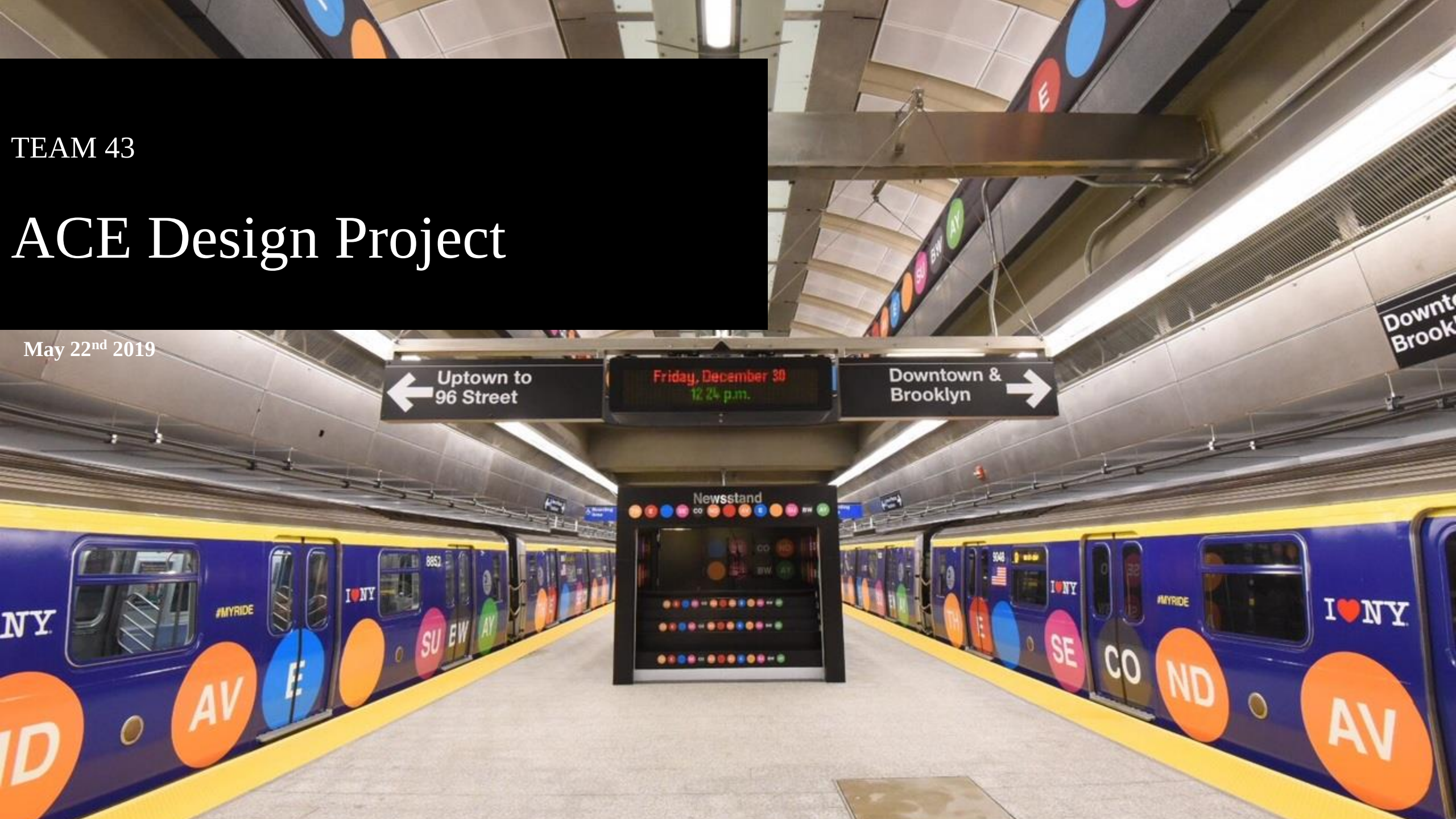
TEAM 43

# ACE Design Project

May 22nd 2019



Team 43

ACE MENTOR PROGRAM
ARCHITECTURE • CONSTRUCTION • ENGINEERING

ARUP

1. Challenge

2. Solution

3. Final Remarks

1. Challenge

2. Solution

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# Request For Proposal

**“NYC is welcoming proposals for the expansion of the city’s transportation system.”**

- Provide a **new line or line extension** with a new station
- Deliver a **meaningful and executable design**
- Should **consider the impact** on the community and environment

# About the Subway

**5.7 Million** commuters use the subway on an average weekday, and **1.757 Billion** commuters use it per year.

There are over **665 miles** of mainline track, about **60%** of which is underground.

There are **472 total stations**, most of which were built before 1940.

https://www.6sqft.com/the-new-york-city-subway-in-fascinating-facts-and-figures/

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# Overview

## Project Management

- Cost Estimate
- TBM Duration
- Total Construction Duration Estimate

## Architectural

- Visualization
- Floor plan
- Design aesthetics

## Structural

- Calculations of load
- Structural components
- Material choices
- Capability against natural disasters

## Mechanical

- Heating
- Consumer Ventilation
- Tunnel Ventilation
- Air Conditioning
- Piston Effect

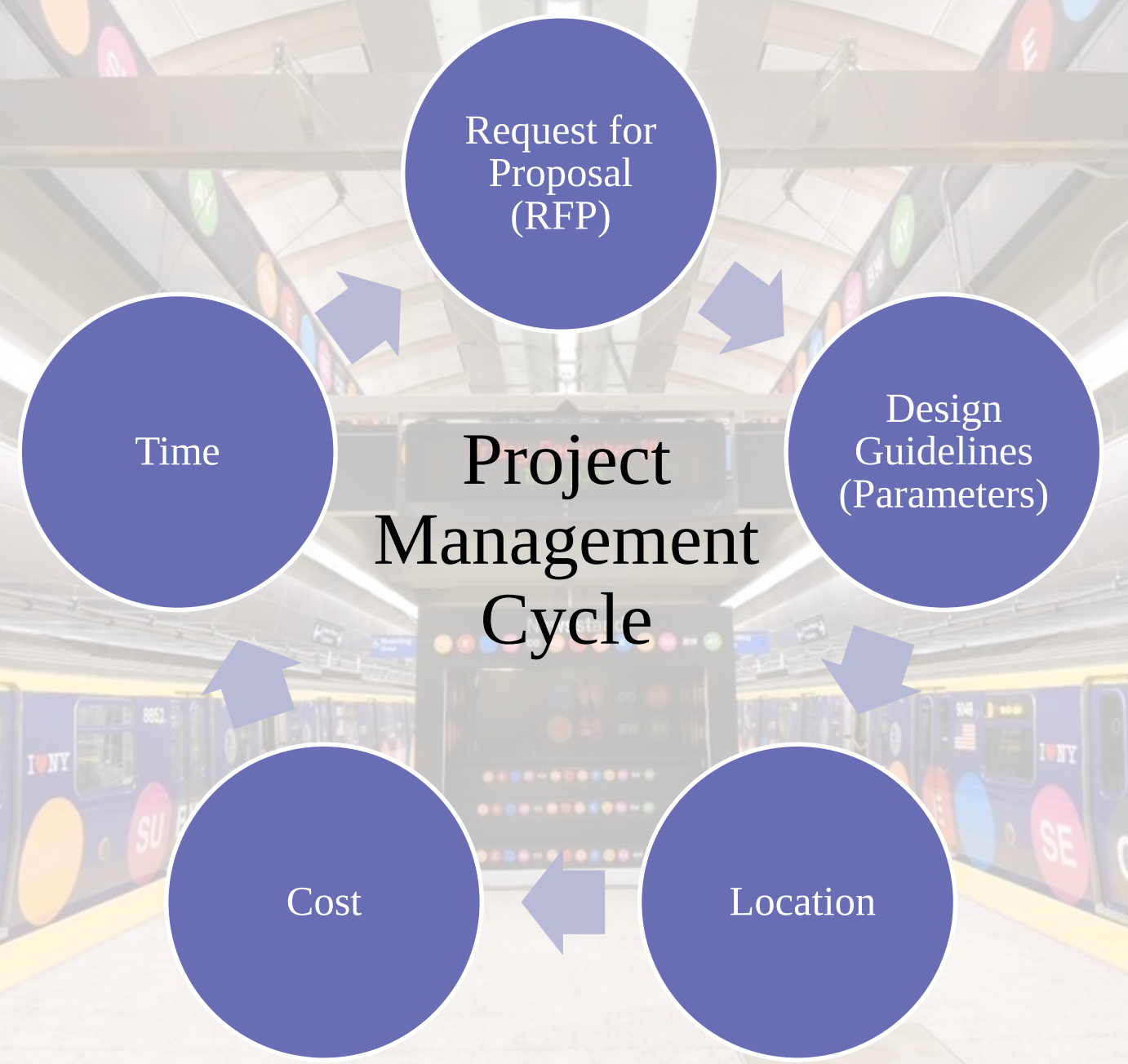
**Deliverables of this workstream**

## Procurement and Design Method

Benefits of Design Build

- Reduces design time
- Reduces construction calendar
- Fast track schedule

**Project Management Cycle**



## Site Selection

**Student Name:**_____

**Example:**

$B_{B1} = A_1 \times B_{A1}$
$.7 = .10 \times 7$

$C = B_{B1} + B_{B2} + B_{B3} + B_{B4} + B_{B5}$
$6.5 = .7 + .6 + 2.4 + 2.4 + .4$

$B_A$ must be a # 1-10!

| Project Criteria *(From RFP and From Team's Input)* | % | Team: _____ | | |
|---|---|---|---|---|
| | A | | $B_A$ | $B_B$ |
| 1. Achieve project objective – People and Planning Benefits | 30 | Meets RFP requirements | | |
| 2. Complexity – Technical Design & Construction | 20 | Can be designed and built with moderate difficulty | | |
| 3. Site selection – Environmental Impacts | 20 | Negative impact = low #<br>Positive impact = high # | | |
| 4. Site selection – Social Impacts | 15 | Negative impact = low #<br>Positive impact = high # | | |
| 5. Regional Economic Impact | 15 | Potential to economic growth beyond what was already there<br>*(higher number expected in less developed area)* | | |
| Total Weighted Score (C): | | | | |

