
General Information

A. Purpose

The purpose of this chapter is to discuss the various trenchless methods of construction and rehabilitation. This chapter does not describe each trenchless method in great detail; rather, it provides the designer with a general description of the various construction methods available and the applications and limitations of each method. The goal of this chapter is to educate the designer to recognize situations where a trenchless construction method may be preferred over open cut construction.

B. When to Consider Trenchless Construction

There are many situations where trenchless construction is preferable to open cut construction. The most common are for road, railroad, and river crossings. However, other situations may be suitable for trenchless construction, such as avoiding possible damage to adjacent structures, homes, and businesses caused by dewatering operations; installations in tight corridors; and minimizing disturbances in environmentally sensitive areas.

C. Cost Analysis of Trenchless vs. Open Cut Construction

Most trenchless construction methods have a higher dollar cost than that of their open cut counterparts. However, one needs to consider the benefits that trenchless construction provides and weigh all of the costs before deciding against using a trenchless technique. It is easy to determine the cost of the tangible work items that trenchless construction avoids, such as pavement removal and replacement, dewatering, surface restoration, right-of-way, or utility easement acquisition. However, the benefits of trenchless construction go well beyond these items and include avoiding public inconvenience and lost business revenue caused by a closed roadway; minimizing utility conflicts; reducing dust, erosion, vibration, tree removal, and other environmental impacts; eliminating danger to workers and the public posed by an open trench; and reducing the potential damage to adjacent structures caused by large scale dewatering operations. Unfortunately, it is difficult to assign a dollar value to these potential situations.

D. Definitions

Annular Space: Free space between the existing pipe and any lining.

Auger Boring: (*See also guided auger boring*) A technique for forming a bore from a drive pit to a reception pit, by means of a rotating cutting head. Spoil is removed back to the drive shaft by helically wound auger flights rotating in a steel casing. The equipment may have limited steering capability.

Back Reamer: A cutting head attached to the leading end of a drill string to enlarge the pilot bore during a pull-back operation to enable the carrier or sleeve or casing to be installed in.

Bent Sub: An offset section of drill stem close behind the drill head that allows steering corrections to be made by rotation of the drill string to orientate the cutting head. Frequently used in directional drilling.

Bentonite: (*See also drilling fluid*) A colloidal clay sold under various trade names that forms a slick slurry or gel when water is added. Also known as drillers mud.

Boring: (1) The dislodging or displacement of spoil by a rotating auger or drill string to produce a hole called a bore. (2) An earth-drilling process used for installing conduits or pipelines. (3) Obtaining soil samples for evaluation and testing.

Boring Pit: An excavation in the earth of specified length and width for placing the machine on line and grade.

Butt Fusion Weld: A method of joining polyethylene pipe where two pipe ends are rapidly brought together under pressure to form a homogeneous bond.

Carrier Pipe: The tube which carries the product being transported and which may go through casings at highway and railroad crossings. It may be made of steel, concrete, clay, plastic, ductile iron, or other materials. On occasion it may be bored direct under the highways and railroads.

Cased Bore: A bore in which a pipe, usually a steel sleeve, is inserted simultaneously with the boring operation. Usually associated with auger boring or pipe jacking.

Casing: A pipe used to line bore holes through which a pipe(s) called carrier pipes or ducts are installed. Usually not a Product Pipe.

Closed Face: The ability of a tunnel boring machine to close or seal the facial opening of the machine to prevent or slow the entrance of soils into the machine. Also may be the bulkheading of a hand dug tunnel to slow or stop the inflow of material.

Closed-circuit Television Inspection (CCTV): Inspection method utilizing a closed circuit television camera system with appropriate transport and lighting mechanisms to view the interior surface of sewer pipes and structures.

Creep: The dimensional change, with time, of a material under continuously applied stress after the initial elastic deformation.

Cured-in-place Pipe (CIPP): A lining system in which a thin flexible tube of polymer or glass fiber fabric is impregnated with thermoset resin and expanded by means of fluid pressure into position on the inner wall of a defective pipeline before curing the resin to harden the material. The uncured material may be installed by winch or inverted by water or air pressure, with or without the aid of a turning belt.

Deformed Reformed Pipe (DRP): A term used to describe some systems in which the liner is deformed to reduce its size during insertion, and then reverted to its original shape by the application of pressure and/or heat.

