Good example of research paper on non-disruptive road crossing (ndrc) techniques ...

Transportation, Road

Fig 1: NDRC Techniques

Introduction

Non-Disruptive Road Crossings are manuals which outline unifying and standardizing measures of Road Engineering Practices. The significant objective of the project is to enhance the management, planning, design, construction, maintenance, and operation of all roads and related infrastructures to ensure a safe and uniform operational and structural capacity throughout the road network in Dubai. The complexity in road construction and to some point other engineering projects leaves very little to be argued about on their significance with respect to the influence they have on the environment. It is a fact that projects like roads, bridges, and dams are an essential part of Dubai which drives its economy and which is behind using Non-Disruptive Road Crossings.

As per Road and Transport Authority (RTA) of Dubai, it is the responsibility of the contractor, engineer, consultant, concerned agency, and any other parties involved in the construction of an NDRC to ensure that road pavement, pertinent services, and adjacent areas such as sidewalks are not damaged and that any effects are within the acceptable tolerances stated in the NDRC requirements. This actually dictates that the process of road construction should not damage adjacent landforms. It is the mandate of the authorities such as RTA and any other parties involved to formulate measures that would protect adjacent areas in the process of road construction

Essentially the mandate of the transport authorities with respect to NDRC procedures is to ensure that there is minimal to no destruction of transport networks in Dubai (e. g. on roads and rail) due to construction of pipelines for drainage systems or any other forms of construction that may affect the transport network. Further, the transport authority ensures that safety standards are as well adhered to when such constructions are taking place. Moreover, the methods used in the construction are of importance in ensuring that the destruction of the roads in Dubai are avoided or kept at a minimum .

NDRC History in Dubai

Non-Disruptive Road Crossing has been in practice since 1986 in Dubai. The history of these projects can be traced by evaluating the operations of the Hydro-tech's NDRC Division in Abu Dhabi, Dubai, Sharjah and Ajman. The company has completed various projects outlined as organizational objectives of its original committee. The corporation is made up of the thrust boring and the directional drilling division which was the first NDRC method used in the UAE.

Its thrust boring division has been very active over the years from its time of active operation with various types of boring machines to cater for different sized pipes and distances. With these, it has successfully completed hundreds of crossings using different pipes with different diameters for varying road lengths. It has however been a recognizable challenge that differences in soil types over their areas of operation have continuously moved them to create new ideas to sort out the issue.

On the other hand, their directional drilling divisions have developed improved techniques and working methods. As an overview of their main undertakings, the process generally includes three distinct phases, which begins with the drilling of the pilot hole from the surface on one side of the landform to be crossed. This level is determined by the nature of the obstacle to be crossed, in fact, there are various obstacles which require different approaches. Drilling continues along a designed profile below and ahead of the obstacle, to exit at the surface on the other side.

The second phase entails the reaming of the pilot hole to a diameter adequately large enough to perfectly match with the pipeline or conduit. In the final phase, the pipeline or conduit is pulled into to place within the enlarged hole. Generally, Non-Disruptive Road Crossing has numerous advantages over other construction methods given its minimized impact on the environment.

Moreover, normal activities for example highway or airport runway traffic can continue with their processes unconstrained during installation because it is not disrupted along the surface of the installation by the processes. They eliminate the need to cut roads, which are expensive to restore and provide traffic diversions. They are ideal in environmentally sensitive areas for minimum disturbance to the surrounding environment. They reduce disturbance to traffic and businesses, and are much faster than conventional methods. To comprehensively evaluate the main constructs of Non-Disruptive Road Crossing, it is important to provide a more detailed analysis of the various methods employed in these operations.

Objectives of NDRC

The objectives of the NDRC are focused on directional drilling employing boring machines to cater for different types and sizes of pipes. The project that begun in 1986 in Dubai has long since been instrumental in the construction of pipelines in Dubai that extensively ensure that there is no destruction to the transport networks. This notwithstanding, several challenges face NDRC with regard to the differences in soil types as well as different nature of obstacles to be crossed. Notably, each challenge requires specific and unique approaches in drilling underground from one side of the obstacle to the other. NDRC methods of construction used in Dubai include; None Steerable soil displacement, Non Steerable soil removal, Horizontal-directional drilling, Micro tunneling, Pilot Pipe Jacking, and Manned pipe jacking. These are discussed as under;