## Tunnel Estimated Construction Cost & Time

**Tunnel Option**

*Construction Cost Estimate*

Est.$/mile: $**1.3B**

Est. cost for 1 new station and 1 rehabilitated station: **$173M**

**Est. Total cost for project: $4.42B**

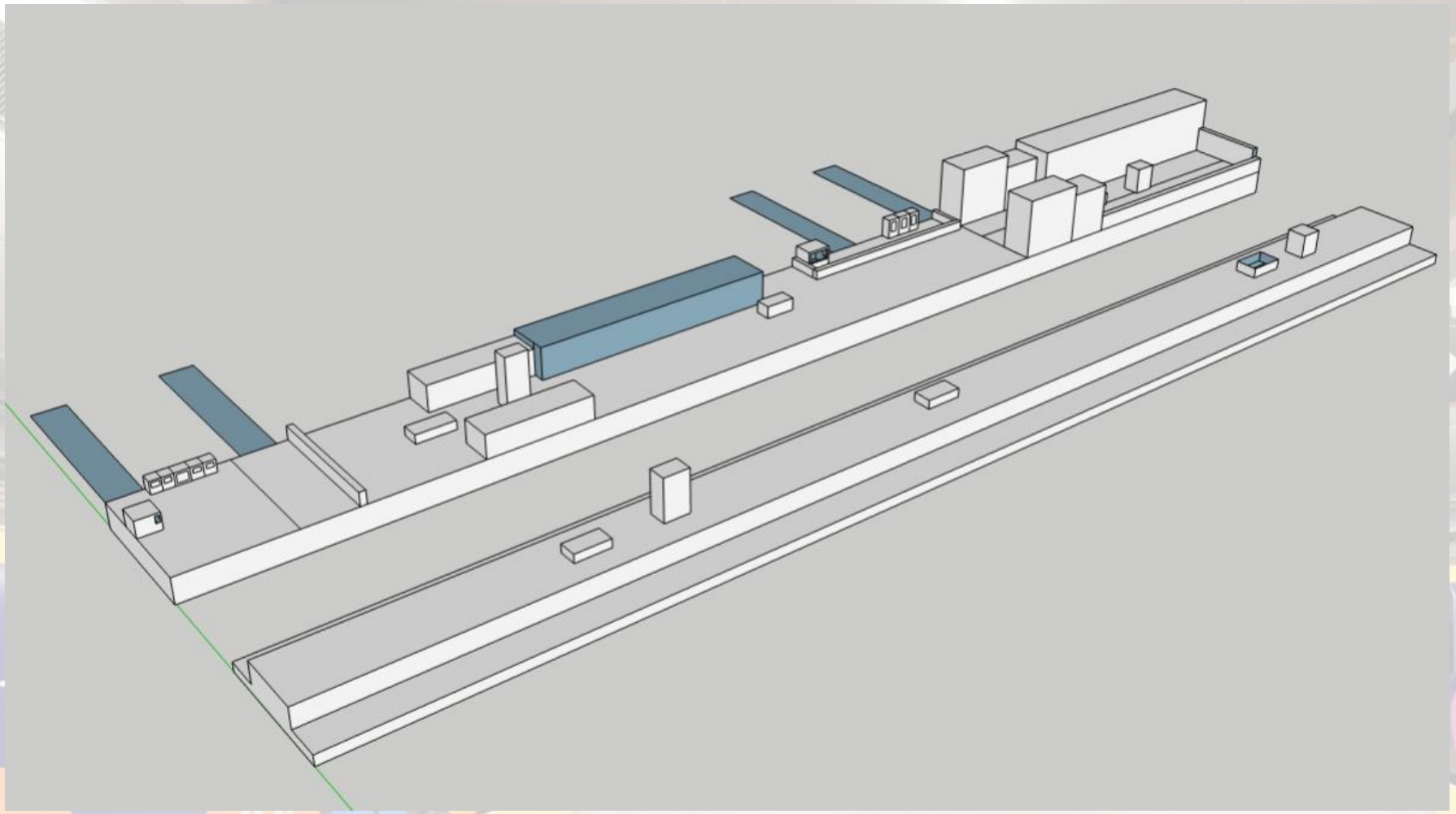
*Construction Schedule Estimate*

**TBM Machine Schedule: 299 days**

**Station Construction** Schedule**: 3 Yrs Max.**

**Total Construction Est.:**
**3-4 Yrs (w/ overlap of construction)**

# Architectural



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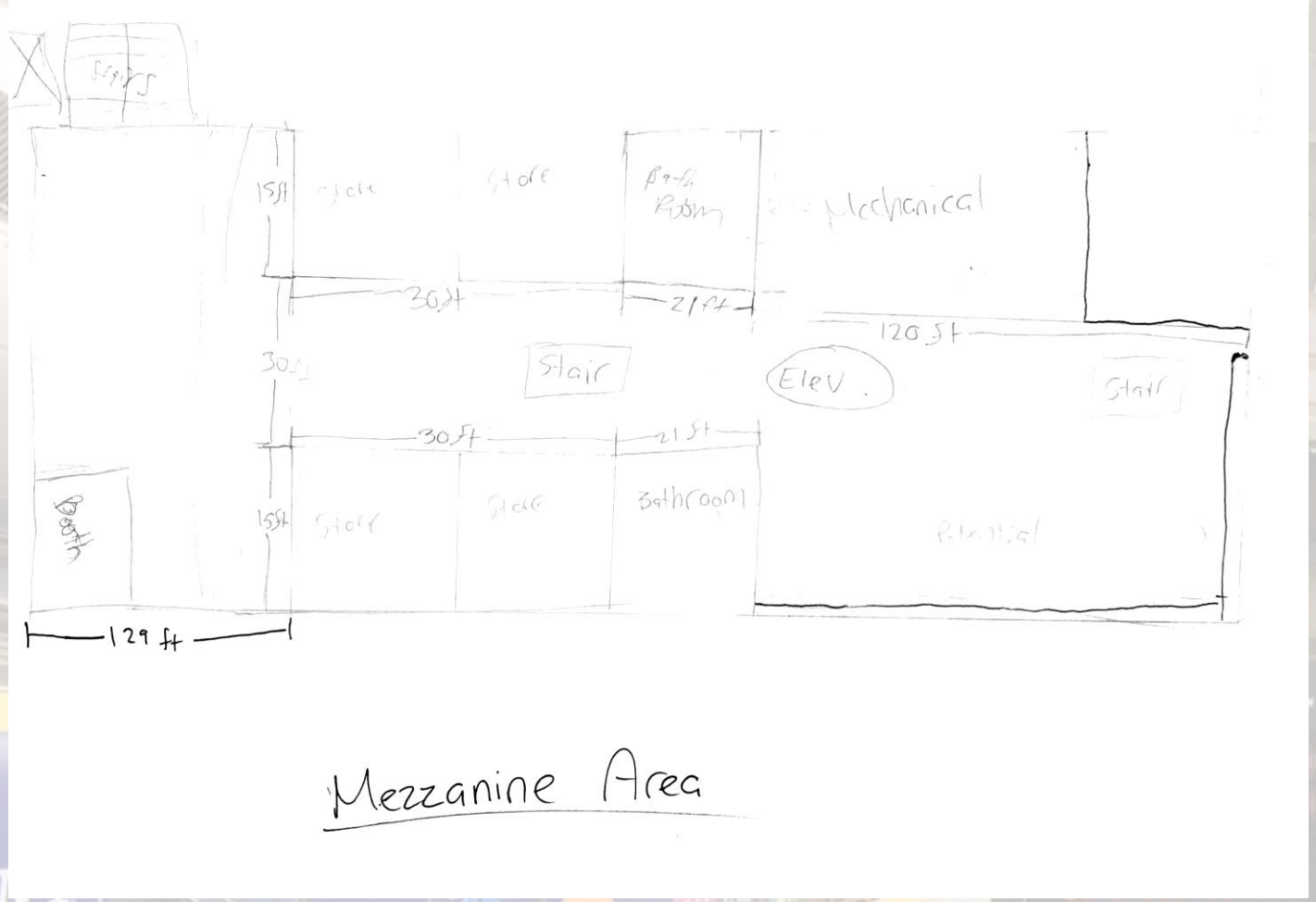


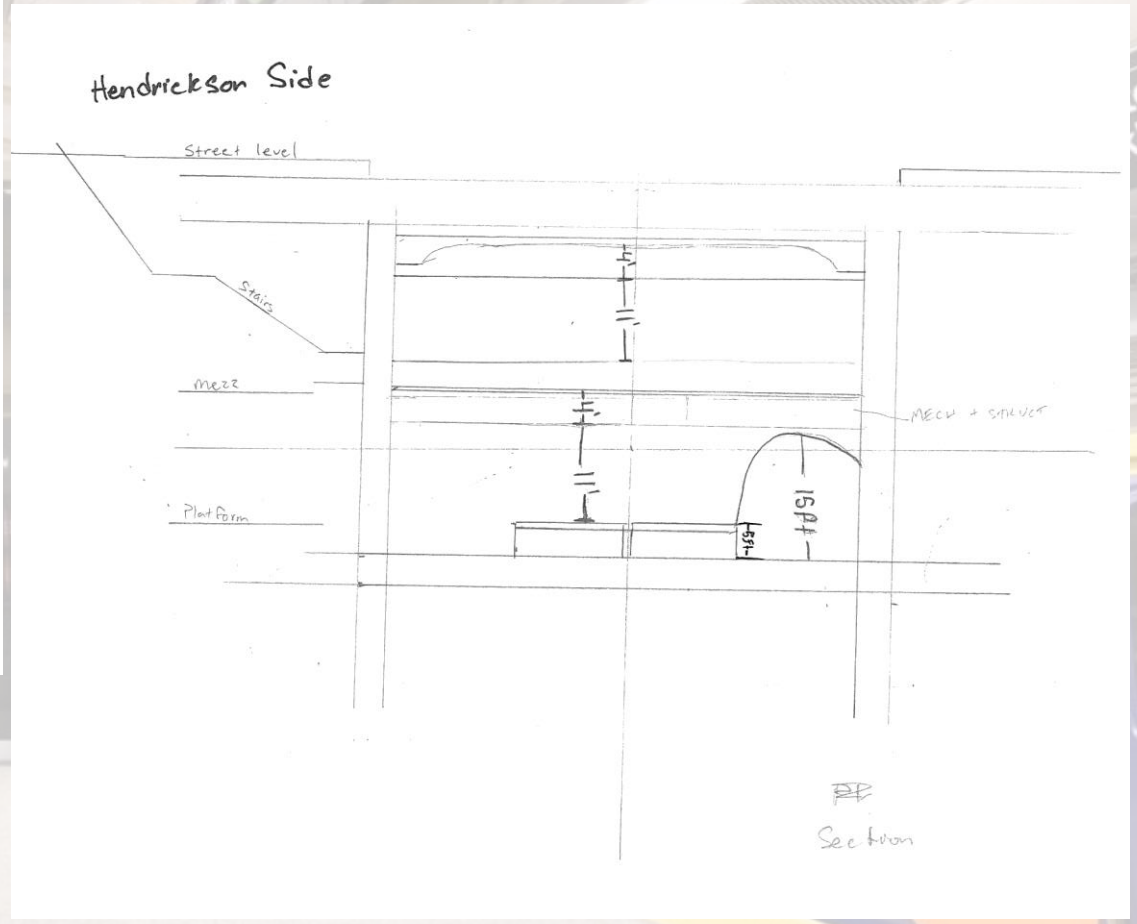

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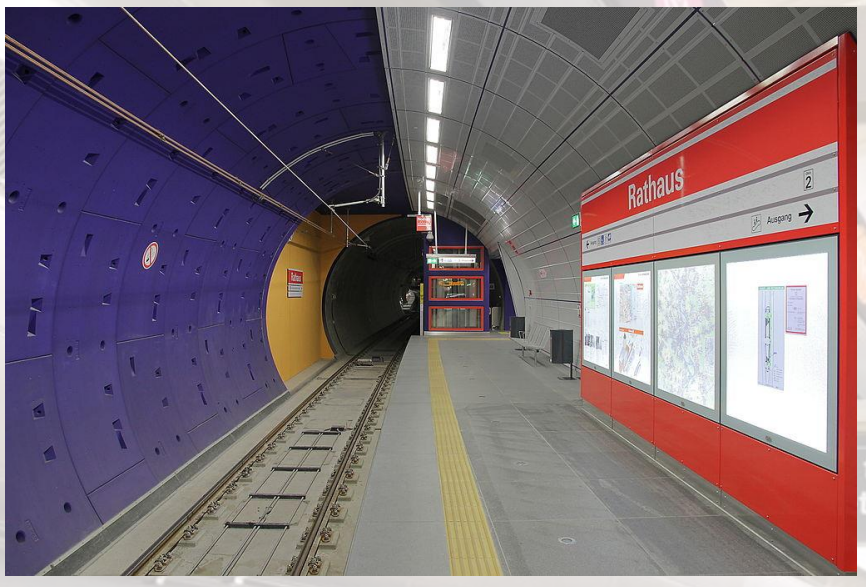


