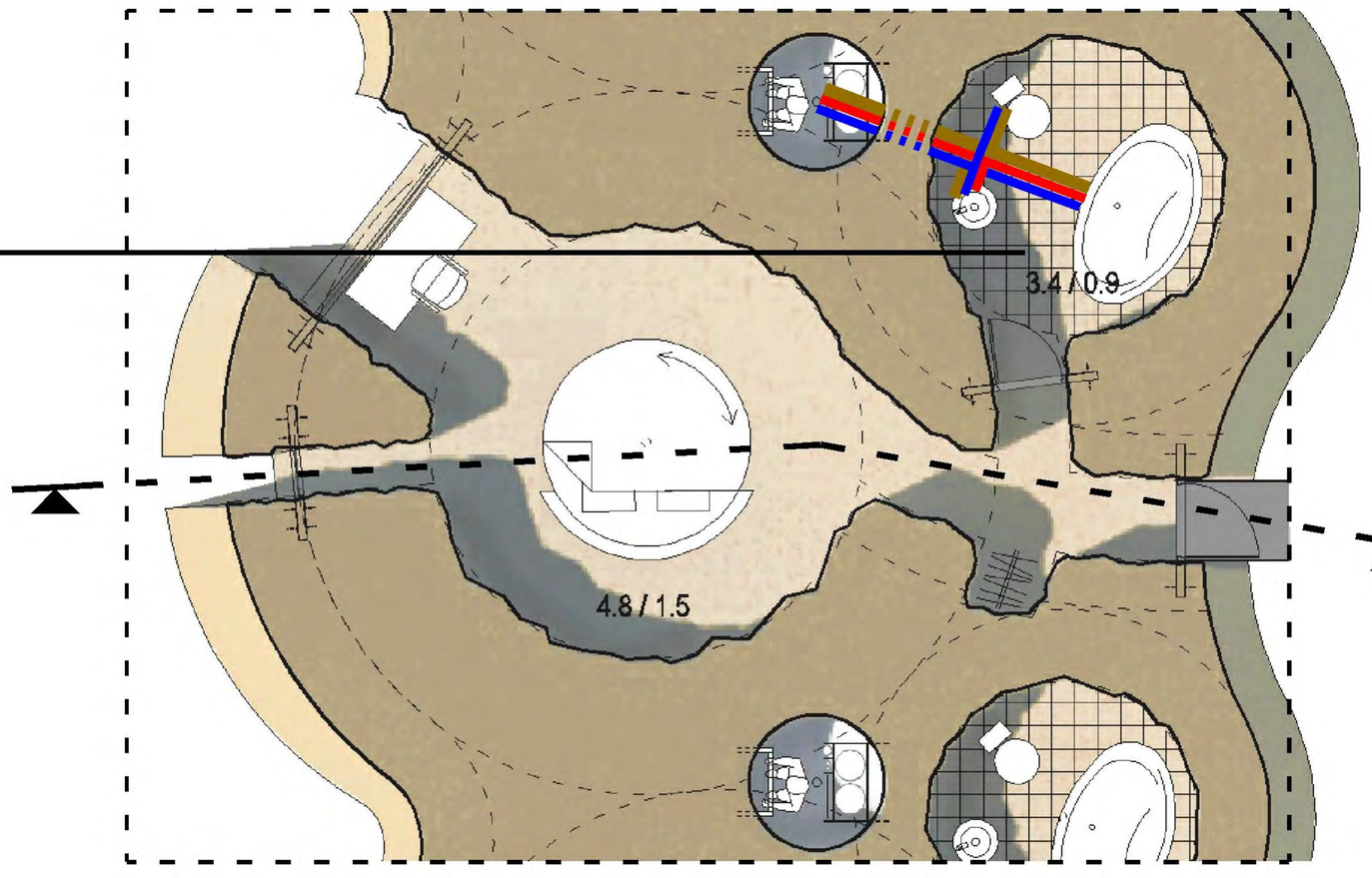




HOTEL ROOMS





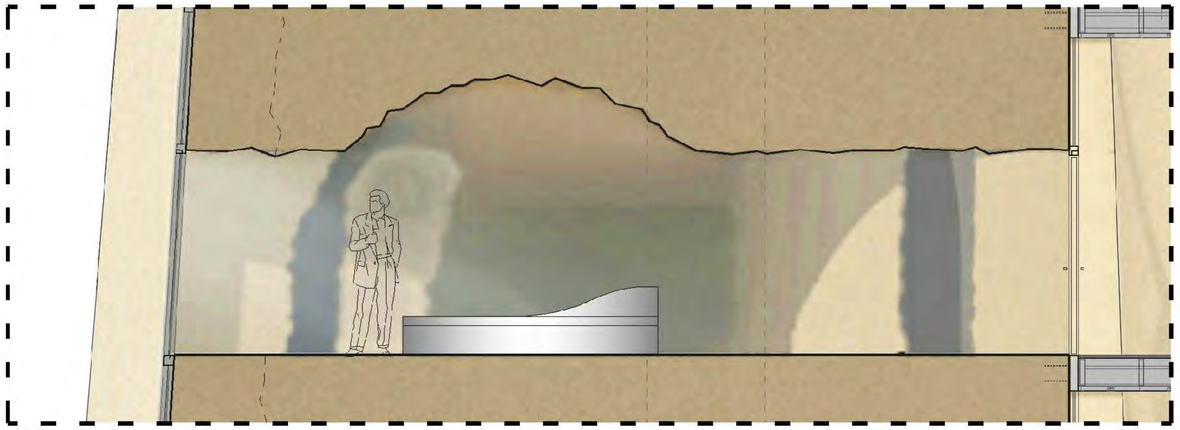


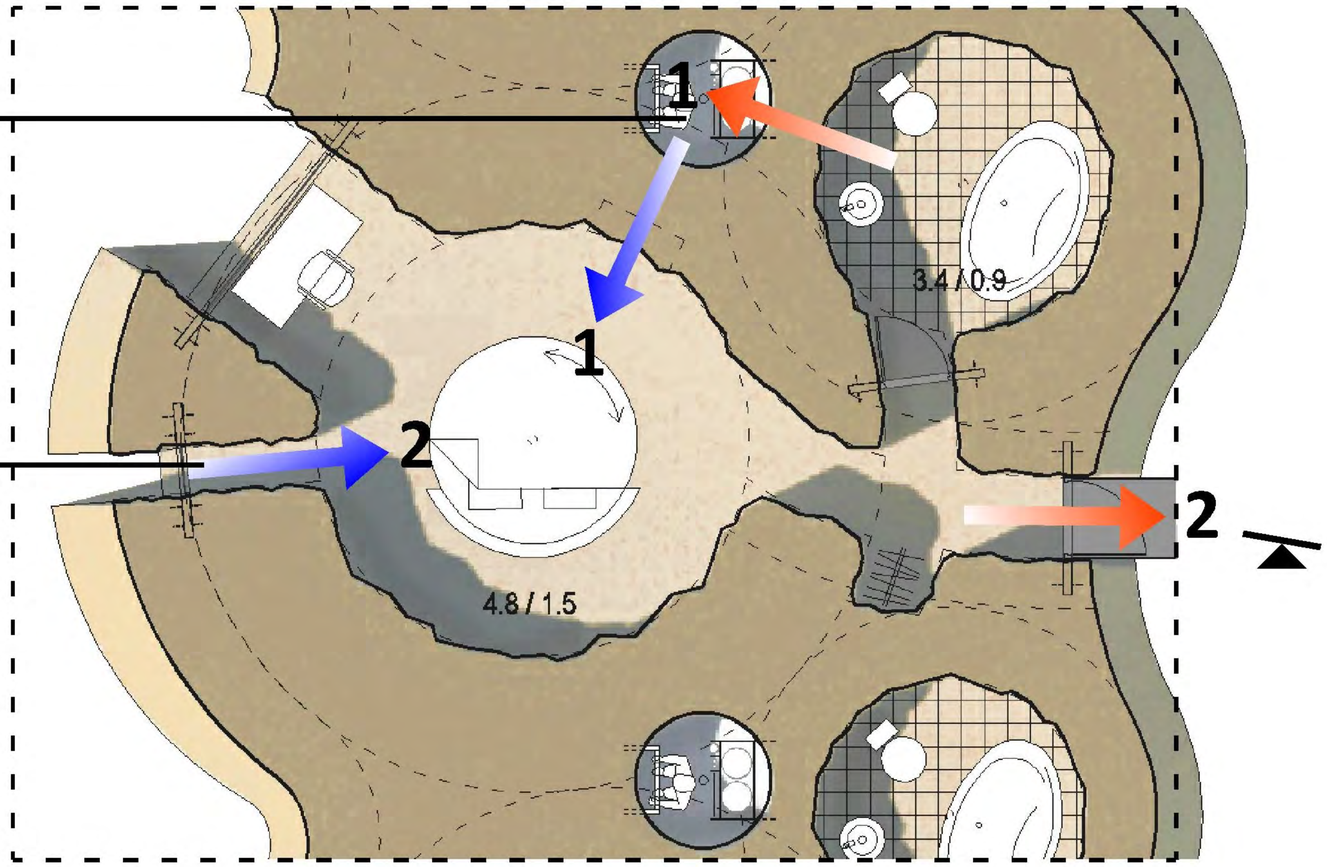
BATHROOM FLOOR

Tiles as in ground floor

No heating cable

HOTEL ROOMS



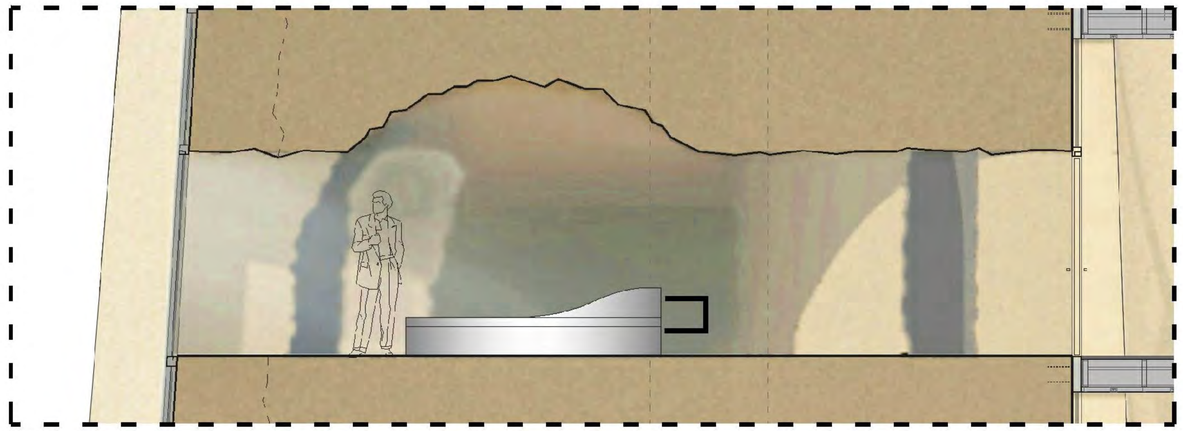


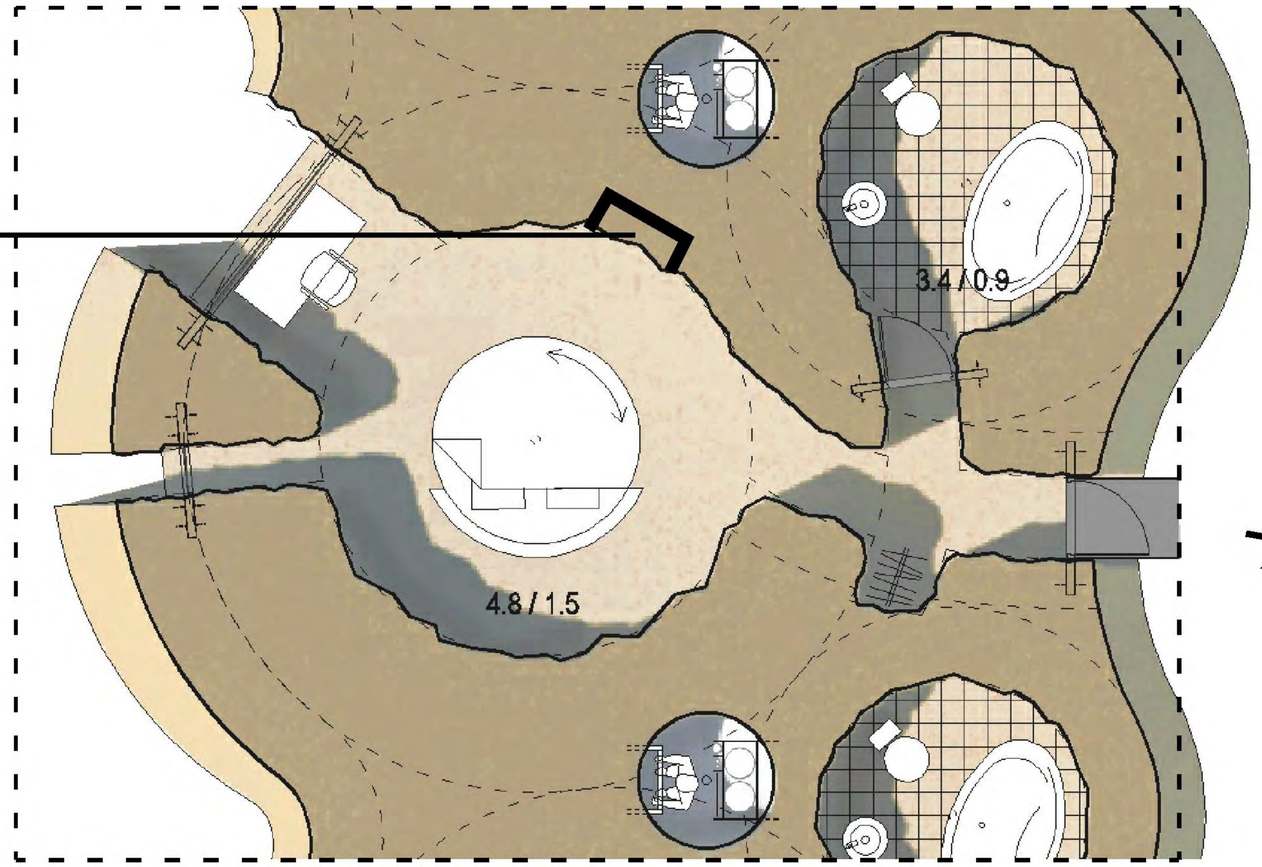
1. FORCED VENTILATION
   Via shaft. Ducts connected to heat exchanger

