Opportunity surges in Montreal for tunnelling and the wider construction industry
Muck transportation systems

During the construction of tunnel projects, large quantities of excavation material are created. Muck transportation systems are among the critical elements in the tunnelling process. All tunnelling projects require haulage of mined material out of the excavation face, and in most cases out of the tunnelling site.

Muck transport and handling operations are partly or entirely on the critical path of the tunnelling process. The facilities required to support the tunnelling operation are primarily oriented toward keeping the muck handling systems operating efficiently and cost-effectively. This requires proper facilities for communication, power supply, environmental control, storage, equipment maintenance, personnel, and administrative functions.

Rail transportation: One of the primary transportation systems for excavated material is by rail. Rail systems (including locomotives and muck cars) have an advantage of straight forward traffic management and can adapt to most tunnelling diameters. However, these require constant extension at the heading and usually impede any construction work on the tunnel invert at the same time. Rail systems are not the most flexible systems in terms of “passing” locations and unloading points. In rail transport, a 3 per cent grade is a standard limit, although higher grades have been used in exceptional cases.

Rubber-tire vehicle (RTV): These systems are known for their flexibility due to not being constrained by fixed points of operation or the type, size, and configuration of vehicles. They can also be used more efficiently in tunnelling projects with more than one heading. In comparison with other methods, RTVs could have infinite options for passing locations and could keep operating, even if accidents or mechanical problems cause interruption for some of the vehicles. The disadvantages of RTV systems include (but not limited to) the requirement for a larger ventilation system and more effort to keep the roadbed in a suitable condition. Roads with grades up to 10 per cent are normal, but up to 20 per cent are also possible.

Belt conveyors: These muck handling systems are used in projects with different tunnelling methodologies, but are particularly suitable for tunnelling projects that utilize mechanized tunnelling such as TBMs. Belt conveyor systems can be designed to have a capacity to handle muck for any conceivable rate of heading advance and can adapt to nearly all sizes of tunnels. Belt conveyor systems can provide continuous operation and require small clearance and relatively low maintenance. Some of the disadvantages include (but are not limited to) limited capacity for large and heavy material such as big boulders [might require crushing facilities] and the fact that mechanical issues at a single location could shut down the entire system.

Modern technology and productive capability of large-diameter hard rock TBMs have encouraged the development and use of vertical conveyor systems with similar capacity to horizontal types. Conveyors are now available for lifting large volumes of tunnel muck, either vertically or on steep inclines, from the tunnel to the surface.

Pipeline transport: Excavated materials can also be transported through pipelines using fluids or air as the transporting medium in high capacities with minimum space requirements in the tunnel. Muck transportation through the pipeline is continuous (similar to conveyor belts) and could be one of the most cost-effective methods to deliver material in vertical settings. Despite this, there is generally a lower limit on the maximum size of material and requires extension as the tunnel advances. Cost of maintenance and keeping the system in good condition might be higher relative to other methods. The most common application of pipeline for muck transport is with slurry TBMs (large-diameter machines and smaller microtunneling applications). Slurry systems typically require a separation plant that needs to be well thought out in terms of cost, footprint, and environmental concerns.

Bulking factor: In estimating the volumes for excavated material, bulking is the phenomenon of volume increase that occurs when solid rock or soil is cut or broken. The volume of broken rock may increase relative to the original volume because the broken rock pieces typically do not fit together perfectly, which results in an increase in void space included with the rock solids. Depending on its initial state of consolidation, bulking also may occur when soil is excavated, resulting in soil volumes higher than the initial volume.

Success in tunnelling nowadays depends on a tunnel design that considers social, environmental, and economic issues. Proper planning for the handling of excavated materials of a tunnel construction project can possibly avoid waste deposits, save resources, as well as energy, and reduce some of the project costs – a contributing factor to a sustainable tunnel design.

References and Suggested Readings:

Materials Handling and Construction Plant
[A. A. Mathews - Tunnel Eng. Handbook]

Planning the handling of tunnel excavation material [S. Rittera, H. Einstein R. Galler]

The bulking factor of rock for underground openings [Goodluck I. Ofoegbu et al.]

Agree or Disagree?

Let us know what your experience has taught you. Or let us know what topic should be included in future Rules of Thumb columns. editor@tunnelsandtunnelling.com