DI04006071: Railway, Harbour & Tunnel Engineering

Lecture 5.38: Surveying Work Operation for Tunnel

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Civil Engineering

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Introduction to Tunnel Surveying I

Tunnel surveying is one of the most critical and challenging tasks in civil engineering. It ensures that the tunnel is excavated along the planned alignment and gradient, connecting the starting and ending portals exactly as designed. The precision required is extremely high, as any deviation can lead to significant cost overruns and structural issues.

Key Points

- Requires high precision to ensure correct alignment
- Connects different headings accurately
- Involves both surface and underground surveying

Stages of Tunnel Surveying I

Surveying for tunneling operations is systematically divided into several distinct stages to maintain accuracy throughout the project lifecycle. These stages transition from surface level planning to deep underground execution, requiring different techniques and instruments at each phase.

Key Points

- Surface Survey: Establishing control points above ground
- Transferring Alignment: Dropping lines from surface to underground
- Underground Survey: Extending the line and grade as excavation progresses
- As-built Survey: Final check of the excavated profile

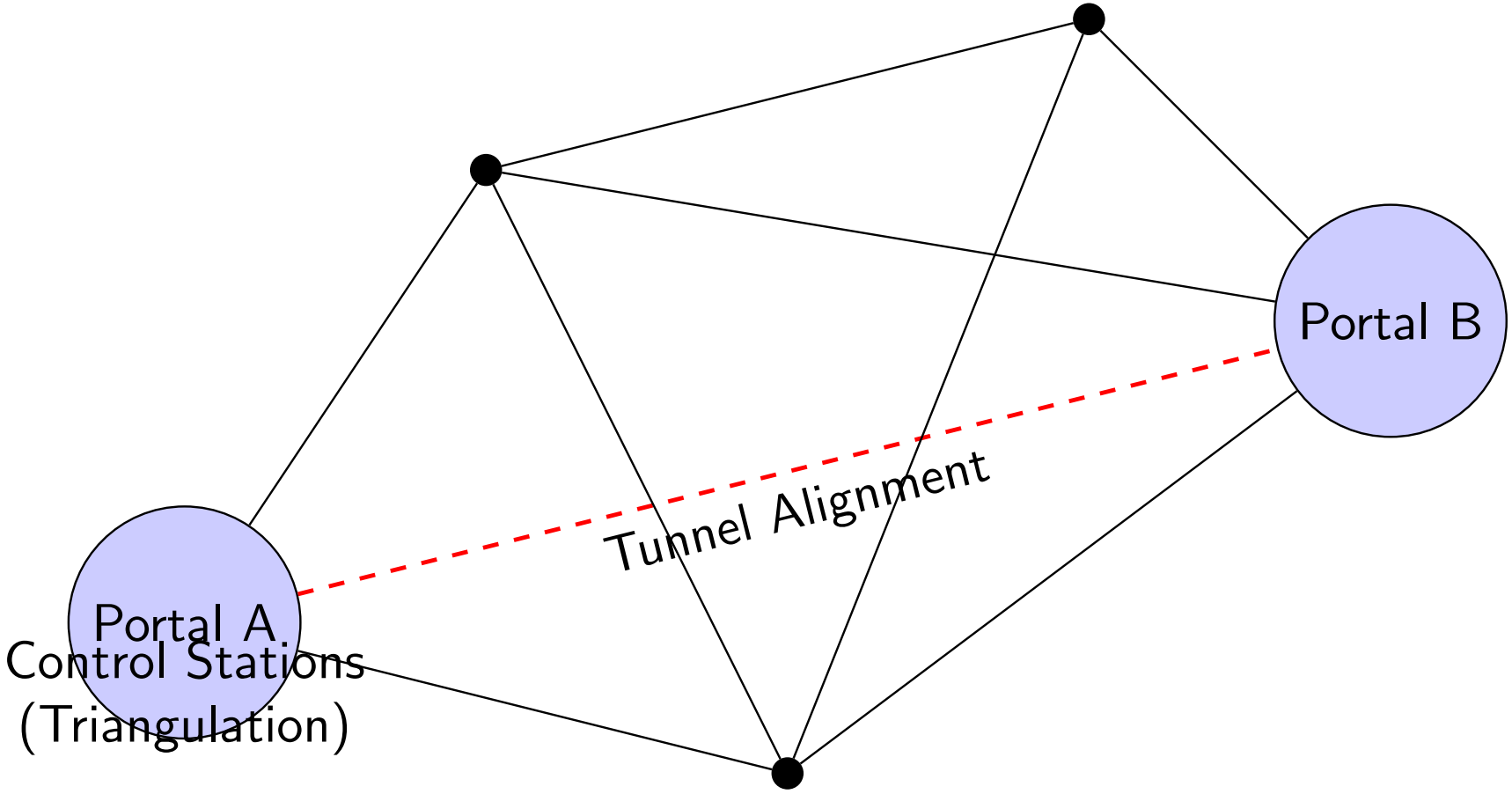
Surface Survey Operations I

The surface survey involves establishing a highly accurate network of control points along the proposed tunnel route. This is typically achieved using precise triangulation or modern GPS/GNSS networks. The baseline must be measured with extreme accuracy, as all subsequent underground work relies on this primary network.

Key Points

- Establishment of a precise triangulation network
- Setting out the main tunnel axis on the surface
- Locating shafts and portals based on the surface alignment