2. NATURAL VENTILATION
   Inlet through windows;
   Outlet under doors and up through atrium

HOTEL ROOMS







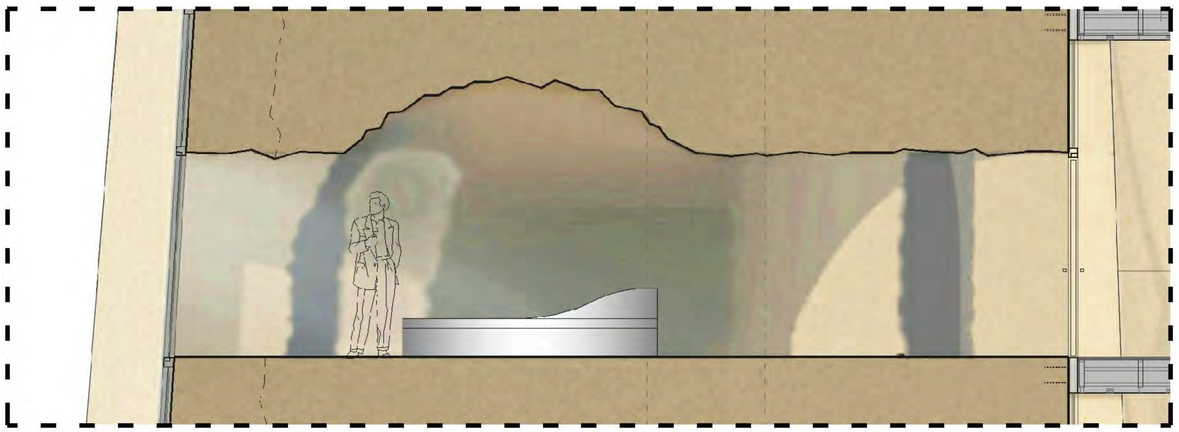
FIREPLACE

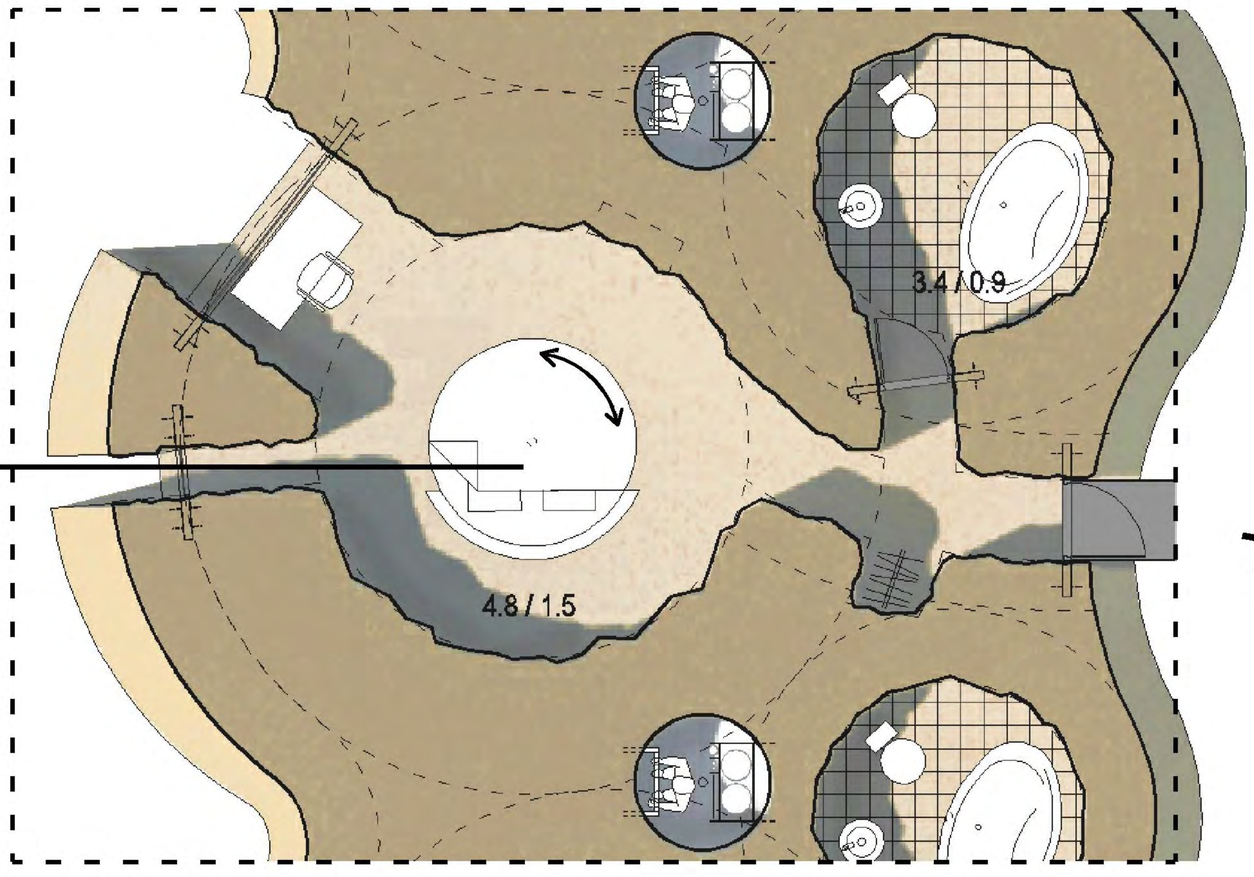
As natural heating source
and thematic reference to ancient
cave-men lifestyle