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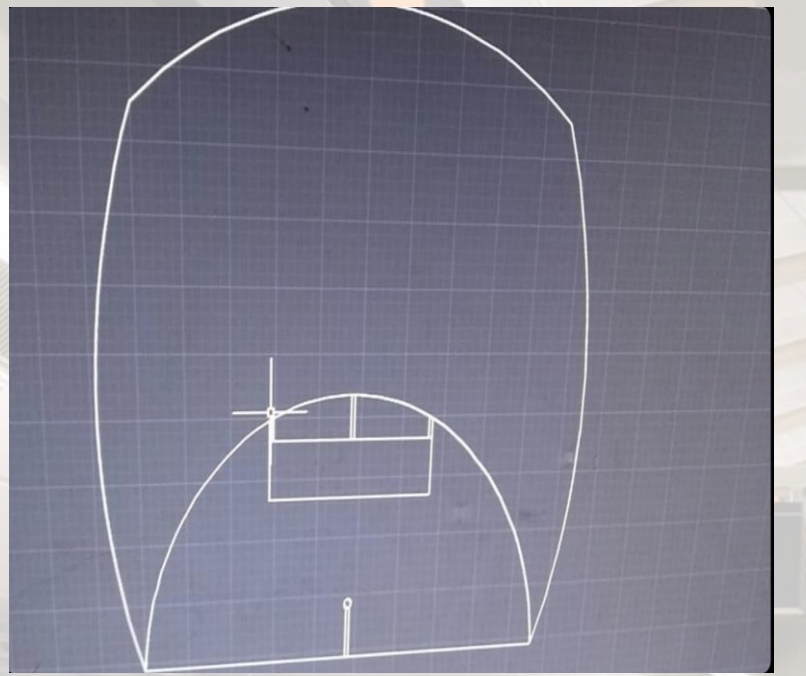
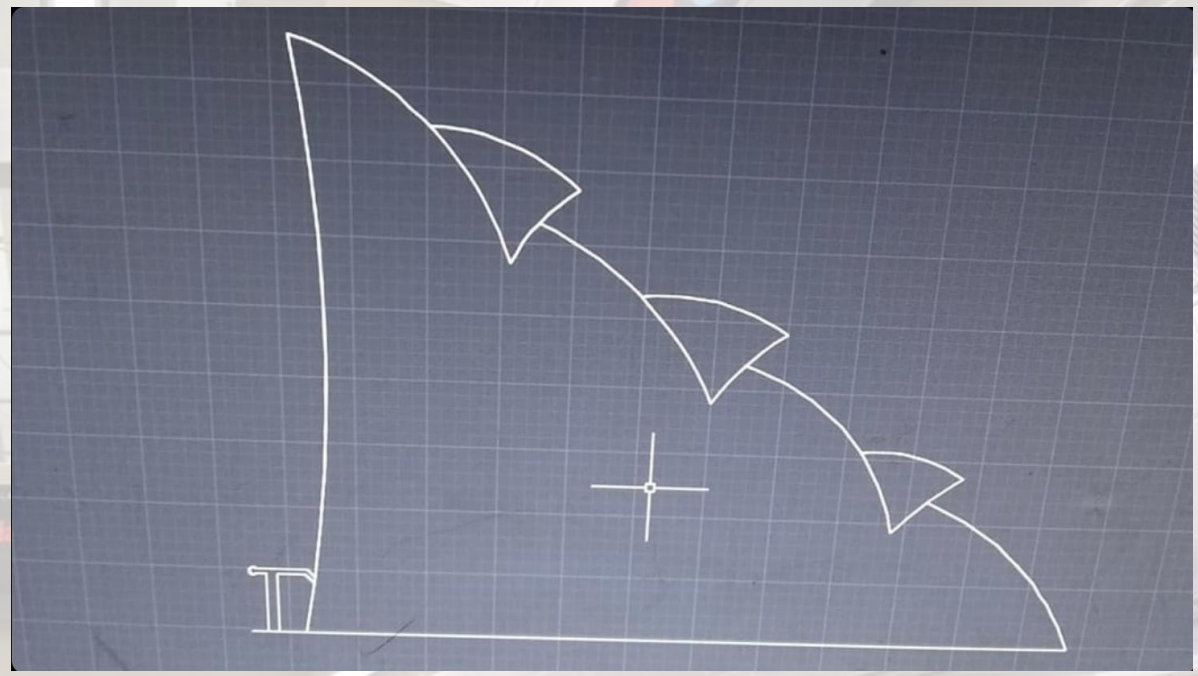
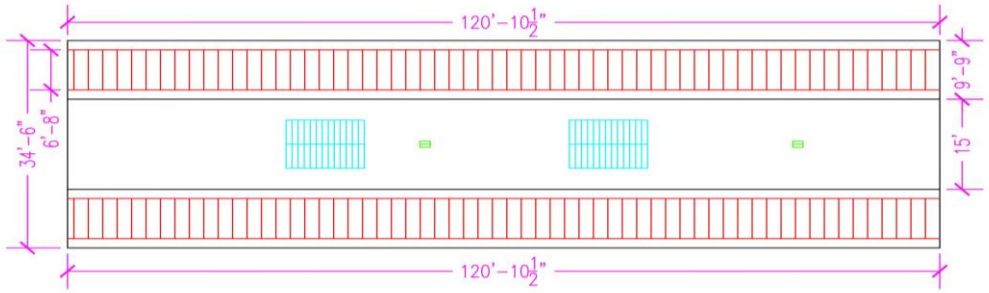
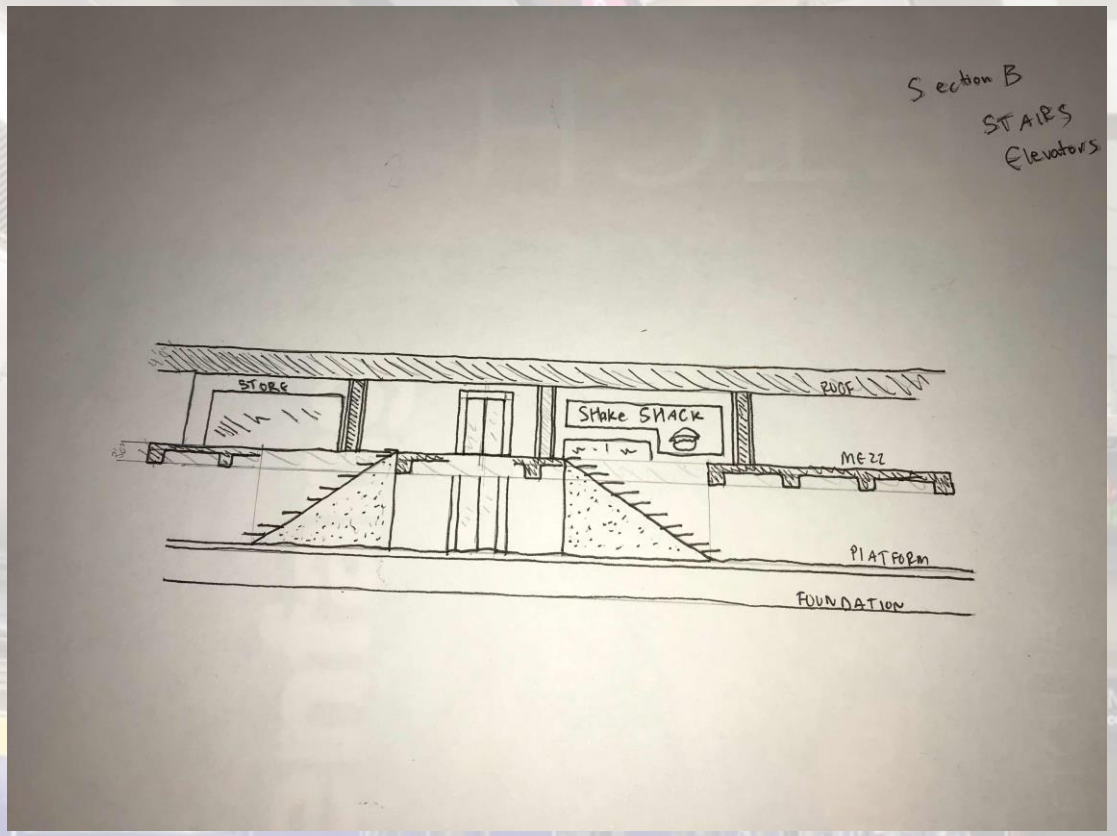