Surface Triangulation Network I



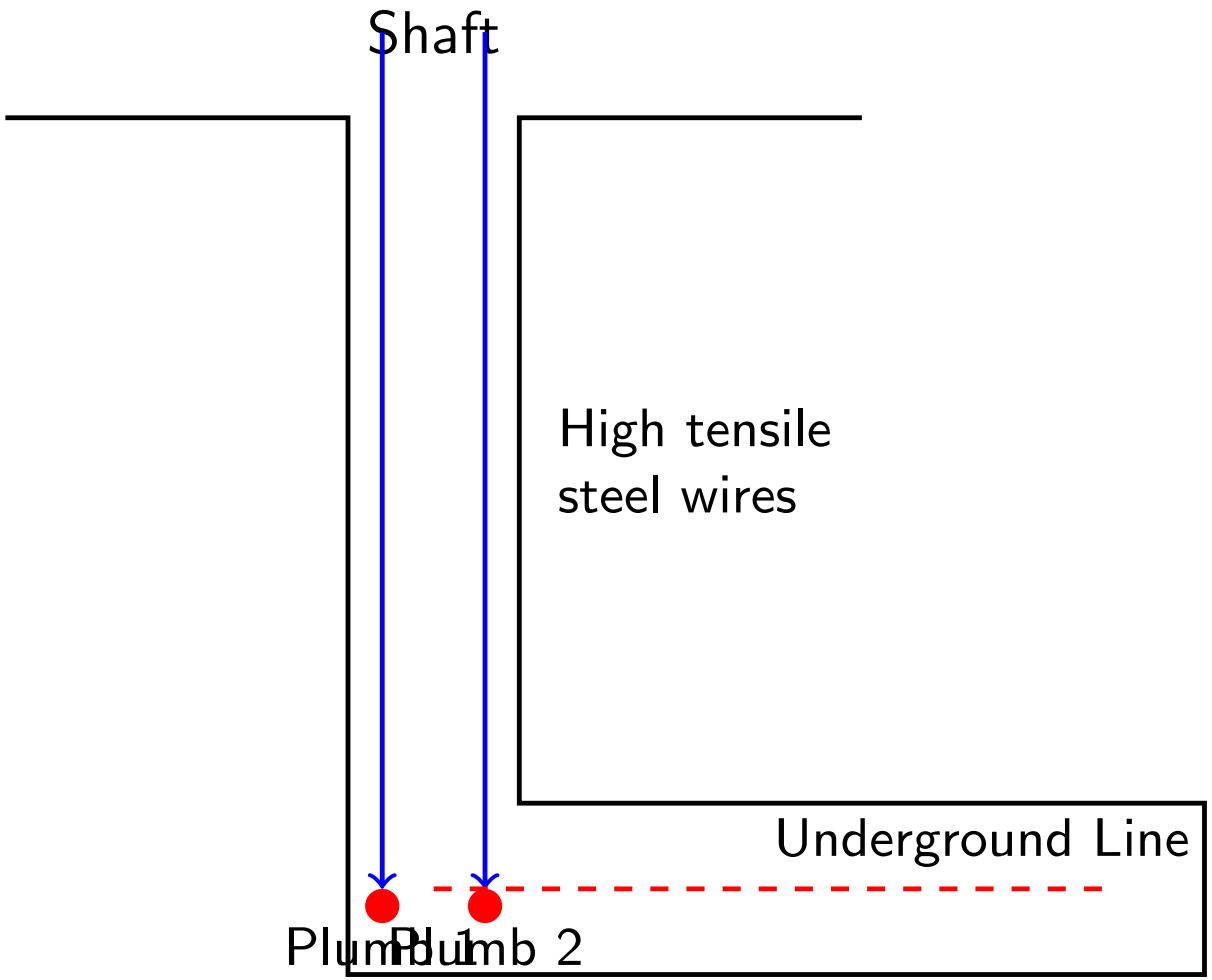
Transferring Alignment Underground I

Once the surface alignment is established, it must be transferred underground. If the tunnel is accessed via adits or portals, the surface line is directly extended using a total station or theodolite. However, when accessed via vertical shafts, transferring the alignment requires specialized techniques like the two-wire or co-planing method.

Key Points

- Direct extension for portals and shallow tunnels
- Use of vertical shafts requires wire plumbing
- Critical for maintaining the azimuthal orientation underground

Shaft Plumbing Method I



Underground Setting Out I

Underground setting out involves extending the transferred alignment deeper into the tunnel as excavation advances. Survey stations are usually established in the roof of the tunnel (using spuds or hooks) to prevent disturbance from construction machinery. Lasers are frequently mounted on these stations to provide a continuous visible line for the drilling jumbos or TBMs.

Key Points

- Stations mounted on tunnel roof for safety
- Frequent checking required due to difficult conditions
- Use of laser targets for continuous alignment guidance

Transferring Levels Underground I

Maintaining the correct gradient is as important as the horizontal alignment to ensure proper drainage and meeting track/roadway specifications. Levels are transferred down a shaft by lowering a vertically suspended steel tape with a tensioning weight. Precise leveling is then carried out underground from this established bench mark.

Key Points

- Use of weighted steel tapes for deep shafts
- Corrections applied for temperature and tension
- Underground bench marks established at regular intervals

Surveying Instruments in Tunneling I