HOTEL ROOMS

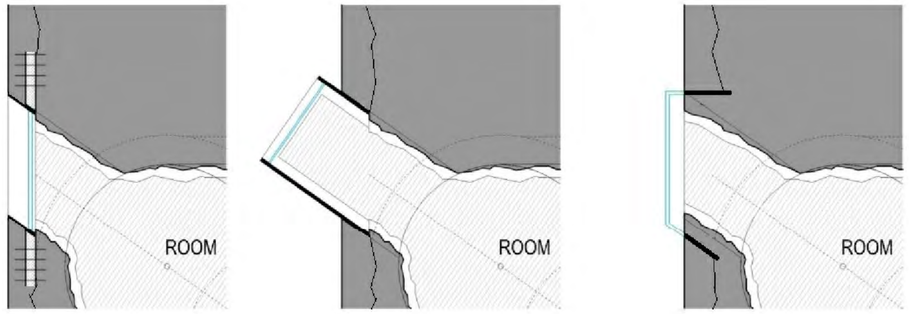


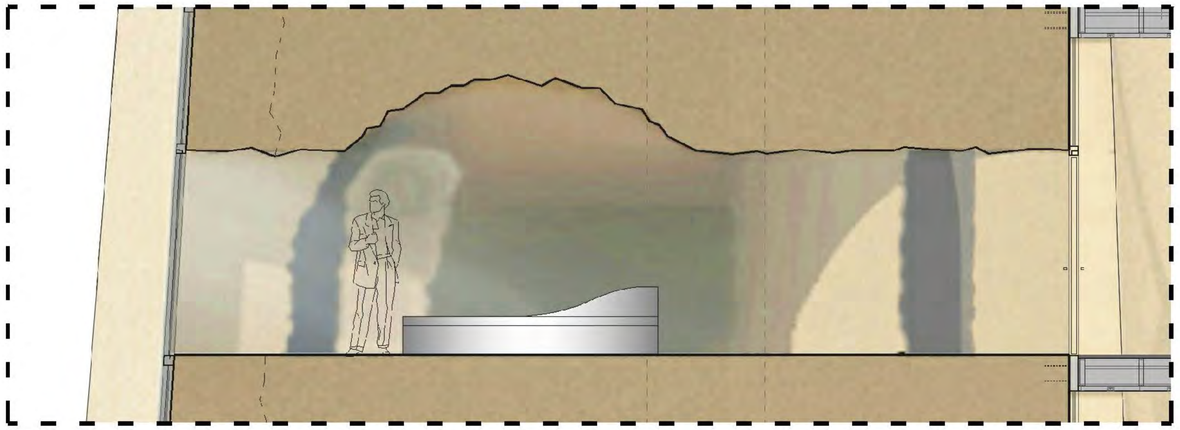


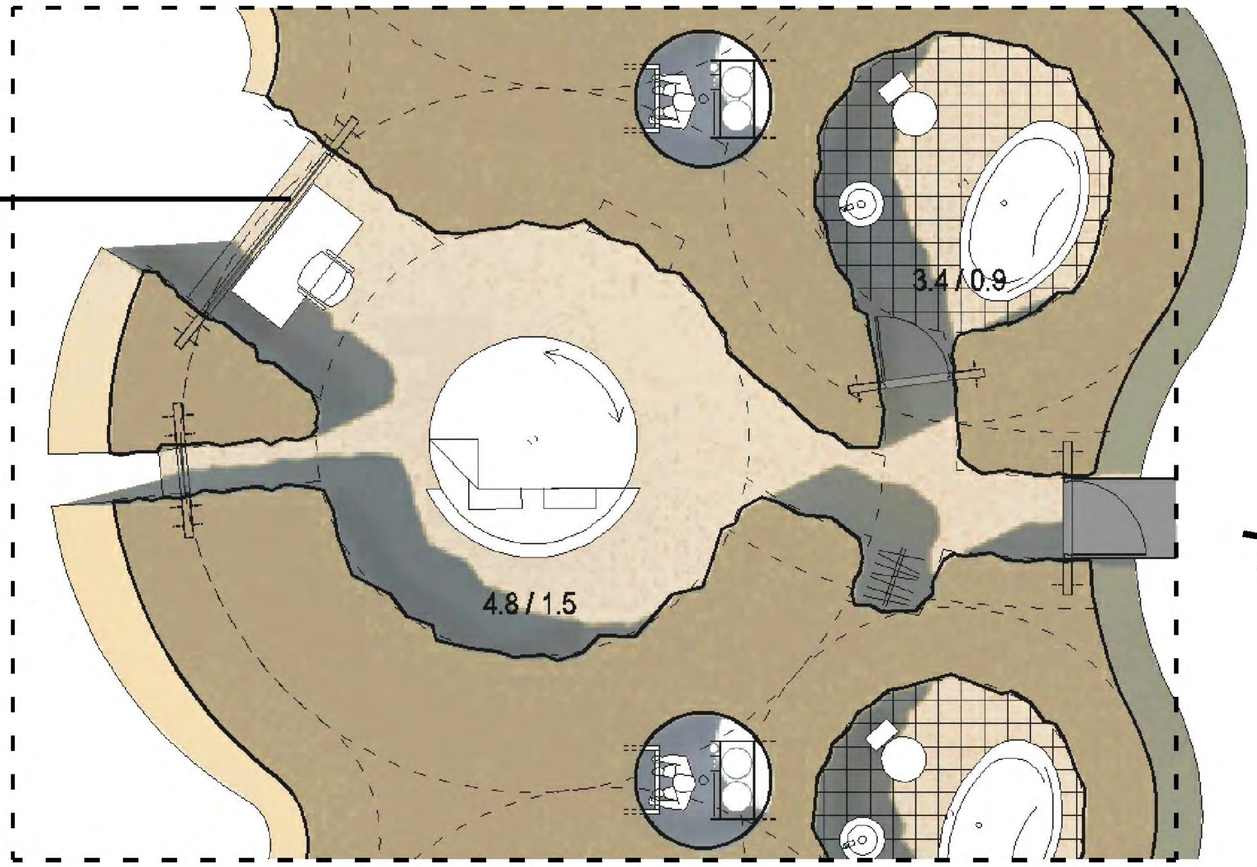


BED
Integrated lighting and television
Rotation option to choose view

HOTEL ROOMS



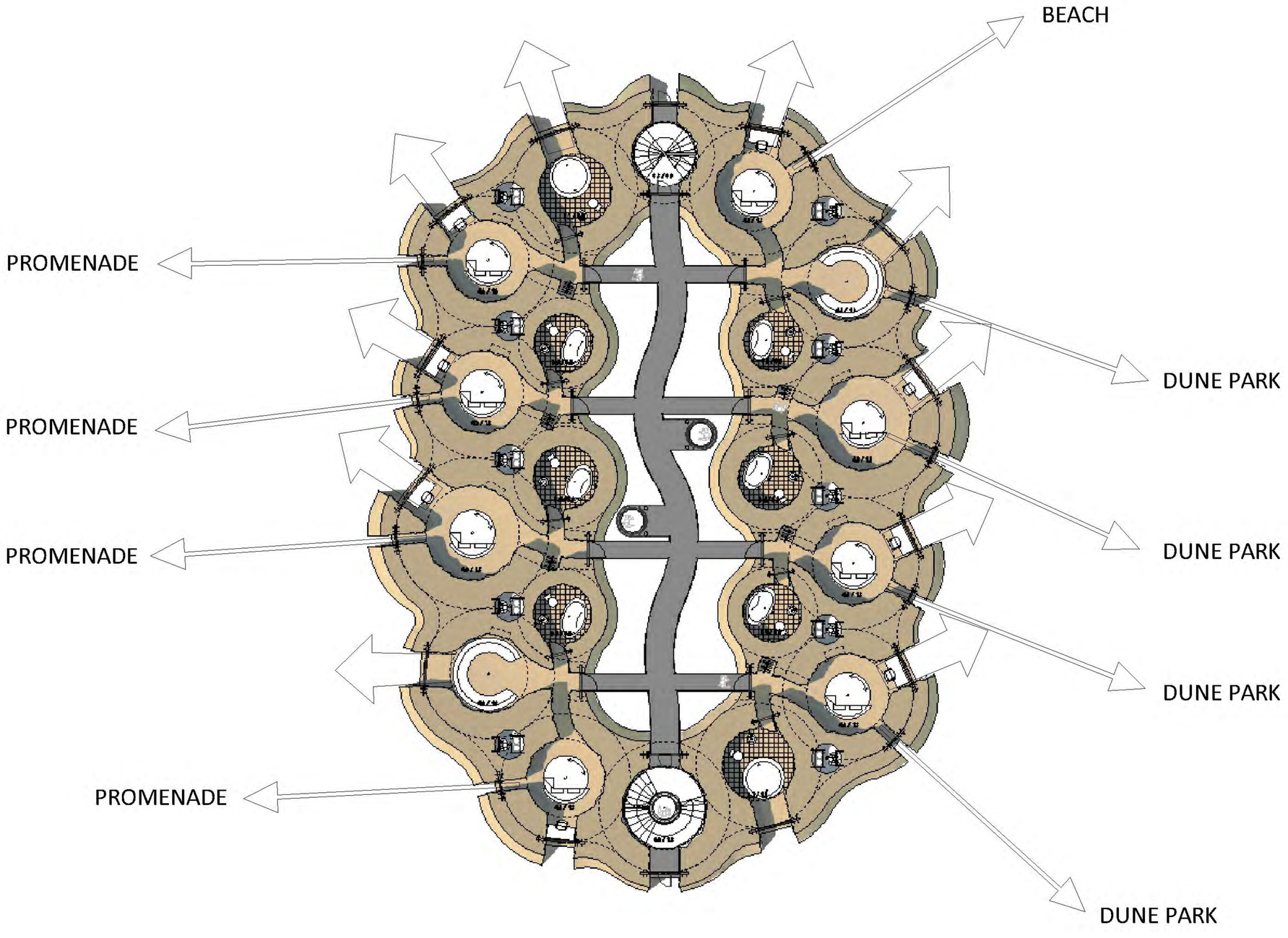




WINDOW (DOOR) SOLUTION

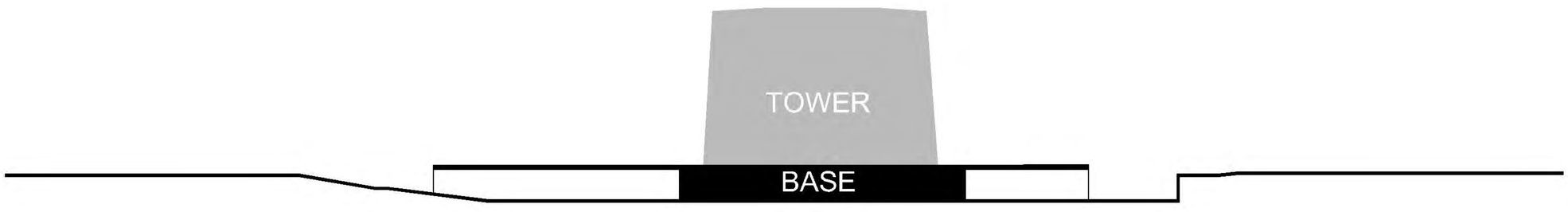
Frame as little visible as possible
Frame installed during pouring
Glazing placed later from outside

HOTEL ROOMS


BEACH
PROMENADE
PROMENADE
PROMENADE
PROMENADE
DUNE PARK
DUNE PARK
DUNE PARK
DUNE PARK

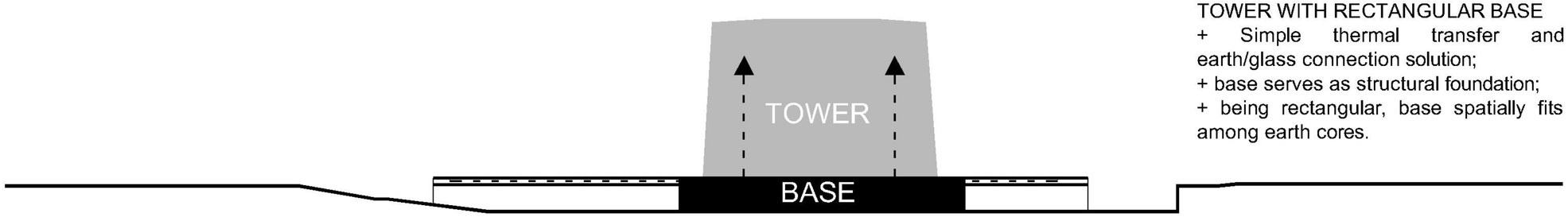


HOTEL ROOMS

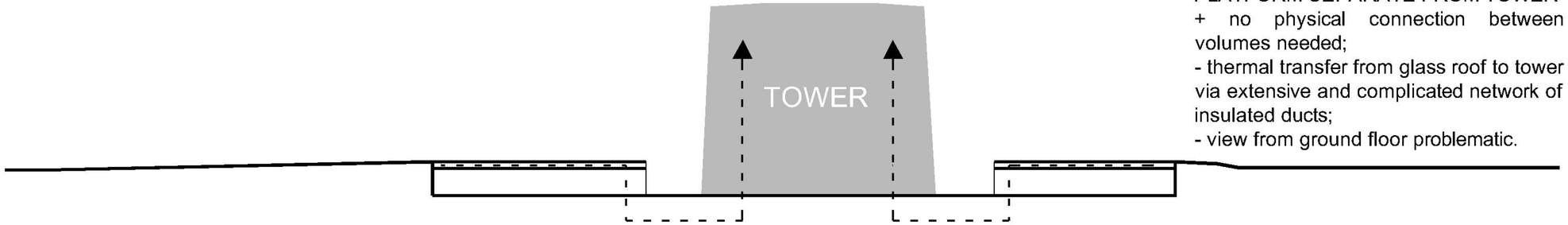




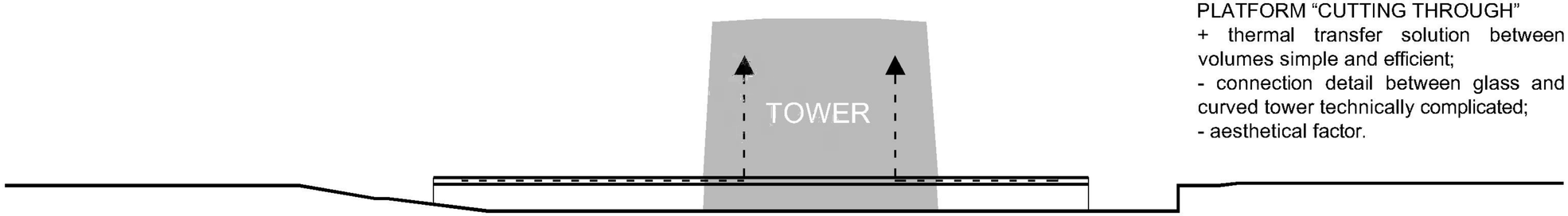
SLEEPING CAPSULES



TOWER WITH RECTANGULAR BASE
+ Simple thermal transfer and earth/glass connection solution;
+ base serves as structural foundation;
+ being rectangular, base spatially fits among earth cores.



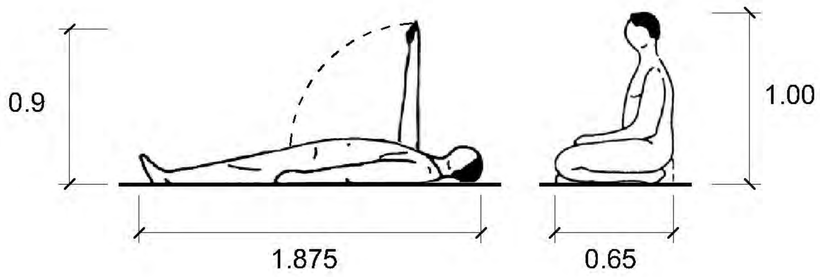
PLATFORM SEPARATE FROM TOWER
+ no physical connection between volumes needed;
- thermal transfer from glass roof to tower via extensive and complicated network of insulated ducts;
- view from ground floor problematic.