Non Steerable Soil Displacement

The method employs a tool known as a soil displacement hammer that does two centrally important purposes. First it drills a path through the soil under the road and secondly, installs a pipe behind as it drills through. The method requires averagely high force to drive the hammer into the ground. However, the force required may vary due to the soil type and obstacles on the path of the drilling hammer. This mechanism is illustrated in figure 2 below;

Fig 2: Non Steerable Soil Displacement

In non-steerable soil displacement methods, various soil displacement methods are used in the piping process. Impact molding also known as the soil displacement hammer is one of the most common techniques used. In this method, a hammering tool uniquely structured with a tapered head is used. The hammering tool is forcefully driven into the ground. This method requires a lot of force as the tool is driven through the soil for displacement. It is a logical fact that different amounts of force will be required at different points on the surface of the earth. This is because different points have varying soil types with divergent soil profiles as well as soil compositions. Actually, the services of a geologist are employed to determine the soil structure and profile before the activity starts given that too much force would destabilize the earth surface.

Otherwise, to compensate or reduce the amount of force required, the hammering tool can either work with compressed air or hydraulically and it displaces the soil as it moves through the ground. The compressed air provides the thrust, which is essentially another type of force. After the displacement of soil has been made in the point of activity, the cable material is initiated. This can be done directly after the hammering tool is removed. However this technique is limited to loose soil conditions with weaker cohesive forces. Alternatively, the piping or cable can be pushed directly behind the hammering tool. In another common technique known as Pipe ramming, a closed pipe is used during the process of soil displacement. It employs the same principle as impact molding or soil displacement hammer except for the fact that it uses compressed air or hydraulically activated ramming device to push a closed steel pipe through the soil hence performing the displacement.

Advantages

This technique has a number of advantages. The processes involved are very quick and easy to use, thereby also very cost effective. Further, due to the fact that the method only requires boring a tunnel underground employing the displaceable hammer; the number of personnel required for the job is also reduced and hence very cost efficient. For every foot of tunneling that the technique is applied, it costs 181 dirham. As a matter of fact, it is cheaper to displace the soil in a single process as compared to a series of processes used in the conventional methods. Moreover, moles or hammering tools are available for many soil conditions and can penetrate soft rock. This makes the possibility of using this technique in various soil profiles a considerable factor. Also, the method involves relatively small entry and exit pits as it concentrates on a limited circumference used for the piping only, a factor that saves the floor level it covers. Furthermore, installing the pipe or cable directly behind the hammering tool minimizes surface settlements.

Disadvantages

On the other hand, this technique has its shortcomings, the method requires that the soil is actually displaceable and surface heave can occur if satisfactory soil cover is not made available above the tunnel. This dictates that the soil profile involved has to be studied and established for drill depths and amount of cover volume to be left. To be precise, a minimum cover of 10 times the outer pipe or hammer diameter is recommended. Additionally, pipelines installed in this technique must be straight. This is because (as the name suggests) there is no steering mechanism employed that would enable the designing of corners or tapering edges.

Furthermore, the alignment of the tunnel can be influenced by the soil conditions, especially obstructions or stratifications that may alter the direction of the tool or pipe. For instance, the presence of a large hard rock along the drilling line would actually affect the process of displacement. As a matter of fact, depending on the size of the obstruction, the contractors may choose to drill a different site.

Finally, this method of pipeline installation cannot be used for designs that require a precise alignment. This is owing to its poor alignment accuracy that reduces the typical lengths for which the methods are appropriate. What is more, this method requires the observation of safe distances to other structures because the influence it has on the soil as well as the underlying rock, may stabilize the structures.

Long term Benefits and Environmental Implications

It is true that the method is easy and cost effective in its application. However, it is limited in terms of when or where the technique can be applied. One requirement for this technique is that that is displaceable. This implies that where there is a hard bed rock or impenetrable obstacles, the method is handicapped. Additionally, surface heaves may form where there is not enough soil cover over the tunnel that is drilled. It is also important to note that the alignment of tunnels constructed using this technique is influenced by soil conditions present during tunneling.

As such, pipes and other products that require precise alignments cannot be installed using this technique. This also has an implication on the distance of installations for which this method is reliable and the effect on other proximate buildings. This makes the long term benefits of this method very limited especially in an age where there is increased construction. The accuracy of pipe installation in this case is very vital. This notwithstanding, the method is very environmentally conscious. This is because the entry and exit pits required are very small. This reduces dereliction of land.