| Instrument | Application | Expected Precision | |—|—|—| | Total Station | Surface network, portal alignment | $\{}pm 1-2$ mm, $1”-2”$ angular | | Gyro-theodolite | Underground azimuth determination | $\{}pm 5”-10”$ angular | | Laser Level | Continuous grade and line control | $\{}pm 2-5$ mm over 100m | | Plumb Bobs | Shaft plumbing for alignment transfer | Variable, highly skill-dependent | | 3D Scanner | As-built profiling, volumetric surveys | $\{}pm 2-3$ mm spatial resolution |

Advanced Tunnel Surveying Techniques I

Modern tunnel surveying relies heavily on advanced technology to mitigate the traditional challenges of underground work. Gyro-theodolites are used to determine true north underground independently of the surface network, correcting cumulative angular errors. Automated motorized total stations and 3D laser scanners provide rapid, highly accurate as-built profiles of the excavated sections.

Key Points

- Gyro-theodolites for independent underground orientation
- Automated Total Stations for continuous monitoring
- 3D scanning for precise cross-sectional profiling

Summary of Surveying Work Operations I

Surveying is the guiding force in tunnel construction, requiring meticulous planning and execution. The operations progress systematically from establishing a robust surface control network to transferring precise coordinates and levels underground. The adoption of modern instruments like total stations, lasers, and gyro-theodolites has significantly enhanced the accuracy and efficiency of tunnel surveying, ensuring that complex excavations meet with millimetric precision.

Key Points

- Surface control networks are the foundation of tunnel alignment
- Transferring alignment and levels requires specialized shaft techniques
- Continuous monitoring and modern tools ensure excavation accuracy