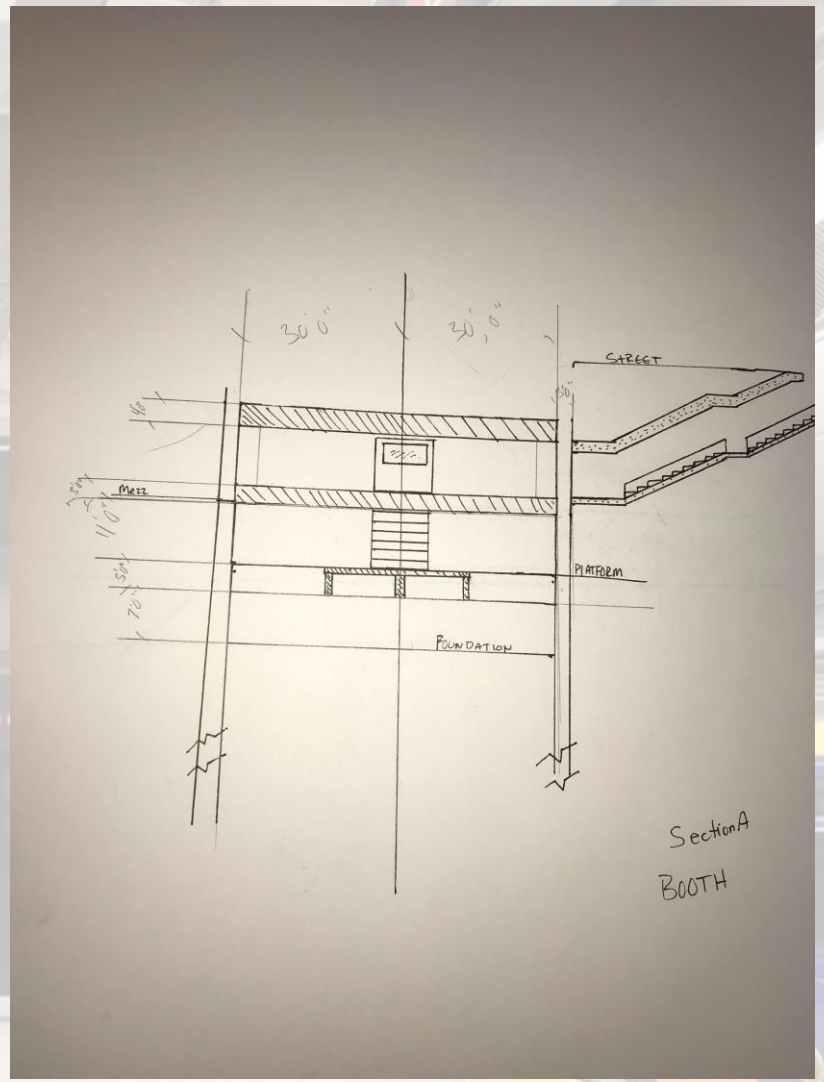




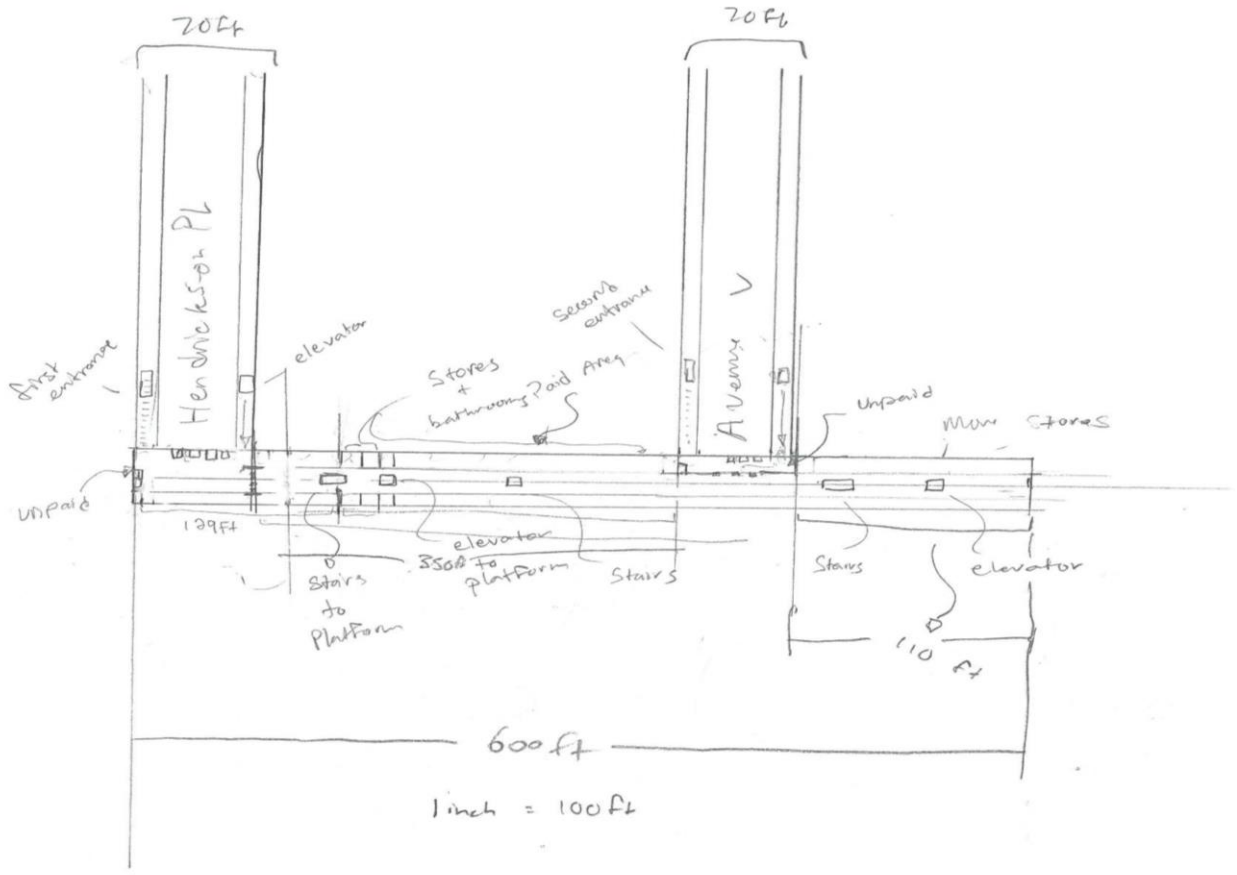

SECTION OF THE TRAIN STATION PLATFORM

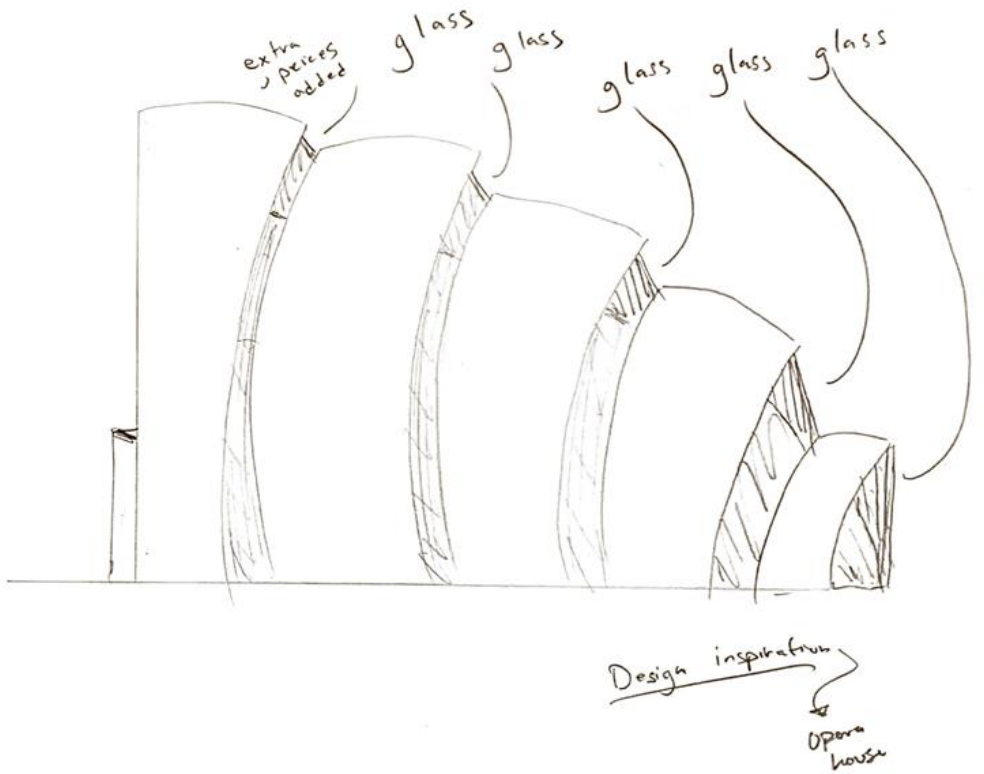
# Architectural



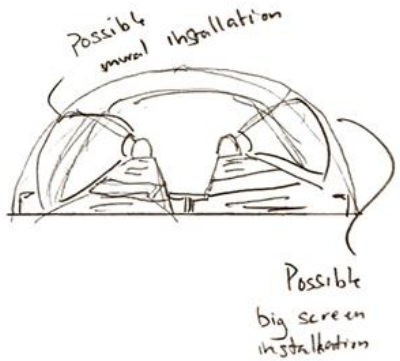



# Architectural

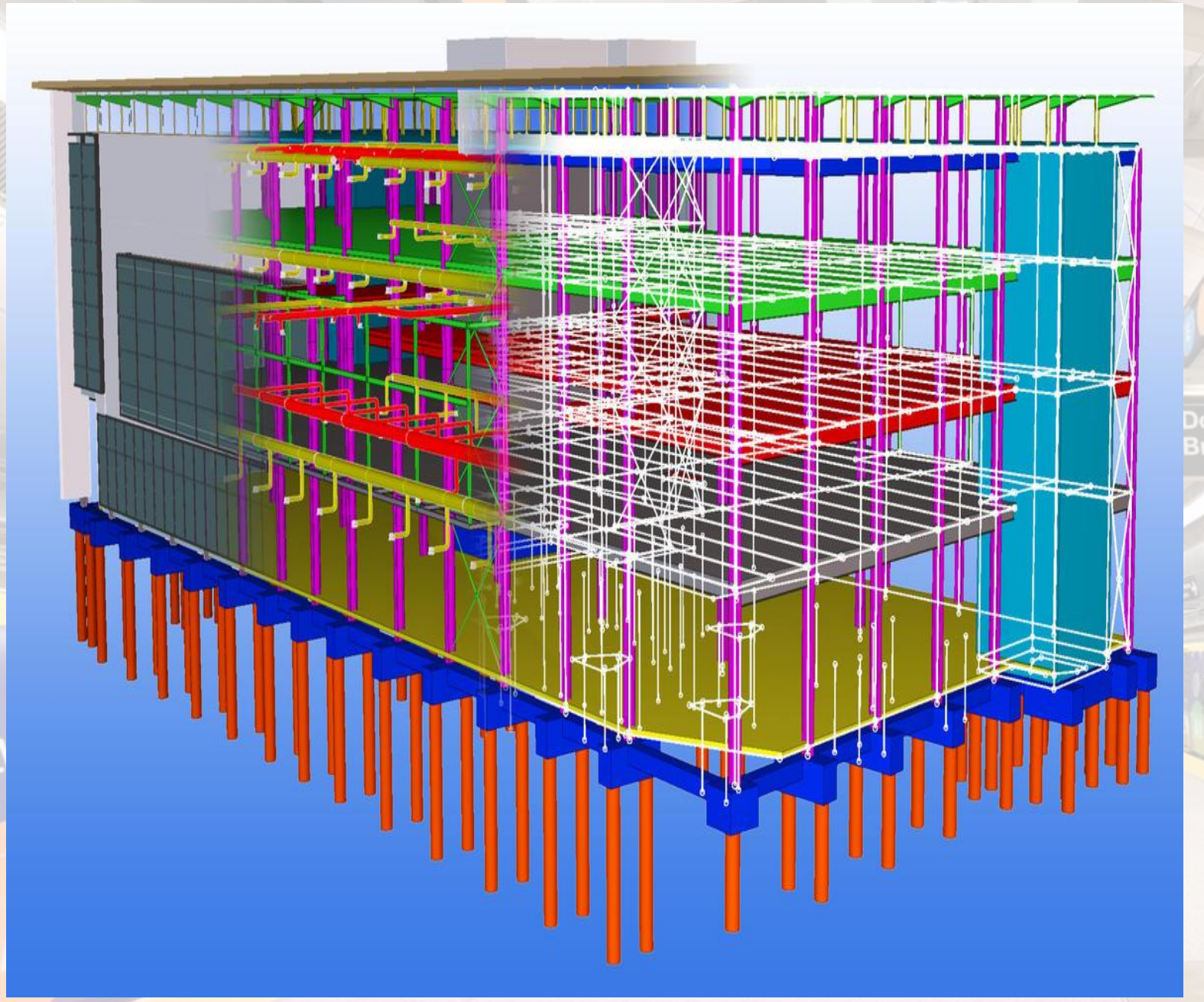



Entrance Design

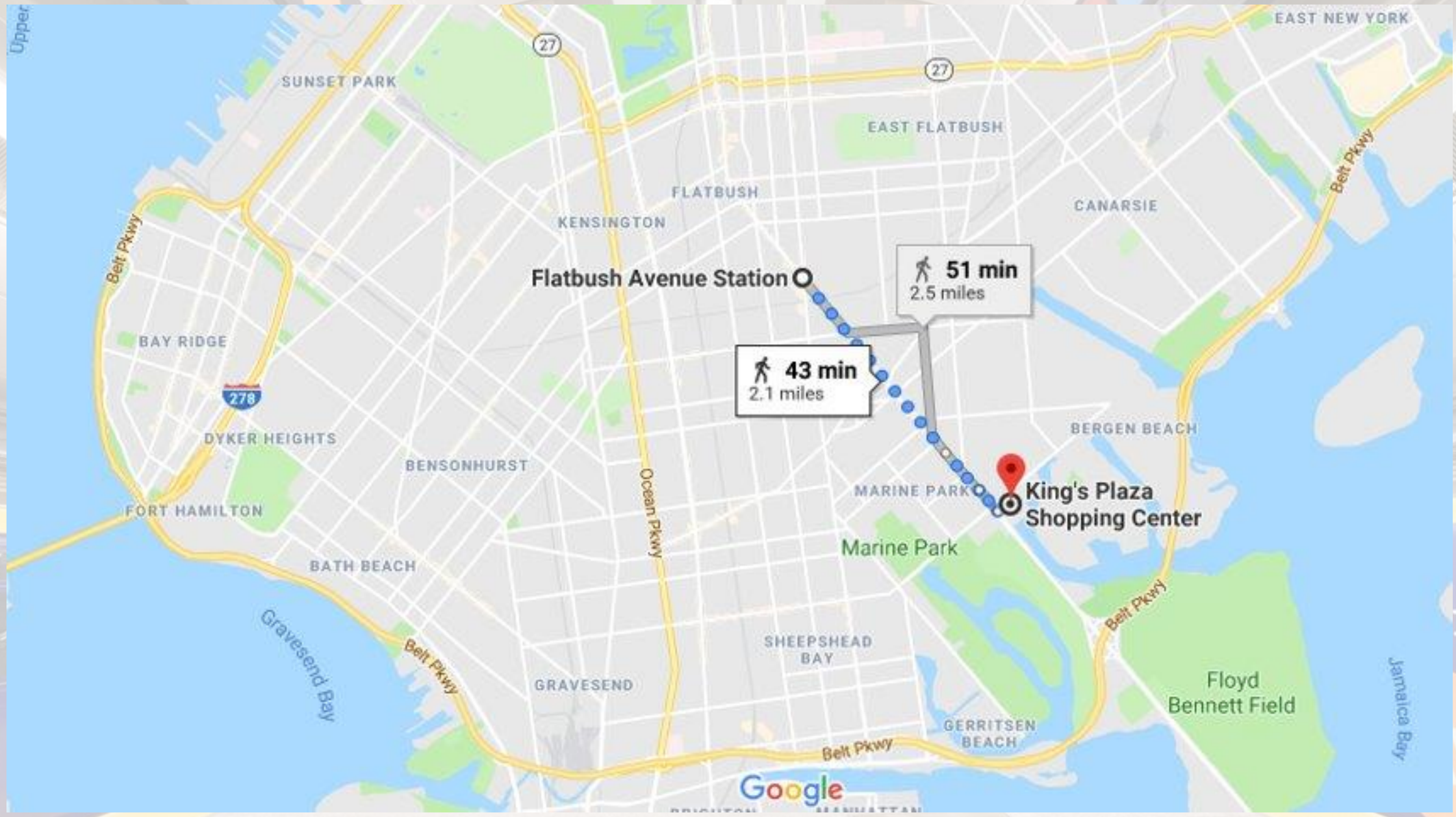


# Structural



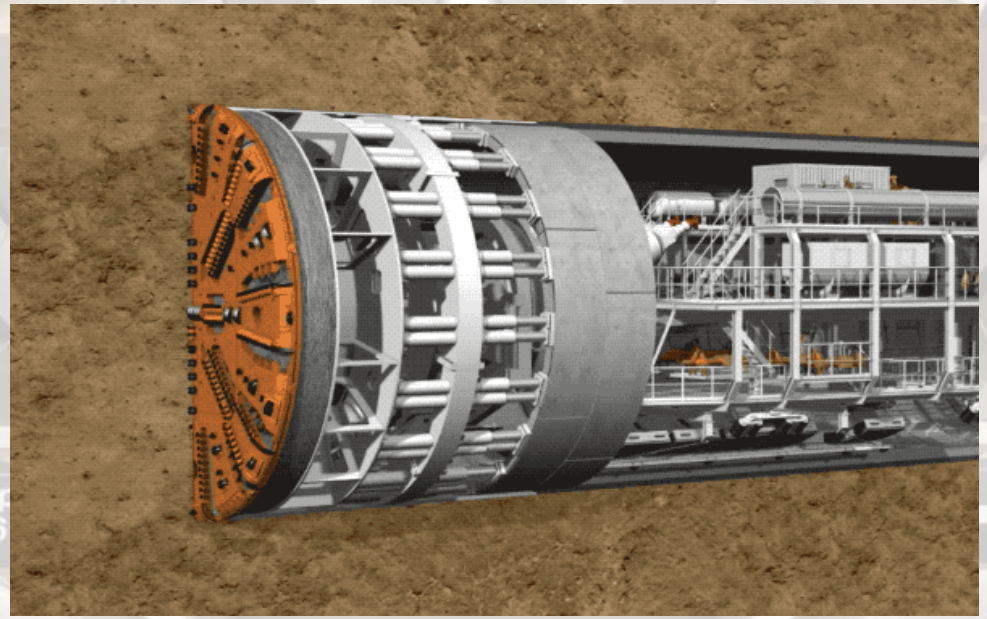
- Calculated the dead and live loads
- The choice of material that will perform the best in a given project
- Precautions against natural disasters