Directional Drilling: A steerable system for the installation of pipes, conduits, and cables in a shallow arc using a surface launched drilling rig. Traditionally, the term applies to large scale crossings in which a fluid-filled pilot bore is drilled using a fluid-driven motor at the end of a bend-sub, and is then enlarged with a back reamer to the size required for the product pipe. The required deviation during pilot boring is provided by the positioning of a bent sub. Tracking of the drill string is achieved by the use of a downhole survey tool.

Drill String: 1) The total length of drill rods/pipe, bit, swivel joint, etc. in a drill borehole. 2) System of rods used with cutting bit or compaction bit attached to the drive chuck.

Drilling Fluid/Mud: A mixture of water and usually bentonite and/or polymer continuously pumped to the Cutting Head to facilitate cutting, reduce required torque, facilitate the removal of cuttings, stabilize the borehole, cool the head, and lubricate the installation of the Product Pipe. In suitable soil conditions, water alone may be used.

Duckbill: Alternative name for the steering device attached to the front of a directional drilling string.

Elastic Modulus: A measure of the stress buildup associated with a given strain.

Face: Wall of the entrance pit into which the bore is made.

Flexural Modulus of Elasticity: Mathematically defined as the stress divided by the strain of the material; measure of the rigidity or stiffness of a material. A high flexural modulus indicates a stiffer material.

Flexural Strength: The strength of a material in bending expressed as the tensile stress of the outermost fibers at the instant of failure.

Fold and Form Pipe: A pipe rehabilitation method where a plastic pipe manufactured in a folded shape of reduced cross-sectional area is pulled into an existing conduit and subsequently expanded with pressure and heat. The reformed plastic pipe fits snugly to and takes the shape of the ID of the host pipe.

Guided Auger Boring: A term applied to auger boring systems, which are similar to microtunneling, but with the guidance mechanism actuator sited in the drive shaft (e.g. a hydraulic wrench that turns a steel casing with an asymmetric face at the cutting head). The term may also be applied to those auger boring systems with rudimentary articulation of the casing near the head activated by rods from the drive pit.

Impact Molding: Method of creating a bore using a pneumatic or hydraulic hammer within a casing, generally of torpedo shape. The term is usually associated with non-steered or limited steering devices without rigid attachment to the launch pit, relying upon the resistance of the ground for forward movement. During the operation the soil is displaced, not removed. An unsupported bore may be formed in suitable ground, or a pipe drawn in, or pushed in, behind the impact molding tool. Cables may also be drawn in.

Inversion: The process of turning a resin-saturated tube inside out by application of air or water pressure.

Jacking Frame: A structural component that houses the hydraulic cylinders used to propel the microtunneling machine and pipeline. The jacking frame serves to distribute the thrust load to the pipeline and the reaction load to the shaft wall or thrust wall.

Jacking Shield: A fabricated steel cylinder from within which the excavation is carried out either by hand or machine. Incorporated within the shield are facilities to allow it to be adjusted to control line and grade.

Launch Pit: Also known as Drive Pit, but more usually associated with "launching" an Impact Molding tool.

Liner Plate: A product used to line tunnels instead of casing, and comes in formed steel segments. When these segments are bolted together, they form a structural tube to protect the tunnel from collapsing. The segments are made so that they may be bolted together from inside the tunnel.

Microtunneling: A trenchless construction method for installing pipelines with the following features: (1) Remote controlled - The microtunneling boring machine (MTBM) is operated from a control panel, normally located on the surface. Personnel entry is not required for routine operation. (2) Guided - The guidance system usually references a laser beam projected onto a target in the MTBM. (3) Pipe jacked - The process of constructing a pipeline by consecutively pushing pipes and MTBM through the ground using a jacking system for thrust. (4) Continuously supported – Continuous pressure is provided to the face of the excavation to balance groundwater and earth pressures.

Mixed Face: A soil condition that presents two or more different types of material in the path of the bore.

Modulus of Elasticity (E): The stress required to produce strain, which may be a change of length (Young's modulus); a twist or shear (modulus or rigidity); or a change of volume (bulk modulus), expressed in dynes per square centimeter.

Open Cut: (*See also conventional trenching*) The method by which access is gained to the required level underground for the installation, maintenance or inspection of a pipe, conduit or cable. The excavation is then backfilled and the surface restored.

Open Face Shield: Shield in which manual excavation is carried out from within a steel tube at the front of a pipe jack.

Ovality: The degree of deviation from perfect circularity, or roundness, of the cross section of a pipe.