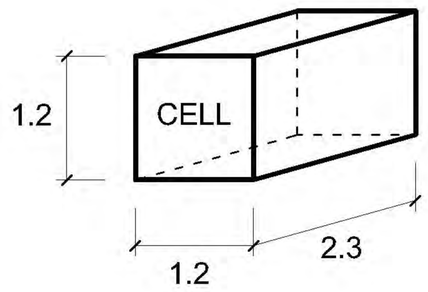


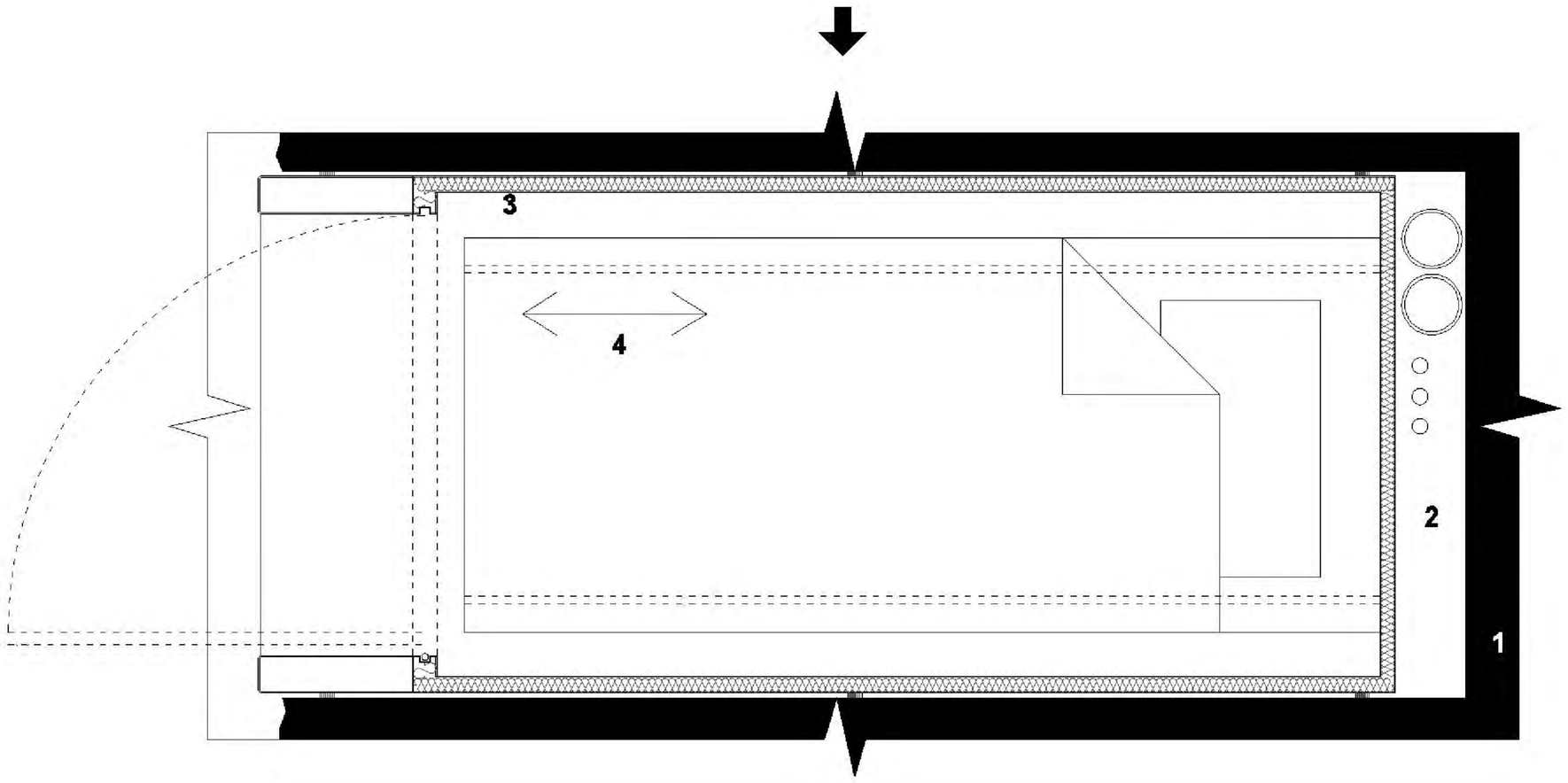
PLATFORM “CUTTING THROUGH”
+ thermal transfer solution between volumes simple and efficient;
- connection detail between glass and curved tower technically complicated;
- aesthetical factor.