Non Steerable Soil Removal

Similar to Non Steerable Soil displacement only that this method ensures that there is no displacement of soil. It also employs cheaper equipment for the job of soil displacement. Centrally, the method employs the use of the use of water jetting, flushing, and compressed air in what is known as mechanical removal of soil. This method drives the pipe through the soil on in a process referred to as pipe ramming where before flushing air in high pressure there are established entry and exit points that the pipe would enter and exit from respectively prior to the commencement of the project. This is as shown in figure 3 below;

Fig 3: Non Steerable Soil Removal

Pipe ramming can also be carried out with an open pipe end and thereby without soil displacement. In this technique, the soil is either removed during the drilling of the pipe or alternatively, it can be removed afterwards. This method uses water jetting, flushing, compressed air, or mechanical removal of soil. For instance, the use of an auger is common.

However, there are important prospects of consideration that must be looked at with this method. For example, when using an auger, a cutting head can be attached to the head giving an improved method for application in harder soils. This makes it possible to navigate through hard soil formations underneath the earth. Moreover, the piping material is typically a steel casing (or sleeve pipe) in the interior which the product pipe or cables can be pulled or pushed after the process of soil removal.

This method necessitates the establishment of entry and exit pits. As a matter of fact, the entry pit may be needed to be lengthy in order to contain the pipe and auger sections along with the ramming or jacking device. In case the drilling reaches below ground water levels, the methods must be used with caution. In such a situation, the process of dewatering must be initiated. Pipe ramming may be achieved if the pipe can be driven completely through before soil removal and the soil plug inside the pipe is sufficiently stable to withstand the ground water pressure while ramming. When auger boring, the auger may become flooded owing to underground water levels giving way for excessive soil loss and major surface settlement. Some manufacturers have designed a sluice system for the auger to counter this effect. This has been a development to compensate the environmental effects deep drilling have on the underground water (Myers, 2012; Swift et al. 2011).

Advantages

These methods have their advantages with respect to other methods of construction, like the other non-steerable methods, are essentially less expensive than similar sized steerable methods owing to the need for fewer and simpler equipment and machinery. Further, the method does not require many people in terms of operational personnel thereby reducing on operational costs. It is generally a cheaper method than non-steerable soil displacement methods. More so the machinery used in these techniques are cheaper and available, actually with the availability of the materials, the piping could be molded. For every foot of tunneling that the technique is applied, it costs 146dirham diameter pipe. Additionally, the method can be used for significantly larger pipe sizes in comparison to displacement techniques (2000 mm diameter or larger). The larger diameter pipelines are typically stiffer and less susceptible to altering direction during installation (Myers, 2012; Swift et al. 2011).

Disadvantages

On the other hand, they have their limitations, as a matter of fact; swelling or extremely plastic soils may prove it impossible for the use of this technique. Practically, pipe ramming cannot be done in rock. Nevertheless with the use of an auger, a cutting head can be attached to the head giving an improved method for application in case the soil profile to be drilled has harder soils. Furthermore, loss of face stability when tunneling below groundwater level can lead to construction difficulties and even failure to complete the tunnel. Actually the same challenges are characteristic of directional control with respect to the non-steerable methods. In the context of its viability, the explanations above highlight conservation measures that are employed to ensure that the drilling actions do not harm the environment. It obeys the principles that underground water bodies are the main supplements of the surface water bodies (Myers, 2012; Swift et al. 2011).

Long Term Benefits and Environmental implications

This method is also handicapped in terms of the places where it can be applied. When faced by rocks beneath the soil surface, the method is unreliable because pipe ramming is not possible in rock. Construction difficulties can also occur when tunneling is done below the ground water level. These difficulties can quickly escalate to failure to complete projects. This method is also limited in hard soils. However, another cutting head is attachable in order to improve its applications. The method is environmentally friendly because it reduces dereliction of land.

Horizontal Directional Drilling

Perhaps the most widely used NDRC technique it employs the use of the HDD (Horizontal Directional Drilling) rig that drills a hole through the ground that the pipe is fitted into as illustrated below;

Fig 4: Horizontal directional Drilling

As mentioned earlier, HDD is widely used owing to its versatility in uses and the fact that it can be conducted from the ground surface without the need of deep penetration using shafts. As a matter of fact, the installation size can range from small diameter single cable crossings up to 1200 mm diameter pipes. Drilling distances can reach as much as 1500-1800 m in a single drill. However, longer drills have been achieved using intersecting methods which make it possible to surpass the limits of normal depths in drilling.