Pilot Bore: The action of creating the first (usually steerable) pass of any boring process which later requires back-reaming or similar enlarging. Most commonly applied to Guided Boring, Directional Drilling, and 2-pass microtunneling systems.

Pipe Bursting: A replacement method, also known as Pipe Cracking and Pipe Splitting. A technique for breaking the existing pipe by brittle fracture, using force from within, applied mechanically, with the remains being forced into the surrounding ground. At the same time, a new pipe, of the same or larger diameter, is drawn in behind the bursting tool. The pipe bursting device may be based on an Impact Molding tool to exert diverted forward thrust to the radial bursting effect required, or by a hydraulic device inserted into the pipe and expanded to exert direct radial force. Generally, a PVC or HDPE pipe is used.

Pipe Eating: A replacement technique, usually based on microtunneling, in which a defective pipe is excavated together with the surrounding soil as for a new installation. The microtunneling shield machine will usually need some crushing capability to perform effectively. The defective pipe may be filled with grout to improve steering performance. Alternatively, some systems employ a proboscis device to seal the pipe in front used of the shield to collect and divert the existing flow, thus allowing a sewer, for example, to remain “live.”

Pipe Jacking: A system of directly installing pipes behind a shield machine by hydraulic jacking from a drive shaft such that the pipes form a continuous string in the ground.

Pipe Ramming: A non-steerable system of forming a bore by driving an open-ended steel casing using a percussion hammer from a Launch Pit. The soil may be removed from the casing by augering, jetting, or with compressed air.

Pipe Splitting: Replacement method for breaking an existing pipe by longitudinal slitting. At the same time, a new pipe of the same or larger diameter may be drawn in behind the splitting tool. See also Pipe Bursting.

Ramming: A percussion hammer is attached to an open end casing, which is driven through the ground. The spoil within the casing is removed to leave an open casing.

Reception/Exit Shaft/Pit: Excavation into which trenchless technology equipment is driven and recovered following the installation of the Product Pipe, conduit, or cable.

Resin Impregnation (Wet-out): A process used in cured-in-place pipe installation where a plastic coated fabric tube is uniformly saturated with a liquid thermosetting resin while air is removed from the coated tube by means of vacuum suction.

Resins: An organic polymer, solid or liquid; usually thermoplastic or thermosetting.

Shield: A steel cylinder at the face of a utility tunnel or casing, which may sometimes employ the use of a mechanical excavator and may be steerable, and provide hazard protection from the area covered.

Sliplining: (1) General term used to describe methods of lining with continuous pipes and lining with discrete pipes. (2) Insertion of a new pipe by pulling or pushing it into the existing pipe and grouting the annular space. The pipe used may be continuous or a string of discrete pipes. This latter is also referred to as Segmental Sliplining.

Slurry: A fluid, normally water, used in a closed loop system for the removal of spoil and for the balance of groundwater pressure during microtunneling.

Swab (Bull Plug): A steel plug that is pulled through a horizontal bore to remove the cuttings.

Thermoset: A material, such as epoxies, that will undergo or has undergone a chemical reaction by the action of heat, chemical catalyst, ultraviolet light, etc., leading to an infusible state.

Trenchless Technology: Techniques for utility line installation, replacement, rehabilitation, renovation, repair, inspection, location and leak detection, with minimum excavation from the ground surface.

Tunnel Boring Machine (TBM): (1) A full-face circular mechanized shield machine, usually of Man-Entry diameter, steerable and with a rotary cutting head. For pipe installation, it leads a string of jacked pipes. It may be controlled from within the shield or remotely. (2) (Mole, Tunneling Head) A mechanical excavator used in a tunnel to excavate the front face of the tunnel.

Tunneling: A construction method of excavating an opening beneath the ground without continuous disturbance of the ground surface and of large-enough diameter to allow individuals access and erection of a ground support system at the location of material excavation.

Upsizing: Any method that increases the cross sectional area of an existing pipeline by replacing with a larger diameter pipe.

Utility Tunneling: A process in which a temporary support liner is constructed as the tunnel is excavated. The liner typically consists of steel or concrete liner plates, steel ribs with wood lagging, or an all wood box culvert. Personnel are required inside the tunnel to perform the excavation and/or spoil removal.

Wing Cutters: Appendages on cutting heads that will open to increase the cutting diameter of the head when turned in a forward direction, and close when turned in a reverse direction. They are used to cut clearance for the casing pipe.

Definitions Source: North American Society for Trenchless Technology.