SLEEPING CAPSULES





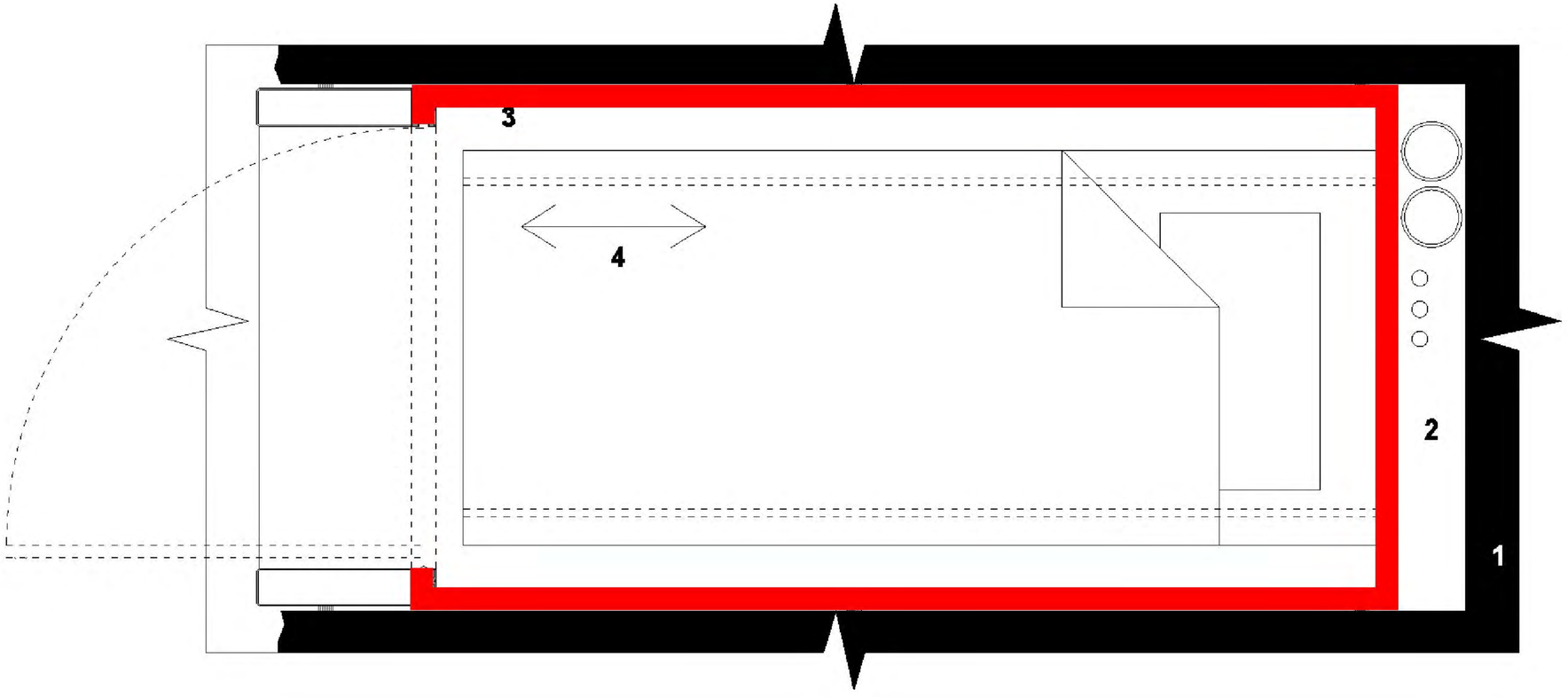




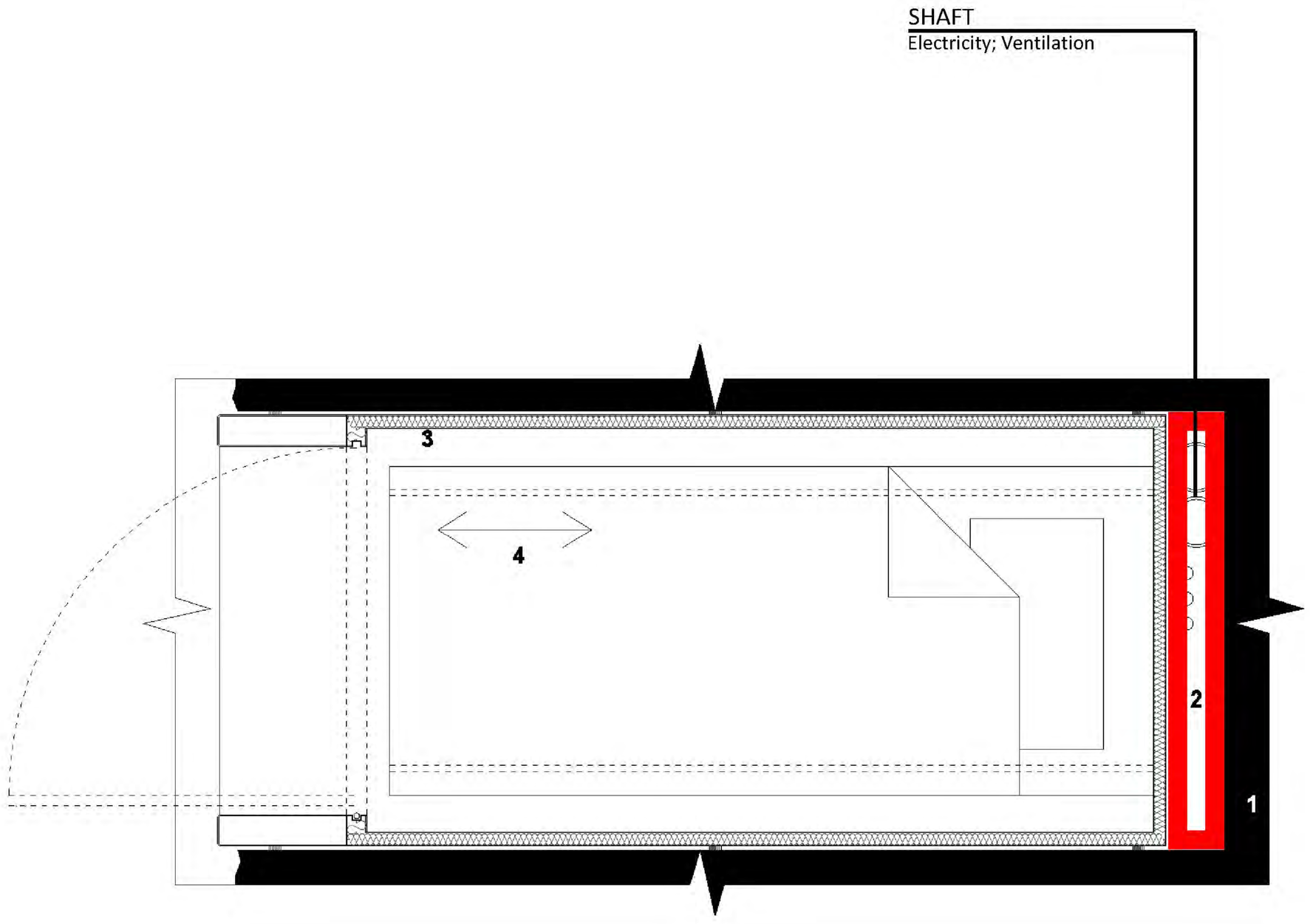
SLEEPING CAPSULES



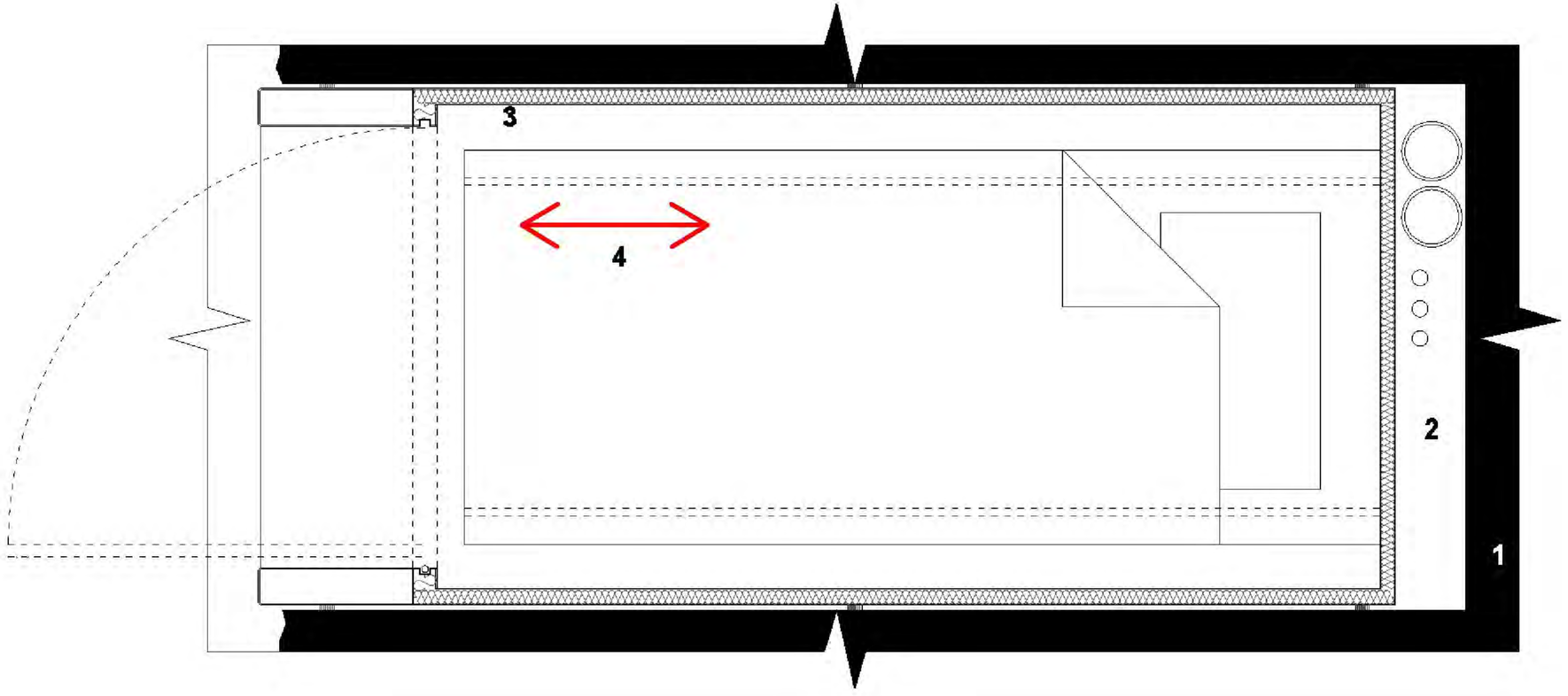
t°



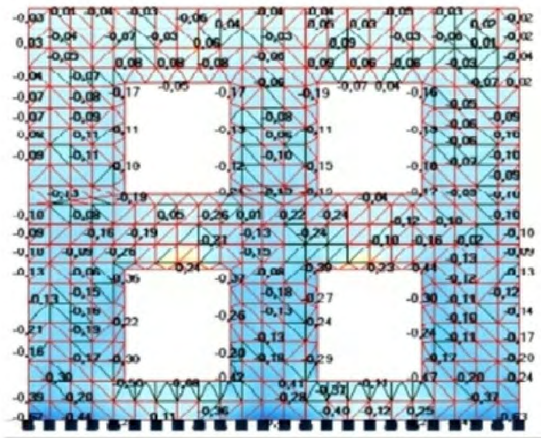
SLEEPING CAPSULES



SLEEPING CAPSULES



SLEEPING CAPSULES

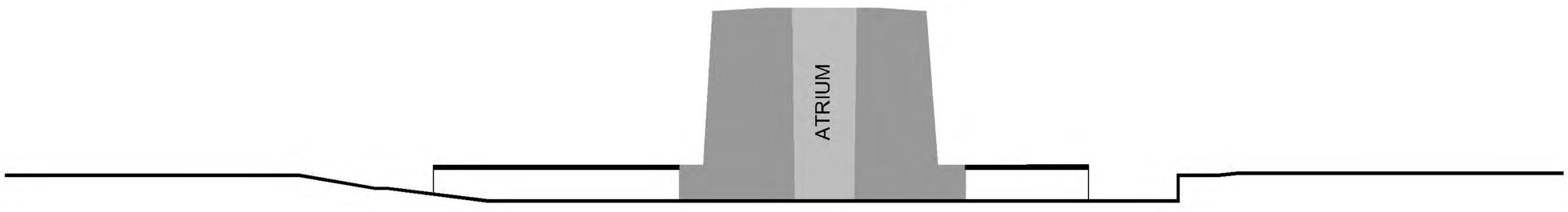


UNSTABILIZED EARTH:
- 23% gravel
- 45% sand
- 20% silt
- 12 % clay

STABILIZED, IMPREGNATED, INSULATED EARTH

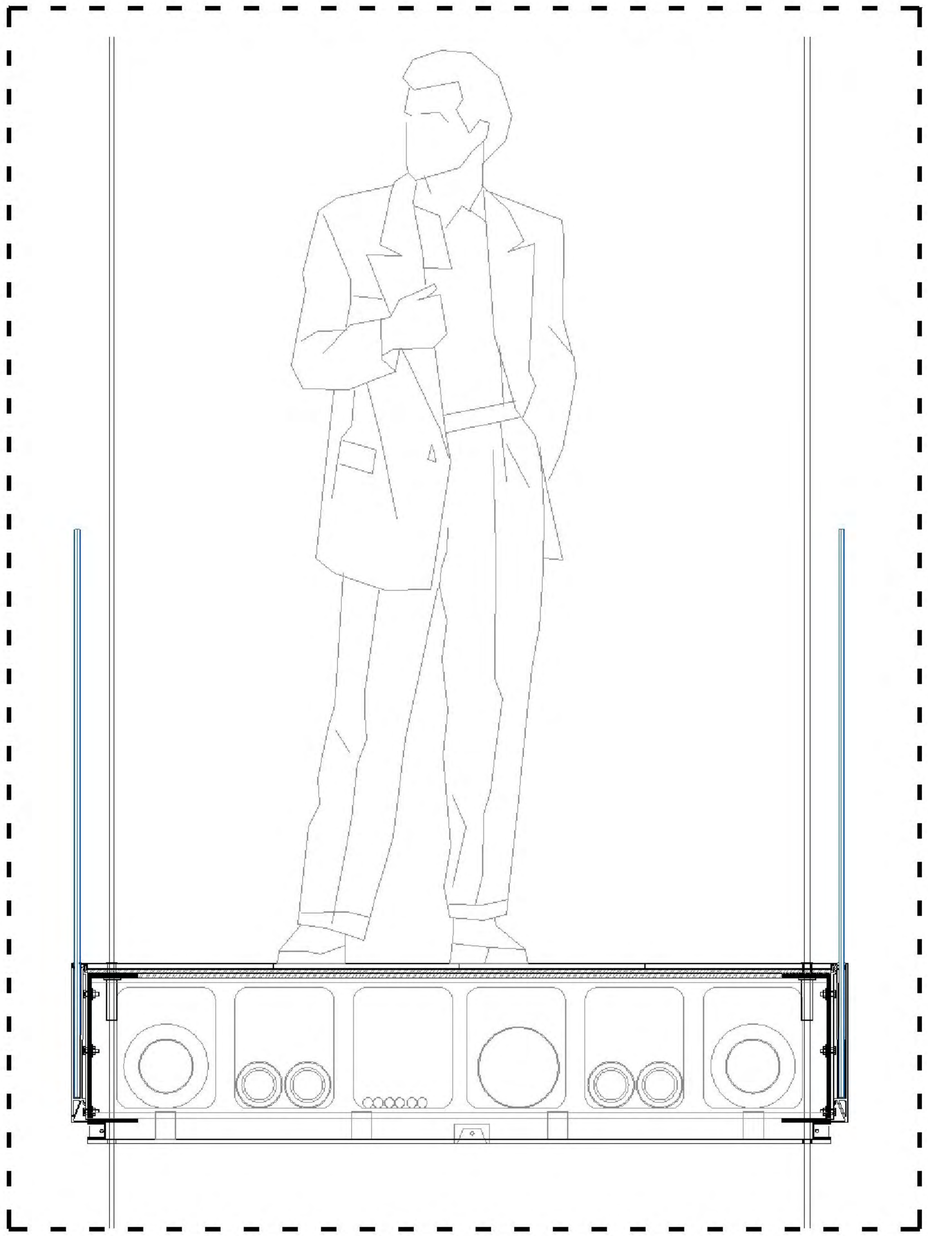
23% expanded glass
43% sand
20% silt
7 %clay
2%bitumen
5%cement

