Case Study: Application of Diaphragm Wall, Underpinning, and Box Jacking Techniques in Urban Infrastructure Development

Project Overview: A large-scale urban development project in a densely populated city required the construction of an underground metro station, alongside the reinforcement of adjacent historic buildings. The site was located under an existing highway, making surface disruption a significant challenge. The project demanded a combination of **Diaphragm Wall**, **Underpinning**, and **Box Jacking** techniques to achieve stability, safety, and minimal disruption.

1. Diaphragm Wall Construction for Underground Metro Station

- **Objective**: The underground station required deep excavations to create a large open space for passenger movement, ticket counters, and platforms. The soil was weak and prone to water seepage, making diaphragm wall construction essential.
- **Challenges**:
    - The station was located in a highly congested area, requiring noise and vibration control.
    - Controlling water ingress due to the high groundwater table.
- **Solution**:
    - **Diaphragm Wall**: A slurry-supported diaphragm wall, reinforced with steel cages, was constructed around the perimeter of the future metro station. This created a watertight retaining structure, allowing excavation to proceed without soil collapse or flooding.
    - **Execution**:
        - **Slurry Trench Method**: A trench was dug, and bentonite slurry was used to support the excavation.
        - **Reinforcement**: Steel cages were lowered into the trench.
        - **Tremie Concrete Placement**: Concrete was placed using the tremie method, displacing the slurry.
    - **Outcome**: The diaphragm wall effectively secured the deep excavation, preventing soil collapse and ensuring a dry construction site.

2. Underpinning for Historic Buildings Adjacent to the Metro Station

- **Objective**: The metro station's deep excavation could cause ground movement, potentially damaging nearby historic buildings. Underpinning was required to stabilize the foundations of these structures before excavation began.
- **Challenges**:
    - The buildings were old, with shallow and fragile foundations.
    - Ensuring minimal disruption to the occupants of the buildings.
- **Solution**:
    - **Mini Piled Underpinning**: Mini piles were installed beneath the foundations of the buildings to transfer the structural loads to deeper, more stable soil layers. This method was chosen due to the limited space and the depth required for stability.
    - **Execution**:
        - Small-diameter piles were driven beneath the foundations using minimal excavation, ensuring that the buildings remained fully operational during the work.
        - New beams were cast to transfer the building load to the piles.

- **Outcome**: The underpinning successfully stabilized the buildings, preventing structural damage during the metro excavation. The buildings remained intact throughout the project.

3. Box Jacking for Road Underpass Construction

- **Objective**: The metro station required an underground pedestrian underpass beneath an existing highway. Box jacking was employed to avoid interrupting traffic flow during construction.
- **Challenges**:
  - Ensuring highway traffic was not disrupted.
  - Achieving precise control of jacking to avoid settlement issues affecting the highway.
- **Solution**:
  - **Box Jacking**: Precast concrete boxes were jacked into position beneath the highway while traffic continued above. This method minimized surface disruption and accelerated construction.
  - **Execution**:
    - Excavation was performed in stages beneath the highway, and the precast concrete boxes were gradually jacked into position using hydraulic jacks.
    - Soil was continuously removed from the front of the box to reduce friction and prevent excessive ground movement.
  - **Outcome**: The underpass was completed without any significant traffic disruption or settlement issues on the highway. The precision of the box jacking method ensured safe and efficient completion of the project.

Conclusion:

The use of diaphragm walls, underpinning, and box jacking techniques enabled the successful construction of the underground metro station and pedestrian underpass while ensuring the stability of adjacent historic buildings and minimizing surface disruption. These advanced techniques were crucial in overcoming the challenges posed by urban construction in a high-traffic, densely populated area.

Key Learnings:

1. **Diaphragm Wall**: An effective solution for deep excavations with weak soils, providing both structural support and water-tightness.
2. **Underpinning**: Essential for stabilizing nearby structures, especially in areas prone to ground movement due to excavation.
3. **Box Jacking**: A valuable technique for constructing underground infrastructure without disrupting surface activities, particularly in urban areas with high traffic flow.

This case study highlights the importance of selecting appropriate construction techniques to ensure safety, efficiency, and minimal impact on existing infrastructure and communities.