# Structural


Flatbush Avenue Station
51 min
2.5 miles
43 min
2.1 miles
King's Plaza Shopping Center
SUNSET PARK
EAST FLATBUSH
FLATBUSH
KENSINGTON
CANARSIE
EAST NEW YORK
BAY RIDGE
DYKER HEIGHTS
BENSONHURST
FORT HAMILTON
BATH BEACH
BERGEN BEACH
MARINE PARK
Marine Park
SHEEPSHEAD BAY
GRAVESEND
GERRITSEN BEACH
Floyd Bennett Field
Gravesend Bay
Jamaica Bay
Belt Pkwy
Ocean Pkwy
Google

# Structural

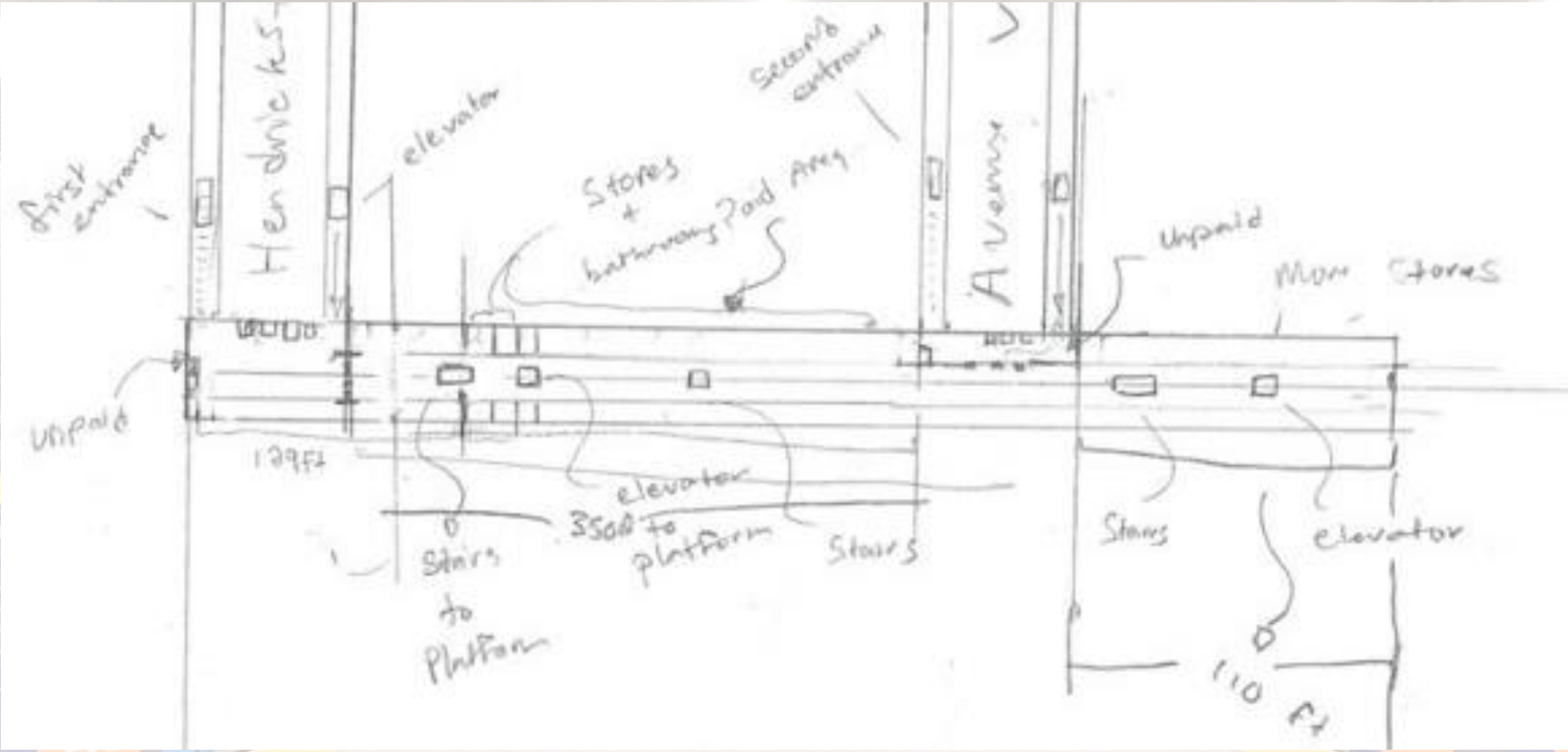
Drilling and Blasting



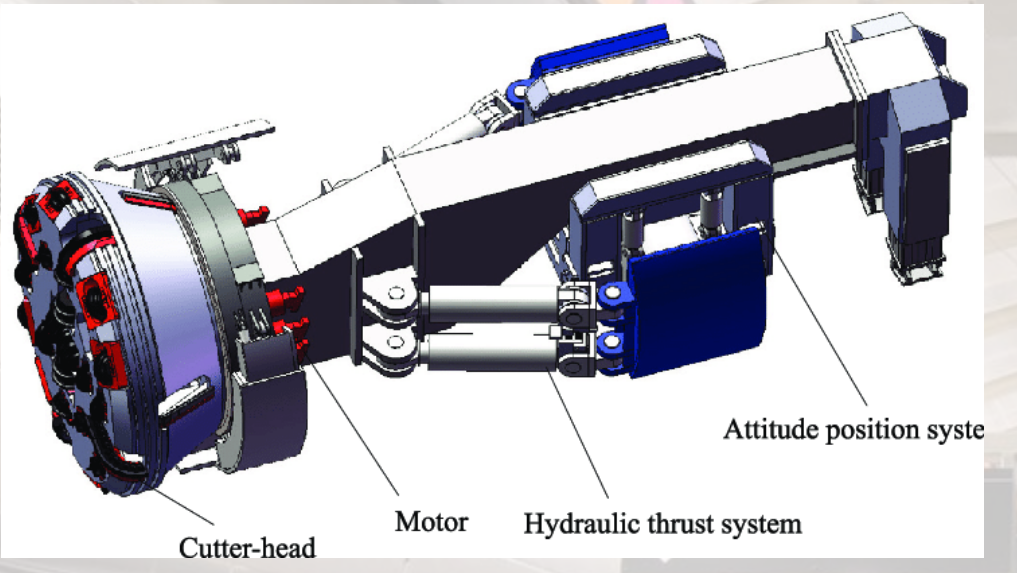
Tunnel Boring

Cut and Cover

# Structural

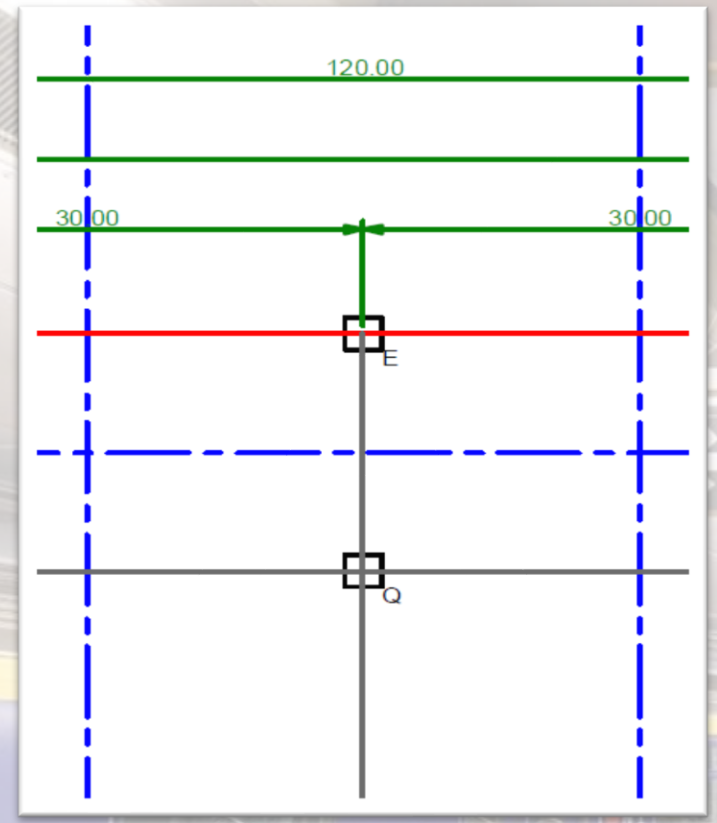

First entrance
Henderick St
elevator
Second entrance
Stores + hallway Paid Area
A Venue
Unpaid
Mom Stores
Unpaid
129 ft
elevator
350# to platform
Stairs
Stairs
Stairs to Platform
Stairs
elevator
110 ft