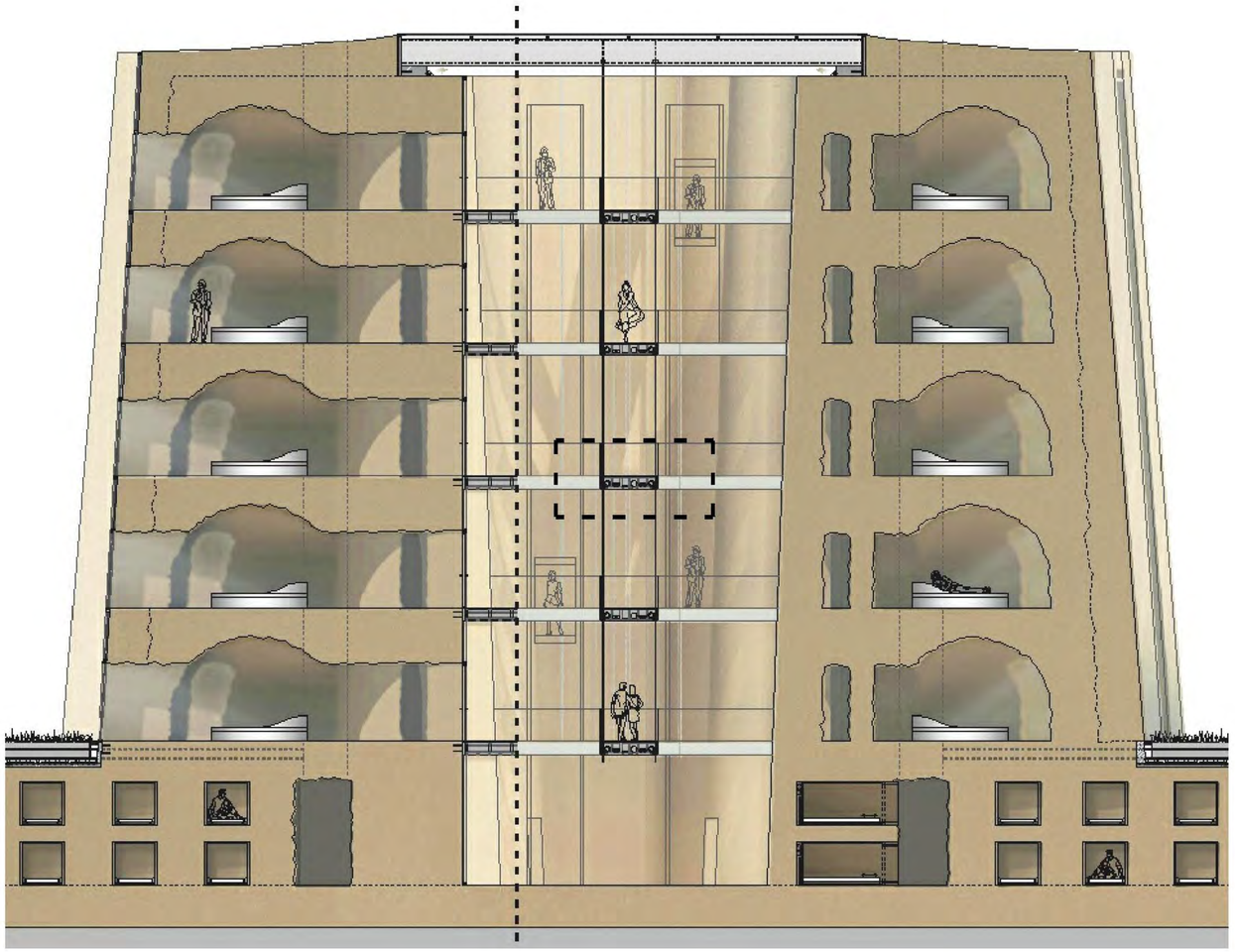
ATRIUM



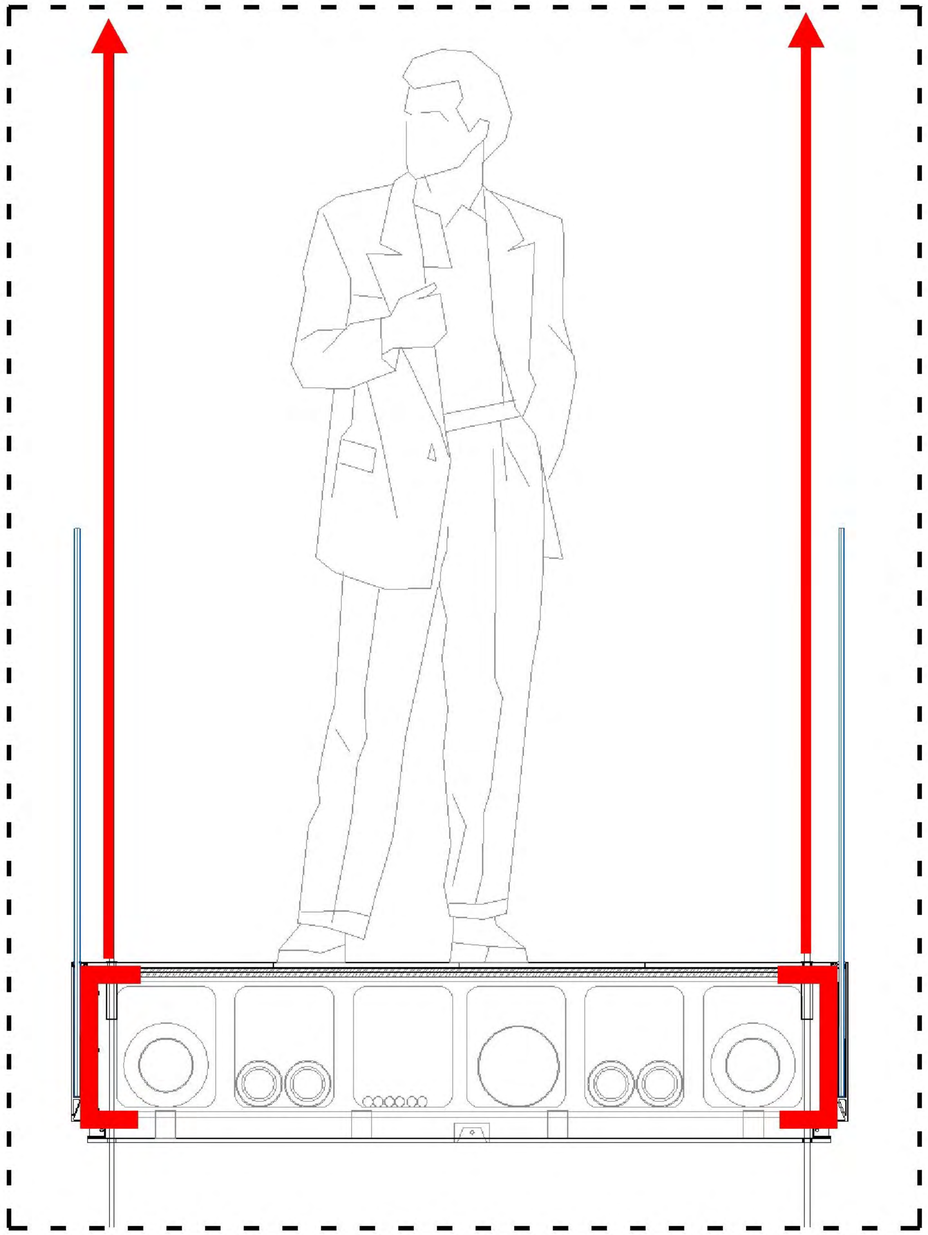


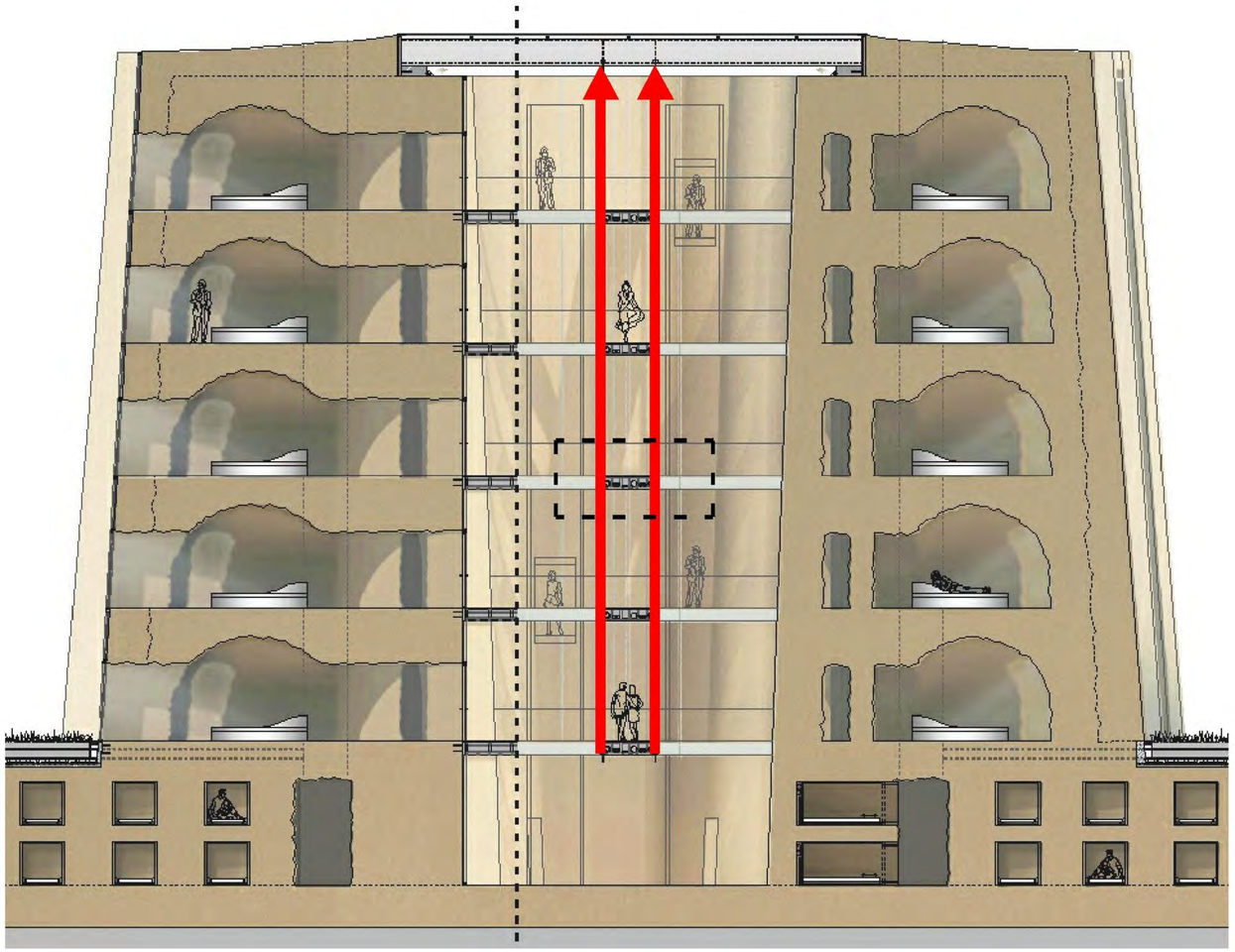
ATRIUM



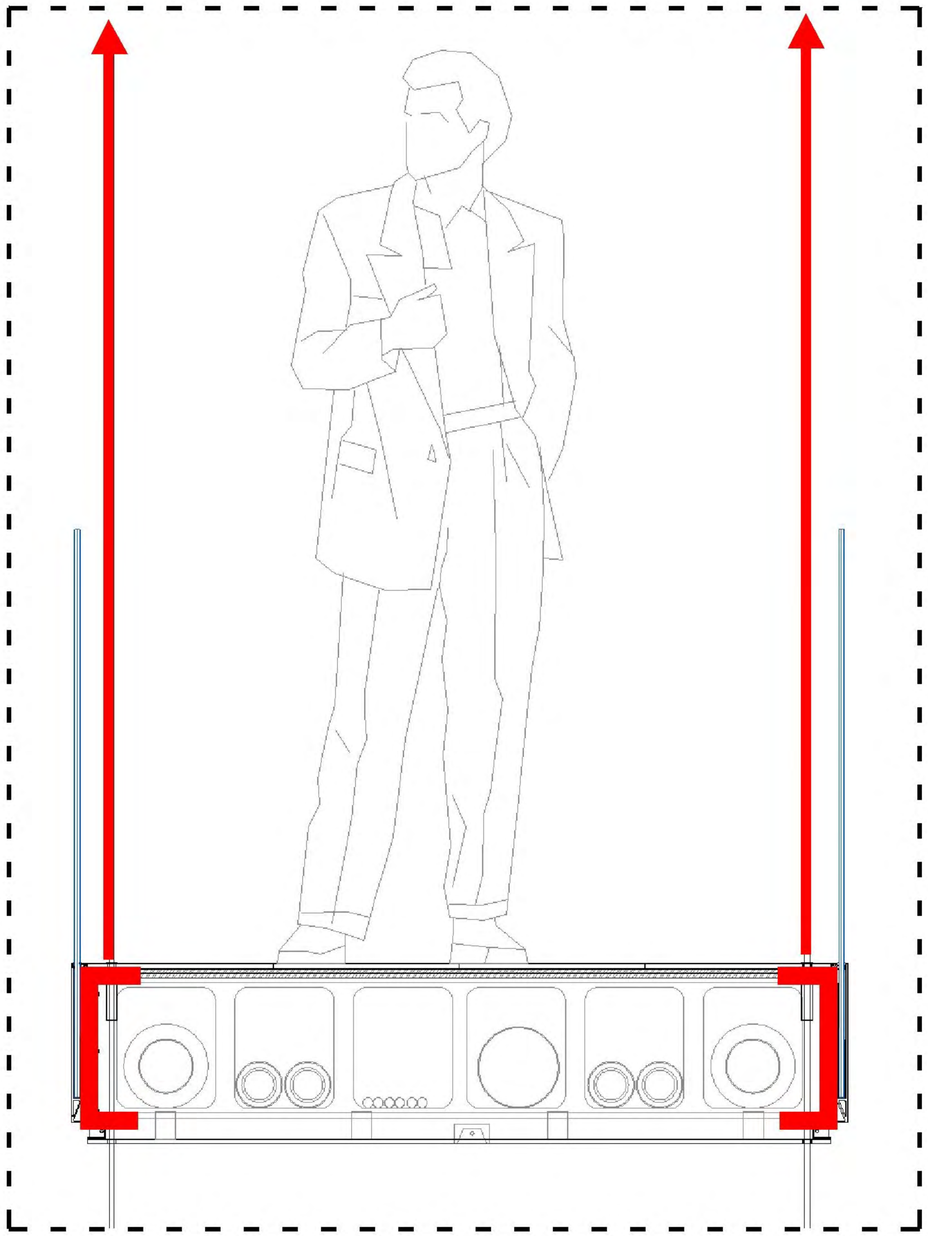


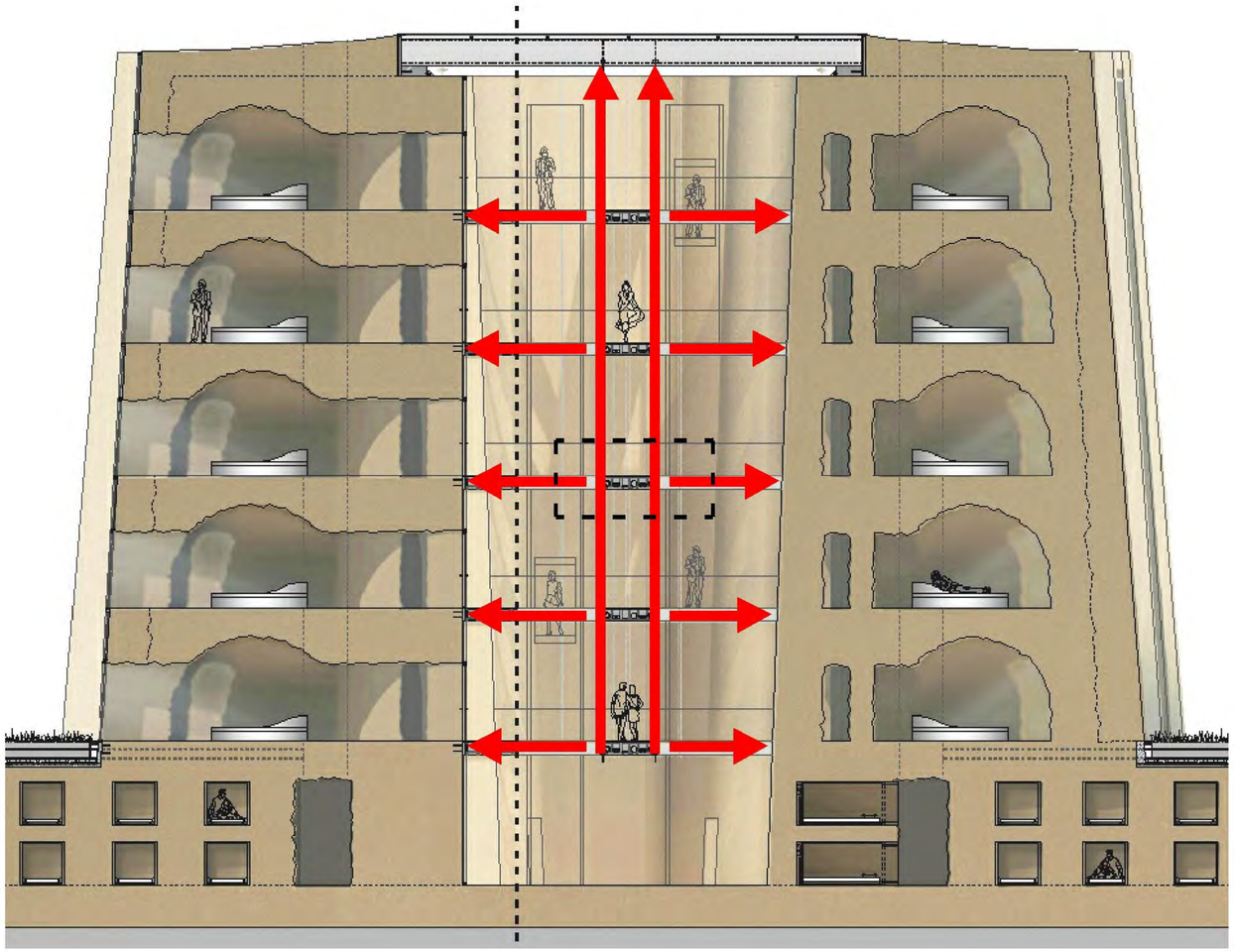
ATRIUM



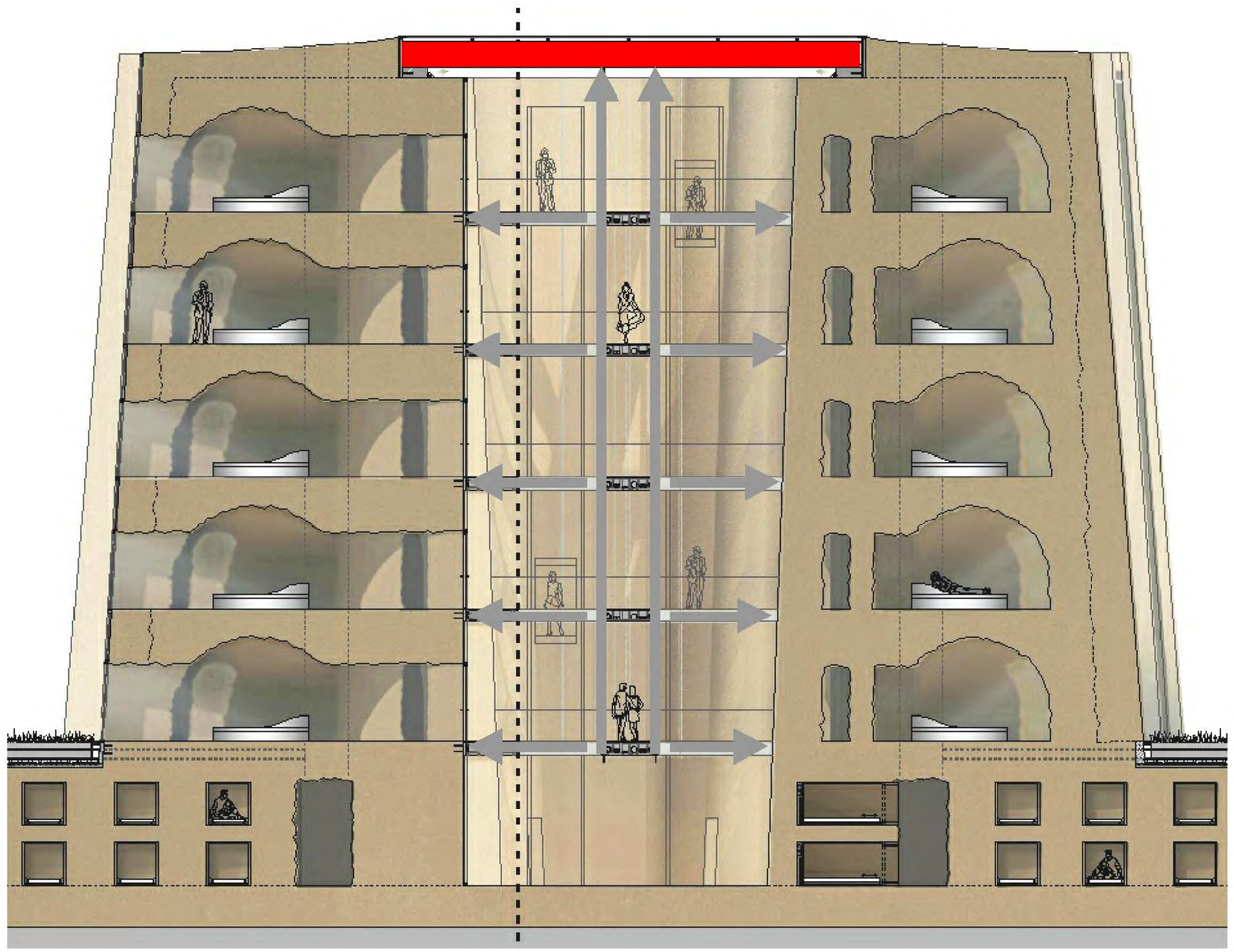


ATRIUM

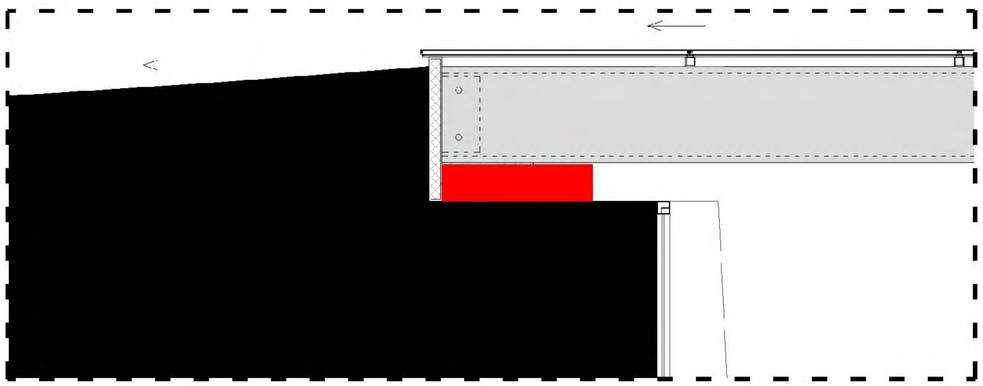


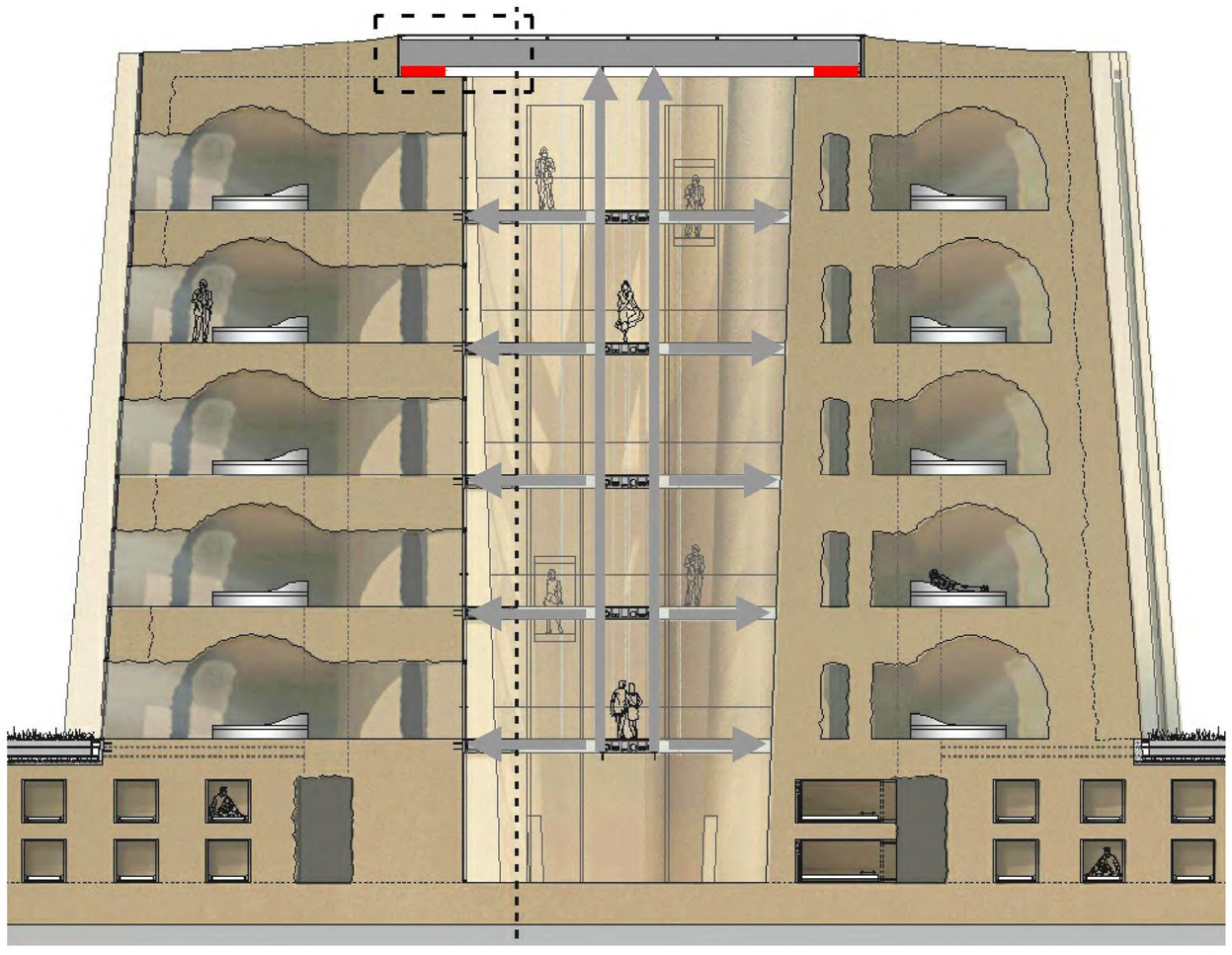


ATRIUM



ATRIUM

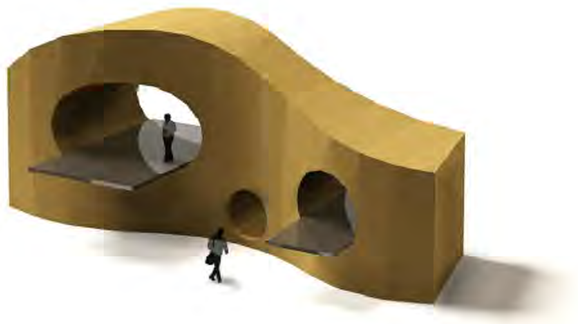