This method requires a HDD rig. This tool is capable of applying torque and thrust required in the process of drilling pipe through the ground. As mentioned before, the magnitude of these forces and thrusts depends on the nature of the soil profile in which the structure is to be built. However, the HDD rig is capable of producing tremendous magnitudes of torque which makes it possible to be applied in various areas independent of the soil profile or soil type.

A steerable drilling head, technically designed for the soil conditions, is situated at the front end of the pipes. Additionally, a probe or transmitter sending signals through the ground is situated directly behind the drill. The signals produced by the transmitter can be tracked from the ground surface, thereby determining the position and depth of the drill. This is actually the principle behind observing the environmental viability of the process. Constant tracing of the drill depth is important to ensure that dangerous depths are not reached. Furthermore, the direction of the drill can be altered by the asymmetrical steering face of the drill head.

After completing the drill, the borehole is lengthened to the required size by attaching reamers to the drill pipe and pulling back in one or more steps. After numerous reamers have been attached and pulled out, the intended pipeline is finally attached behind the last reamer to guide the piping into the borehole. In order to remove the spoils and establish considerable support to the borehole, a drilling fluid is pumped continuously.

The most widely used fluid is the bentonite suspension, which owing to its several chemical and physical characteristics serves well in the borehole. This is made possible by structuring the reamer larger than the piping so that when the piping is finally fitted, there is enough space for the application of the drilling fluid. As a matter of fact, the clearance between the reamer and the piping should leave enough space for the mixing of the drilling fluid and the soil.

Advantages

There are numerous advantages that are coupled with these techniques. Primarily, the wide size range and the ability to carry out HDD without large entry and exit pits and without groundwater lowering are the main advantages of this method. The direction of the drill can be altered according to the design of the structure while drilling making it possible to install a curved pipeline. Due to this technique, it has been possible to create more sophisticated structures embedded in the ground. Moreover, it is possible to vary the amount of soil left on the top part to ensure safe weights are determined. Furthermore, a great advantage of this technique is its ability to maneuver around other obstructions that exist below the ground. This actually depicts this technique as a very flexible and cheap undertaking (McFeeley, 2012; Swift et al. 2011).

Disadvantages

On the other hand, it has a number of limitations which hinder its wide use and is essentially the principle behind the choice of alternative construction techniques. However, it is an arguable fact that this method is environmentally friendly and the pollution that comes out of its operations can be minimized by strategic adjustments. Fundamentally, the possible alignment accuracy is normally insufficient for pipelines that require high precision alignment.

Engineering and technological studies emphasize the importance of maintaining a certain clearance for certain designs. This shows that a shift in the designed alignment causes a corresponding shift in the desired clearance. This actually reduces the accuracy of the technique. As well, maximum pipe diameters are limited to about 1200mm. This dictates that the method can only be done on pipes with diameters below 1200 mm., essentially, a sudden change in soil type (from say clay to sand) can destabilize the fluid pressure. Consequentially, it can ultimately disintegrate the compact formations of the soil annulus around the pipe. The occurrence of such situations usually damages the soil profile as well as other structures around; moreover, the pipe may be stuck leading to loss of the HDD string. The cost implications of the HDD method are as well disadvantageous to some extent given the fact that acquisition of the HDD rig is quite a costly venture. Drilling horizontal wells is much more expensive compared to drilling vertical holes. The costs of horizontal wells may run from between four million to seven million dollars for horizontal shale well. Purchasing the equipment is also an expensive feat. The 2011 Ditch Witch JT4020 All Terrain costs 1, 931, 160

dirhams. Furthermore, any damages to the HDD rig while at work also have costly implications in repairing and in maintenance as well .

Long Term Benefits and Environmental implications

Horizontal directional drilling has very obvious long term benefits, most of which are tied to the environmental considerations the innovative process of the technique encompassed. The technology enhances the ecological balance that existed before any construction was conceived. This is because the technology saves the landscape in the sites where the drilling process is being undertaken. This excludes the anthropogenic impact on the plants and animals in areas where the construction is being undertaken. Additionally, the technology reduces the negative impact on the living conditions of people especially when the construction is being carried out in human settlements. This gives the technology an upper hand over other technologies for the same job (Bayer, 2005).