# Structural

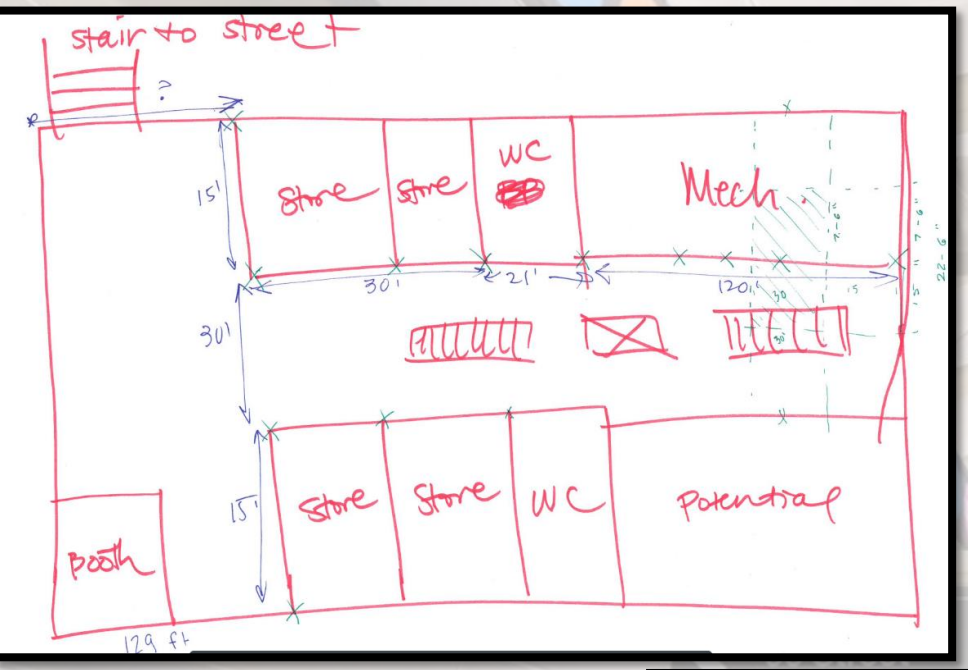


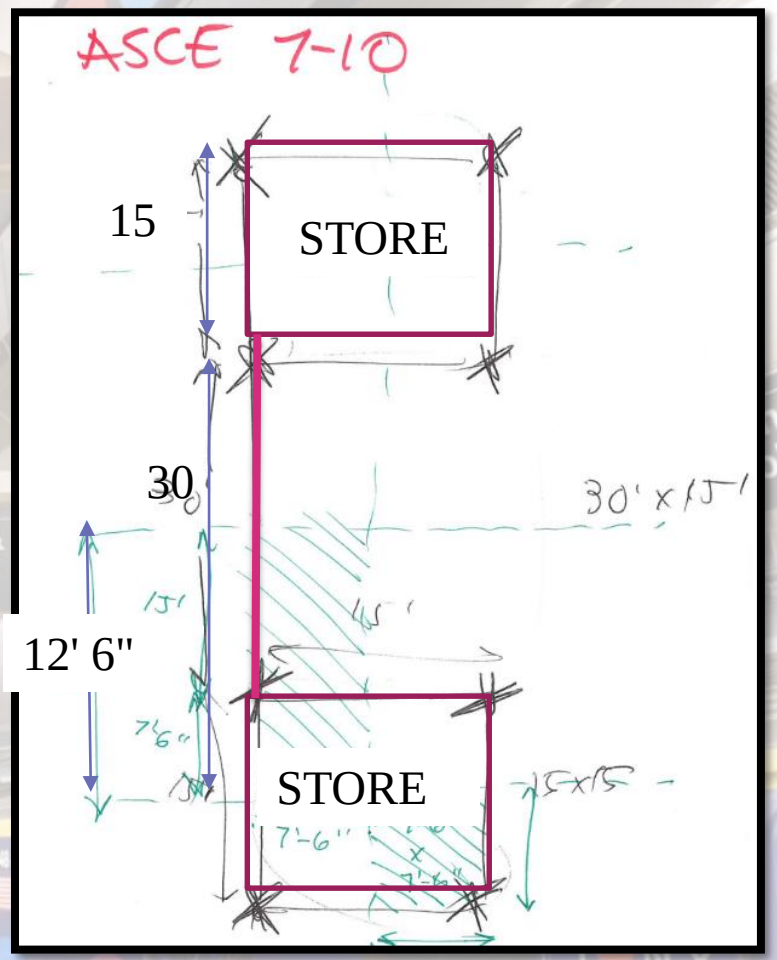

| Pros | Cons |
|---|---|
| ➔ Its faster<br>➔ Doesn't interfere with traffic as much<br>➔ Businesses are not affected as badly<br>➔ **Wouldn't interfere with existing pipes and utilities**<br>➔ Not as loud as cut and over. | ➔ It will get costly; compared to deep cut to cover it would be less |

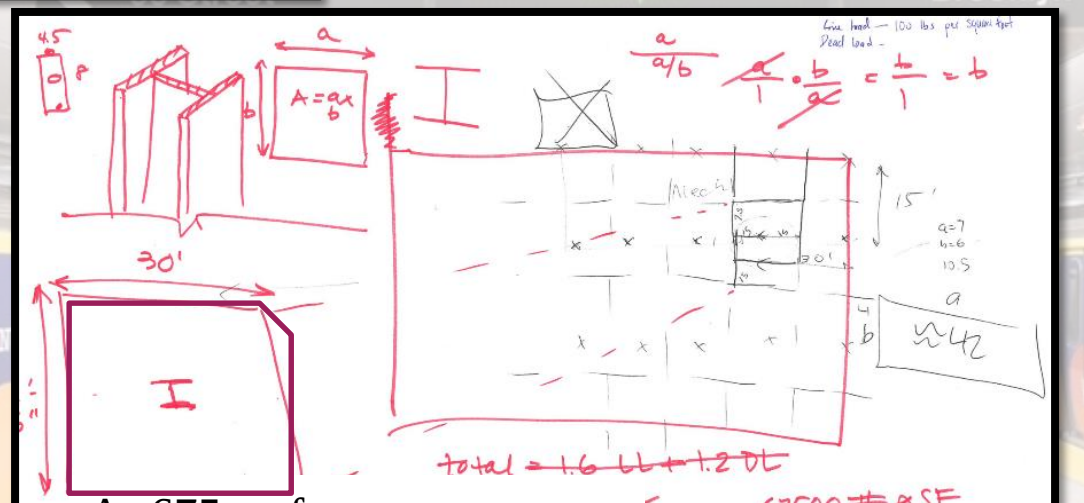
# Structural




| | | | Edge Columns | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Columns:** | **units** | **A** | **B** | **C** | **D** | **E** | **F** |
| 1 | Tributary Area = | sq ft | 75 | 150 | 187.5 | 221.25 | 225 | 191.25 |
| 2 | Uniform Load = | lb/sq ft | 100 | 100 | 100 | 100 | 100 | 100 |
| 3 | Load Factor = | | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 |
| | | | | | | | | |
| 4 | Material = | | Concrete | Concrete | Concrete | Concrete | Concrete | Concrete |
| 5 | Strength = | lb/sq in | 4000 | 4000 | 4000 | 4000 | 4000 | 4000 |
| | | | | | | | | |
| 6 | Area Required = | sq in | 5 | 9 | 12 | 14 | 14 | 12 |
| | | | | | | | | |
| 7 | side 'a' dimension = | in | 2 | 4 | 5 | 4 | 4 | 4 |
| 8 | side 'b' dimension = | in | 3 | 3 | 3 | 4 | 4 | 4 |
| | | | | | | | | |
| 9 | Area Provided = | sq in | 6 | 12 | 15 | 16 | 16 | 16 |
| 10 | Utilization Ratio = | | 0.78125 | 0.78125 | 0.78125 | 0.864258 | 0.878906 | 0.74707 |



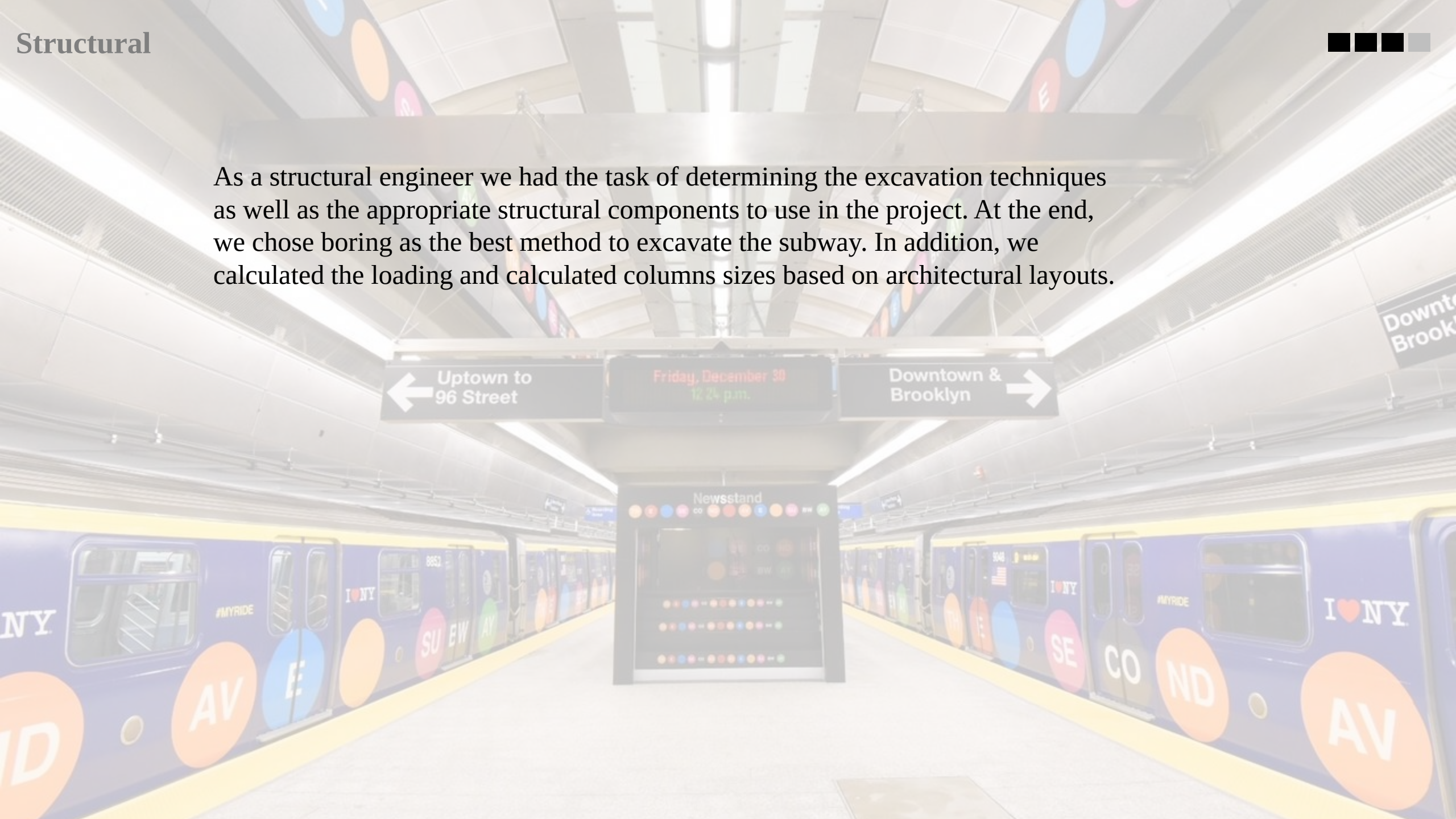

A=675 sq ft

W=100 lbs/sq ft

LOAD = A*W = 67500 lbs

# Structural

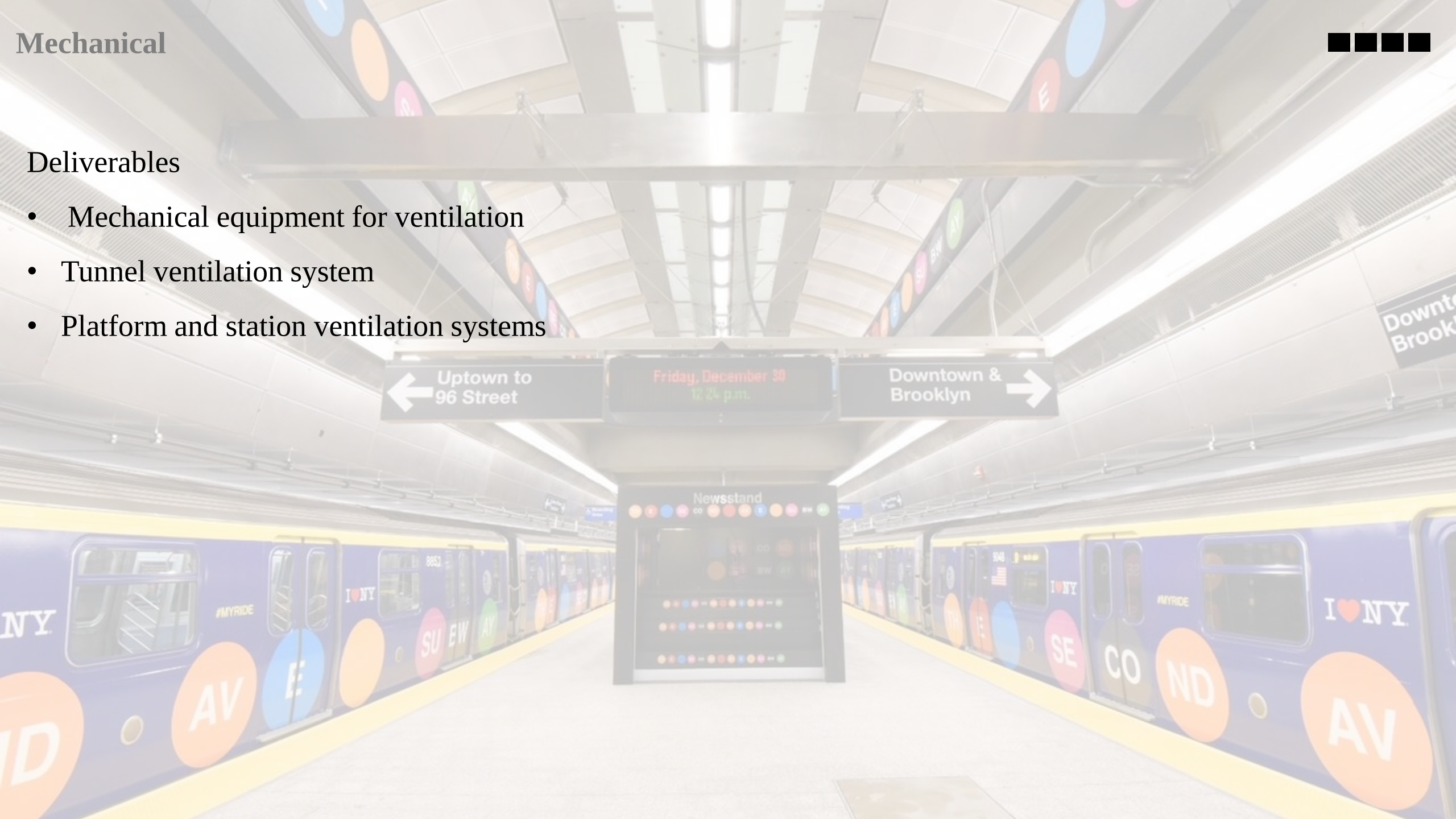
As a structural engineer we had the task of determining the excavation techniques as well as the appropriate structural components to use in the project. At the end, we chose boring as the best method to excavate the subway. In addition, we calculated the loading and calculated columns sizes based on architectural layouts.