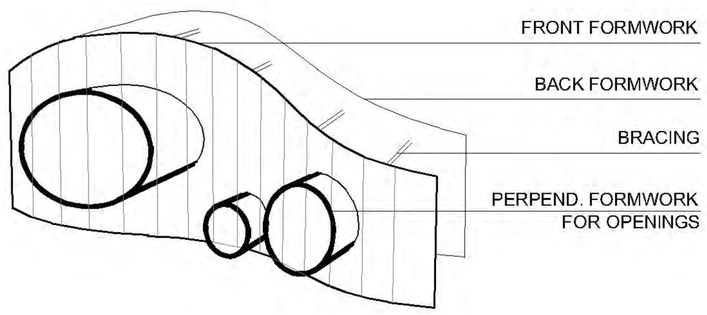




CONSTRUCTION METHODS

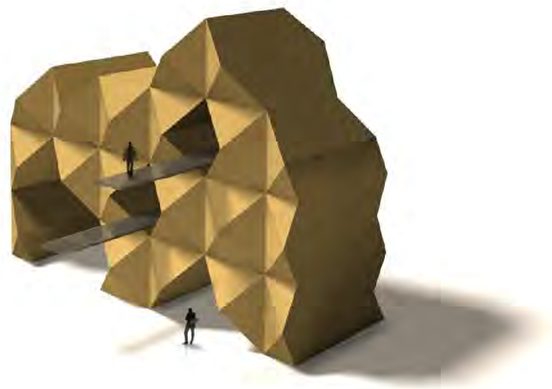
2D INDIVIDUALLY CUSTOMIZED RIGID FORMWORK

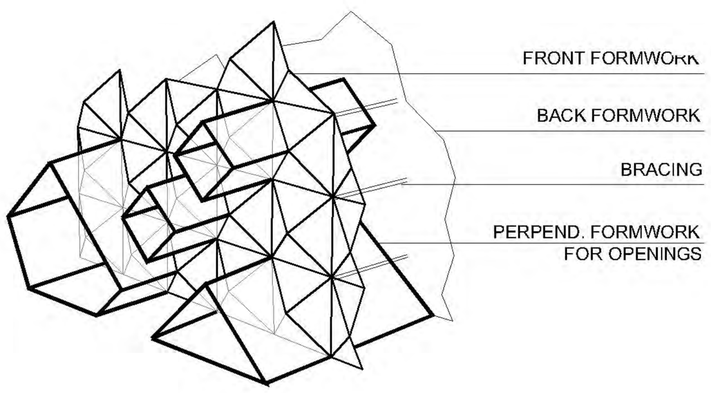




+ Individually customized opening shapes according to spatial, structural etc. needs;
- Expensive, non-standard formwork;
- Aesthetics - experience of caves achieved only partially;
- Significant heat loss through windows.

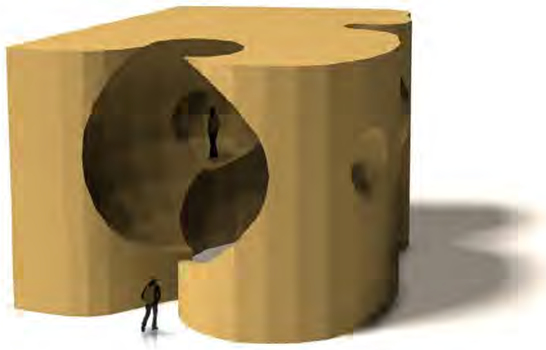
2D FOLDABLE ORIGAMI-BASED RIGID FORMWORK

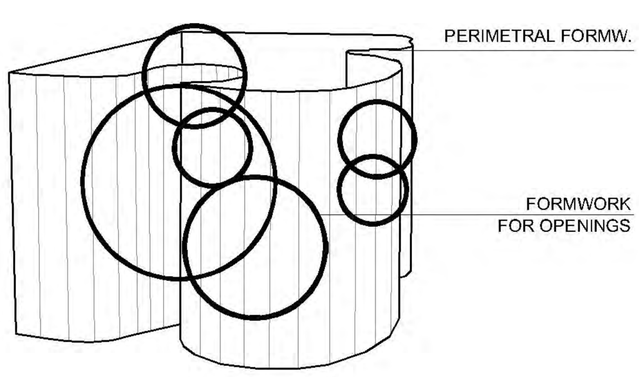




+ Much more cost effective than individual rigid formwork;
- Regularity leads to very limited configuration of openings and visual monotony;
- Sharp corners improper for earth as they cause large stresses and may erode by time.

3D REMOVABLE IN-FILL FORMWORK





+ Allows better thermal and structural utilization of earth;
+ Larger design freedom;
+ Outcome closer to natural caves;
- Complicated formwork.

CONSTRUCTION METHODS

INFLATABLE FORMWORK SYSTEM



+ Quick and easy installation and dismounting;
+ Central axis prevents cushions from lifting up during the pouring process;
- Hardly used in practice;
- Application mainly for thin concrete and composite shells. Might deform under the load of earth;
- Individual order with branches needed.

BUBBLE DECK PLASTIC BALLS IN FABRIC MOLDS



+ After removal can be re-used;
+ Interesting texture on surfaces with curved relief;
+ Lightweight;
+ Removal can be done from anywhere;
- Research needed to understand laying basics and compression properties;
- Removal must be verified;
- Shipment.

CULVERT FORMWORK SYSTEM



+ Verified in practice;
+ Relatively easy dismounting and formwork can be reused;
- Impossible to create "branches";
- Limited shape offer in market.

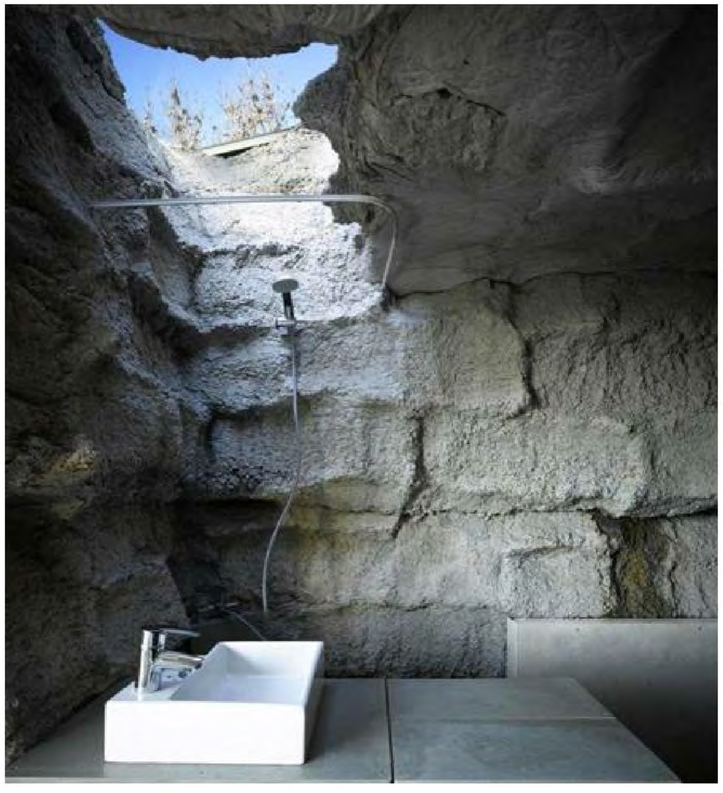
CONTOUR MILLED FORMWORK REMOVED BY BURNING



+ precise and rigid;
+ layer technique can be used to create steps, seating etc in earth.
+ interesting texture on surfaces;
+ burning technique can be used for removal;
- design limitations due to oxygen flow;
- individual, time and resource demanding production;
- no recycling.

CONSTRUCTION METHOD







CONSTRUCTION METHOD





+ Available on site. After use can be returned;
? Textures on surfaces and their relation to earth properties
? Unclear how to remove after casting;
- Removal must start from top only;
- Time consuming.

CONSTRUCTION METHOD



CONSTRUCTION METHOD



CONSTRUCTION METHOD



COVERED WITH
CONSTRUCTION MEMBRANE

WITHOUT COVER

CONSTRUCTION METHOD





CONSTRUCTION METHOD



COVERED WITH
CONSTRUCTION MEMBRANE

WITHOUT COVER

CONSTRUCTION METHOD



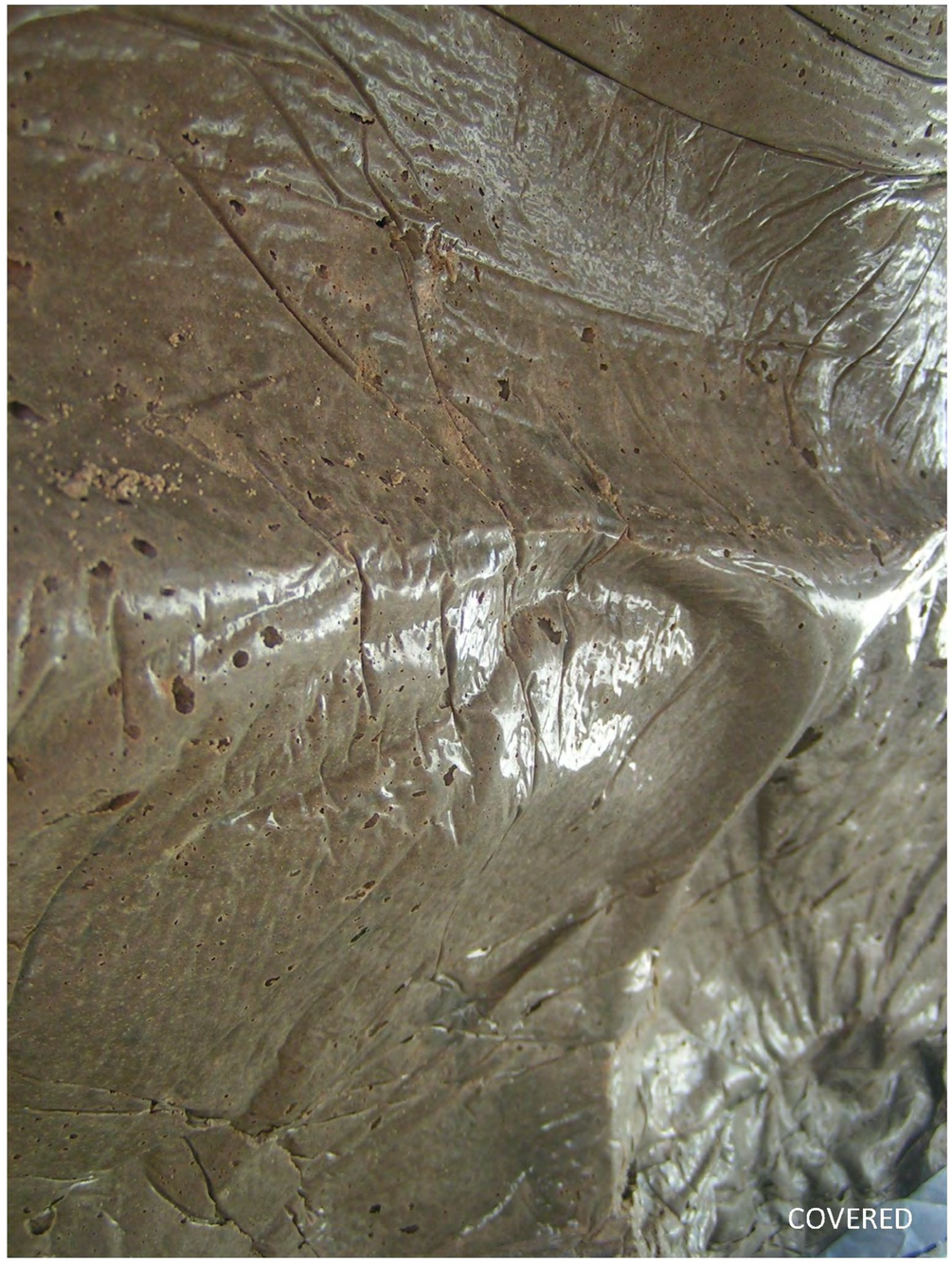
UNCOVERED



COVERED (TOP); UNCOVERED (BOTTOM)

CONSTRUCTION METHOD





CONSTRUCTION METHOD

CONCLUSIONS

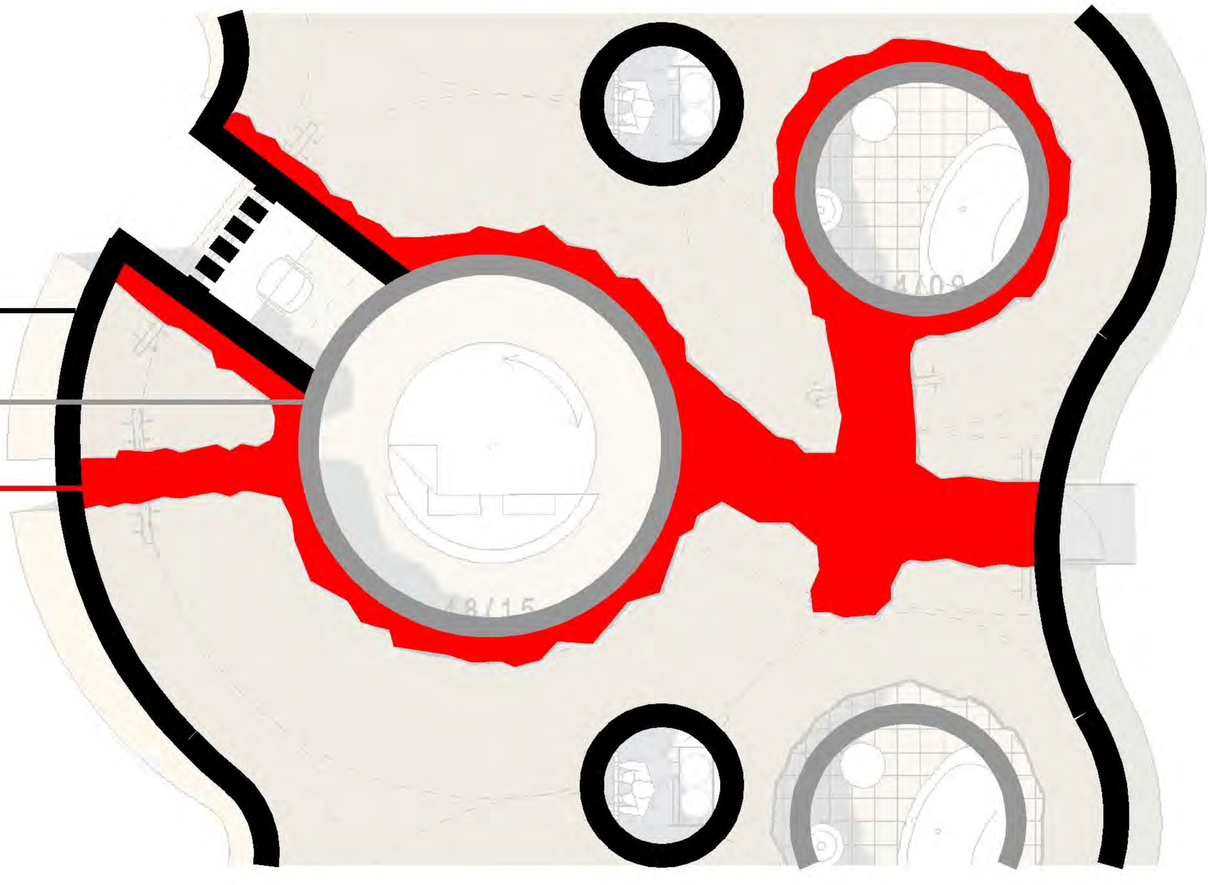
+ Texture created by sandbags covered with construction membrane is suitable for earth application and gives visual impression that fits the design concept;
+ First sandbag should be opened before removal. Others can be removed rather easy without opening

- Voids made entirely of sandbags is too time consuming and expensive for the Netherlands.

INDIVIDUALLY CUSTOMIZED 2D FORMWORK

INDIVIDUALLY CUSTOMIZED 3D FORMWORK
Reused from floor to floor

SANDBAGS




THANK YOU!