# Mechanical

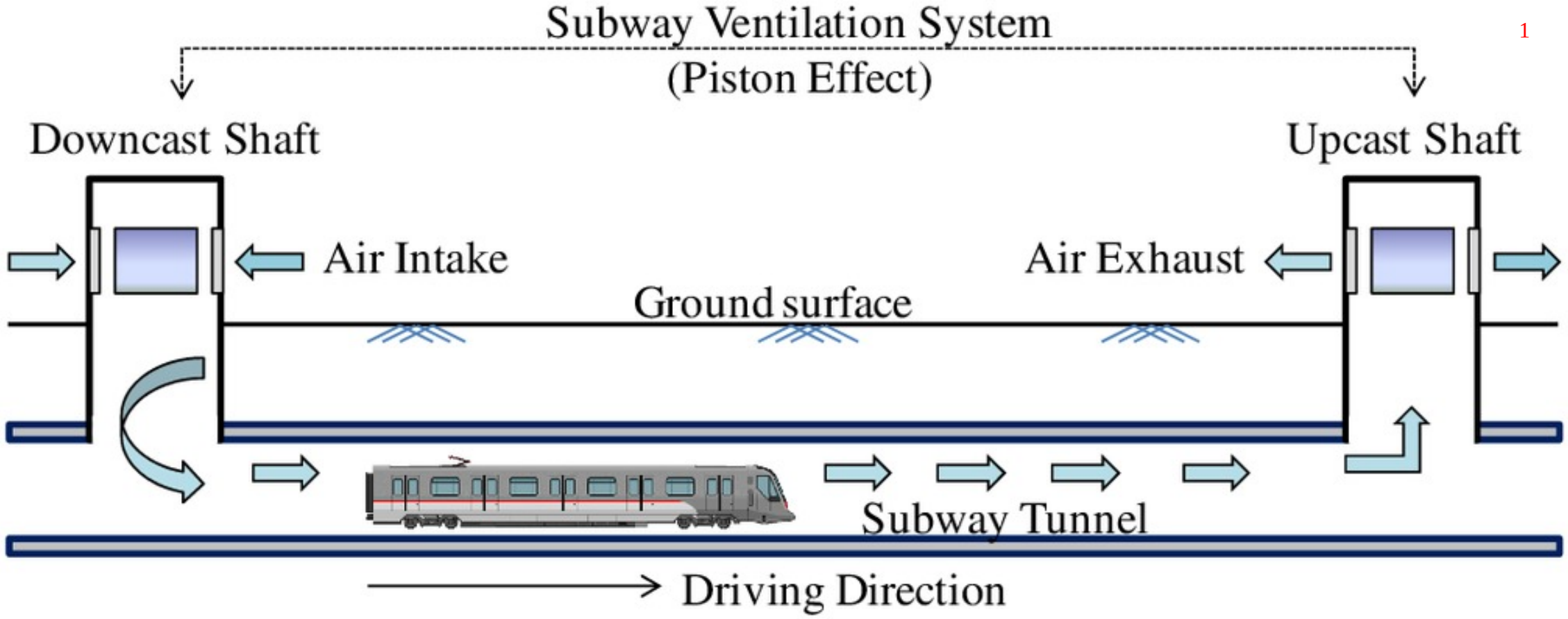
Deliverables

- Mechanical equipment for ventilation
- Tunnel ventilation system
- Platform and station ventilation systems



# Mechanical – Our Problem

The Piston Effect

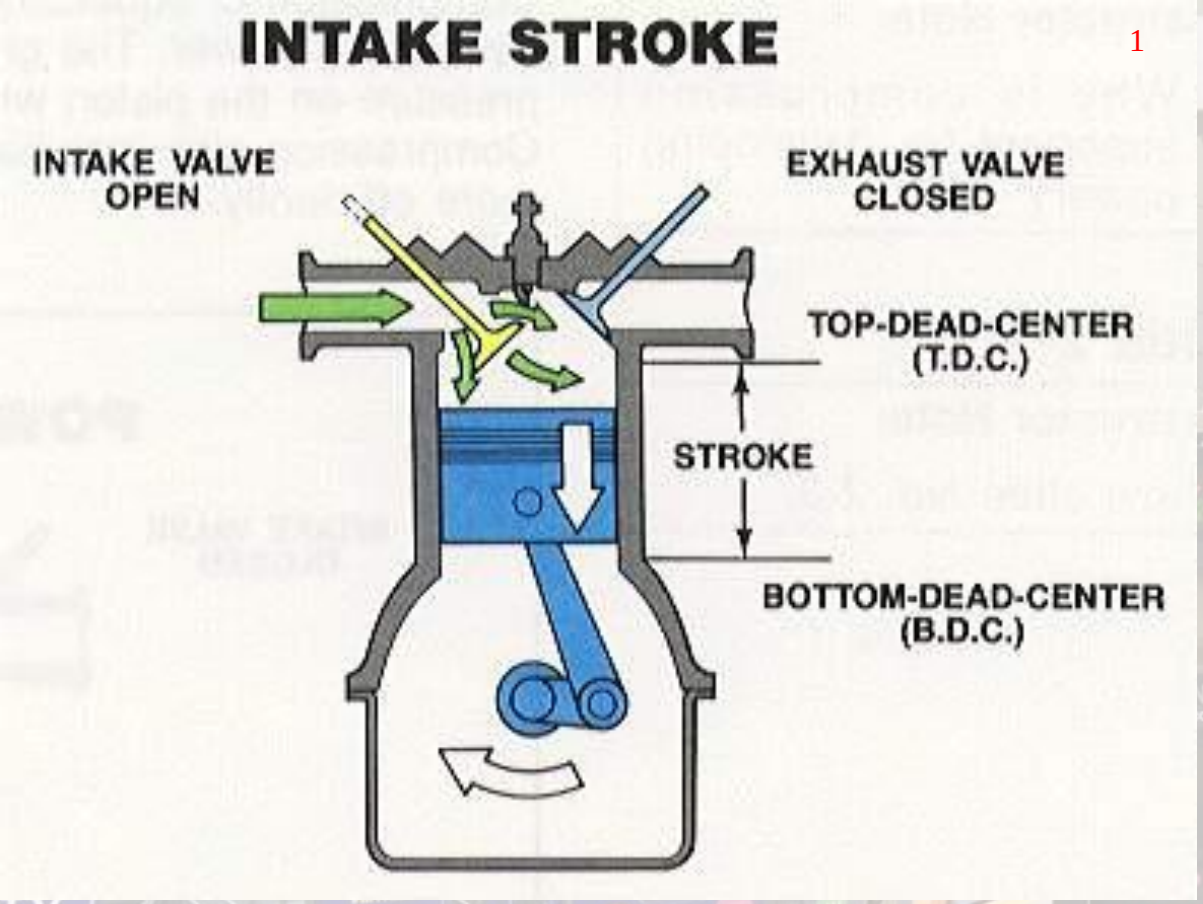


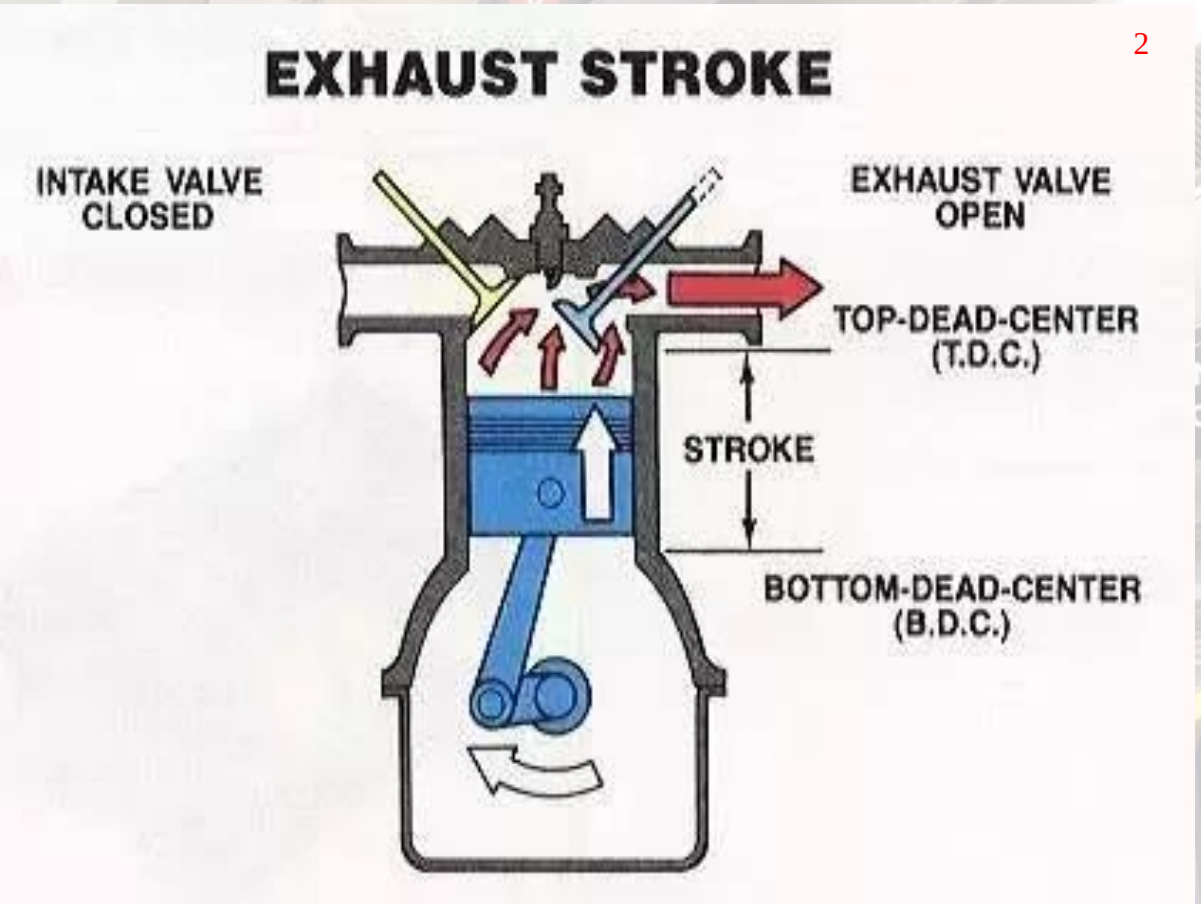

1

https://ascelibrary.org/cms/attachment/54d2407e-1e29-4e6a-8e92-2d03cae35902/figure1.jpg

# Mechanical – Our Problem

The Piston Effect Cont.



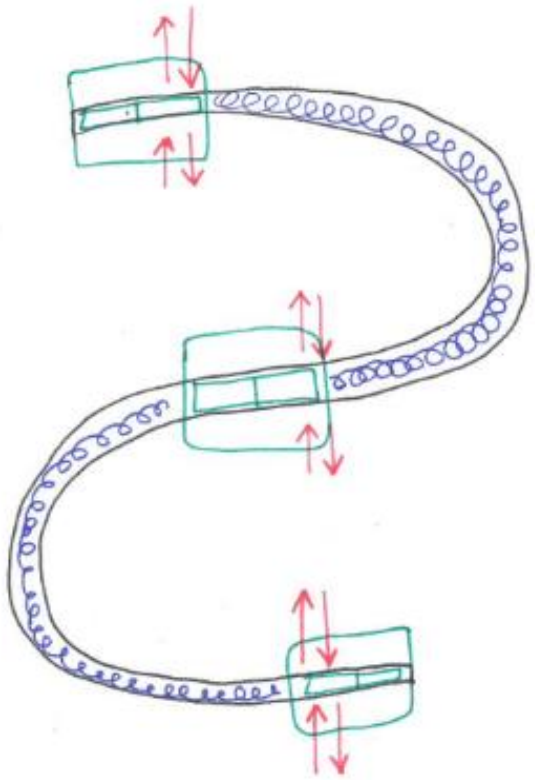

When leaving a station, the train creates a sucking effect.

In addition, the train also creates a pushing effect.

1 http://2.bp.blogspot.com/-klMaBRKD_Zw/VYneyPytY8I/AAAAAAAAAss/Y54Q3qFavGs/s1600/intake.jpg

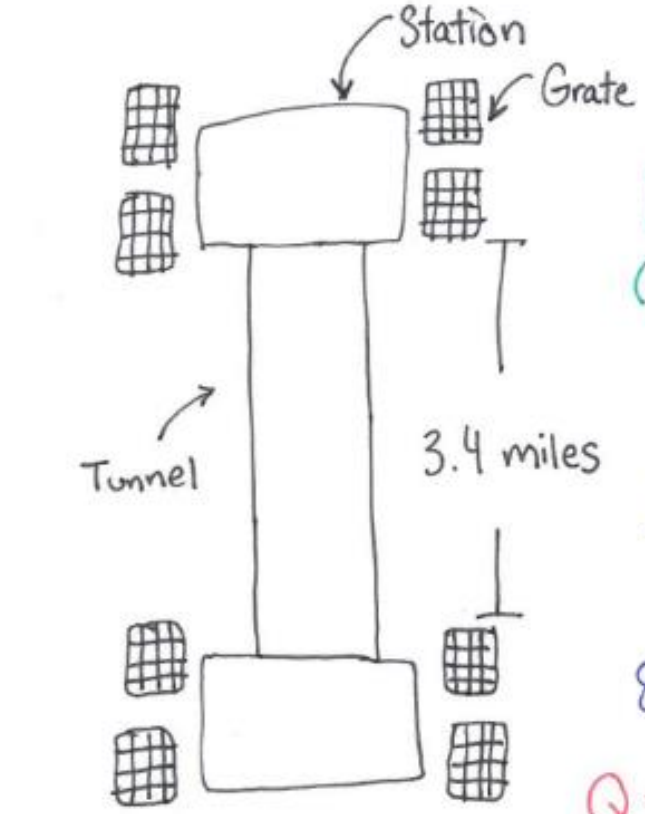
2 https://qph.fs.quoracdn.net/main-qimg-55aa80c2abcaf623d9fb385fa4a9c5a3.webp

# Mechanical – Calculations



**Key:**

- → Tunnel
- → Stations & trains
- Air Flow
- Pressure




1500 FPM = rule of thumb for exit velocity
(Feet per minute)

$$\frac{\pi(7.5^2)}{2} = 88.3125$$

$88.31 \cdot 4840$ ← constant

$$Q = \frac{427,420.4}{1500}$$

Volumetric flow

$A = 284.94\ ft^2$

Average Subway Grate Size
5 ft

$285/5 = 57$

60 Grates @ each end of the tunnel

# Mechanical – Solution

Add Subway Grates

- These are commonly used to reduce the Piston Effect, however they must be sized accordingly so that they are efficient and don't cut too much into funds.

- These would be placed on both ends of the station, diminishing the vacuum/sucking effect as well as the pushing force.


1 https://media-cdn.tripadvisor.com/media/photo-s/0e/56/86/5f/marilyn-monroe-s-subway.jpg

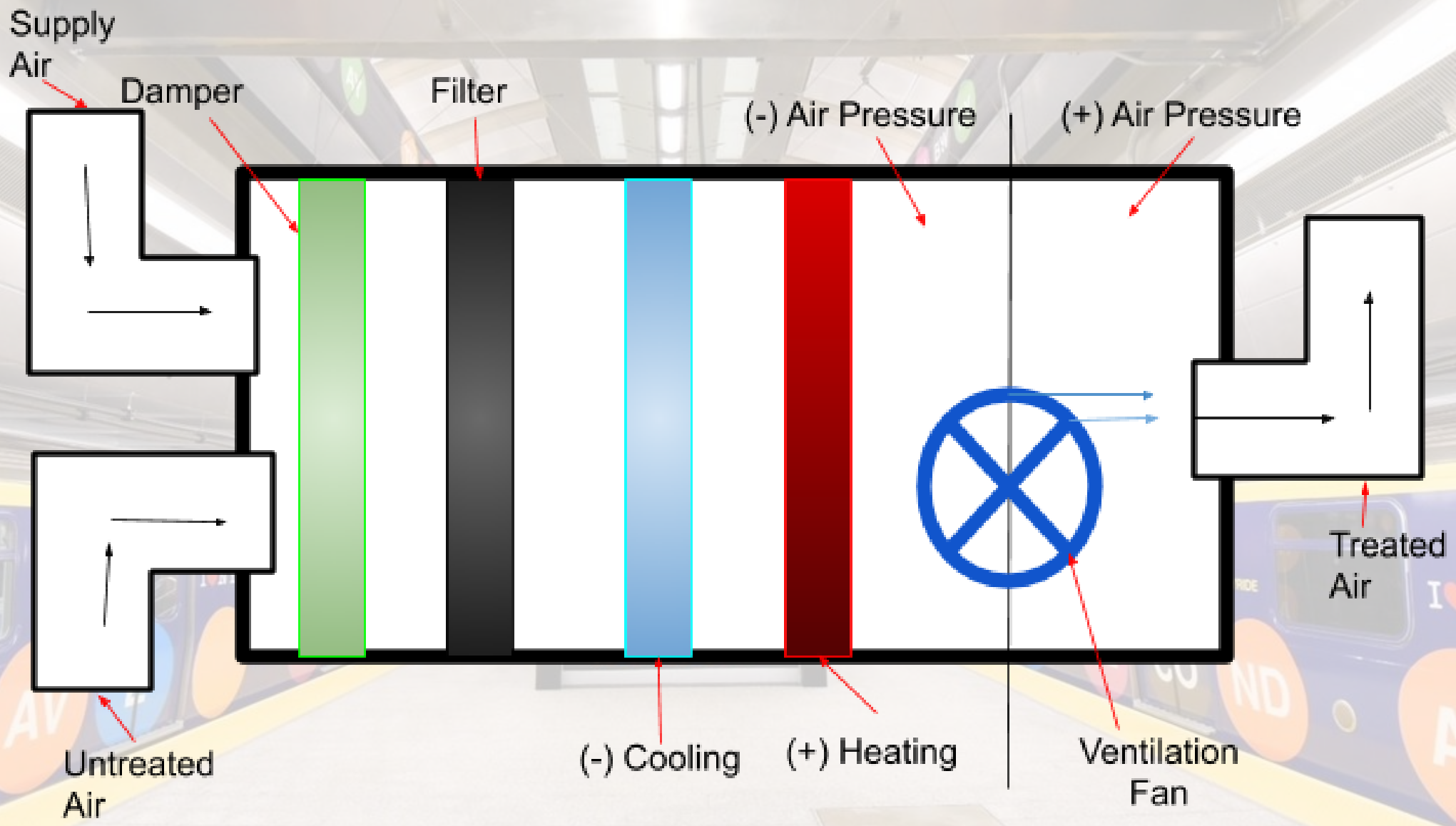
# Mechanical – Problem

Heating and Cooling of the Platform and Station


- https://www.nytimes.com/2019/01/31/nyregion/cold-weather-polar-vortex-nyc.html
- https://patch.com/new-york/new-york-city/heres-how-hot-your-subway-platform-summer-turns-stations-sweaty-hell
- https://www.vice.com/en_ca/article/ev8jye/no-the-subway-doesnt-have-to-be-insanely-hot-and-gross

# Mechanical – Our Solution

Design a ventilation system for heating and cooling the station



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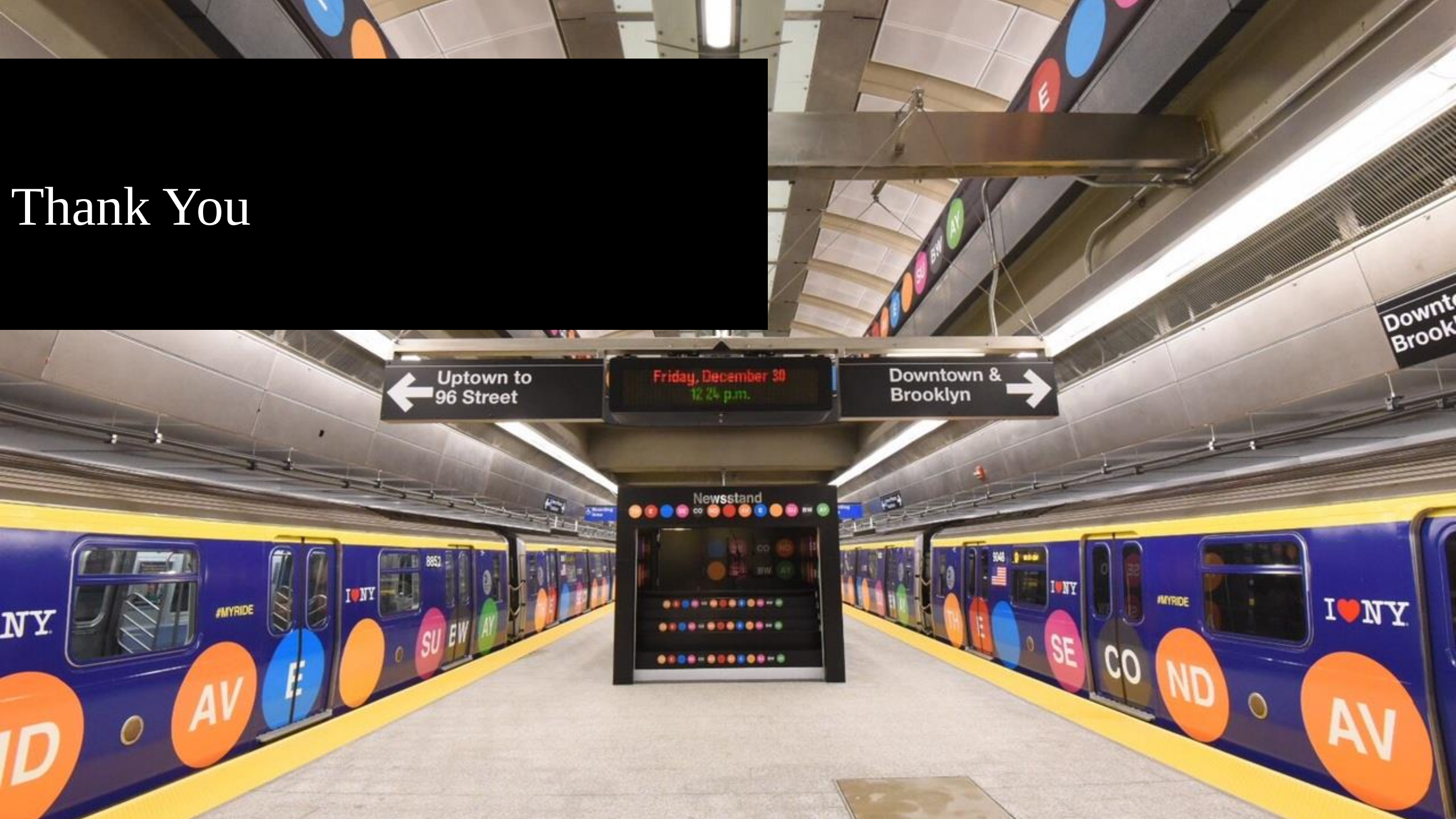
# Thank You


Uptown to
96 Street
Friday, December 30
12:24 p.m.
Downtown &
Brooklyn
Newsstand
#MYRIDE
I ♥ NY
AV
E
SU
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