Micro tunneling

Fig 5: Micro tunneling

Figure 5 shows the implement used for micro tunneling. The equipment, usually known as a Microtunnel Boring Machine is remotely controlled. Its use is very innovative in the construction industry. This is because it canvases the construction procedures in order to deliver products without causing extreme disruption of the activities ongoing in the communities where such constructions are undertaken. This equipment can be used to deliver different products and of different sizes. For instance, the Microtunnel Boring Machine can installs tunnel with varying diameters ranging from twelve inches in diameter to twelve feet n diameter. The implications of this feat are diverse. This means that the equipment can be used to construct pipelines and also tunnels holding underground passages for either trains or automobiles.

Micro tunneling is actually a technique used in drilling in which very small pipes are drilled into the ground. The term is generally related to automatic pipe jacking methods for pipes of very small diameters (usually smaller than 1000 mm). However, machines and equipment which can bore large diameters can also be employed in this technique. This means that the name does not limit the technique to a specified piping diameter.

Contractors have proposed that the term should be used for any unmanned pipe jacking that employs a steerable tunneling machine. In micro tunneling, the pipeline is installed by jacking the pipes forward from the starting shaft. As the pipes are pushed, the tunneling machine excavates the soil at the front of the pipeline hence displacing it. The displaced soil is afterward removed through the pipes that were laid initially. This can be done by various processes, some of which have already been discussed. For instance, the use of auger soil removal technique is an easy and environmentally cautious process which ensures that the displaced soils are properly disposed. In the auger process, the displaced soil is removed mechanically with the continuous line of augers. This process takes the form of the already discussed protocols (Swift et al. 2011; Myers, 2012).

Another technique used in removing the excavated soil is the slurry shield method. This involves the creation of a mixture made up of the excavated soil and a drilling fluid (bentonite slurry suspension) which is then pumped out together as a suspension. This method actually makes excellent use of its waste materials through use and reuse basis. The pumped out mixture is settled and soil is separated from the slurry in a tank. This leaves the slurry for reuse. This not only conserves the fluid but also the soil which reduces its recovery time.

However, this technique is characterized by the same challenges coupled with drilling below ground water levels. In this case, the auger may flood and give way for excessive soil loss. This can be explained by the analysis of forces (cohesive and adhesive) that are responsible in maintaining soil strength as well as compactness. There are structural adjustments embedded on the tunneling machine that counteracts this shortcoming. The slurry shield micro tunneling machine is typically designed with a pressurized partition, where slurry is pumped at a sufficient pressure. This is done to stabilize any loose soil as well as provide a balance for the ground water pressure. This not only reduces the chances of soil loss through collapsing but also prevents the excessive accumulation of slurry hence prevents flooding. This is actually technically explained by a balance of counteracting pressures (Swift et al. 2011; Myers, 2012).

The tunneling machine is controlled by a machinist outside the pipeline. The alignment of engineering structures is of great importance as it is the main construct for stability. In this case, alignment is controlled by laser or gyroscope and water level. These control processes makes it possible to check pipe lengths and design figures after they have been constructed. As a matter of fact, the line is typically straight, but using gyroscope or specialized surveying equipment and short pipe lengths, curved tunnels can be constructed. Piping materials must be designed to endure the jacking forces acting on them under installation as well as during use. There are numerous stresses that are calculated based on the uses of the structure. The values established from these calculations are used in setting the stress threshold of the structure and the strength of the structure. For instance, concrete is often used as piping material along with fiberglass or composites with concrete and fiberglass. Polymer materials especially polymer concretes are becoming more common due to their strength and resistance to corrosion. Studies in material science have shown that polymers exhibit good strengths, a factor which is largely applied in this system of construction (Swift et al. 2011; Myers, 2012).

Advantages

This technique has various advantages that couple its sophisticated nature in comparison to other materials. This technique can be applied in virtually all soil conditions while cutting heads can be modified to deal with weak rocks. This shows that the technique can be used in any part of the earth surface owing to its flexibility with respect to the nature of the surfaces. Additionally, the technique can use machines that can bore large diameters. As a matter of fact, pipes of up to 2000 mm diameter can be installed and can be constructed to a high degree of accuracy. Moreover, its degree of accuracy in maintenance of clearances defined in the design prototype makes the technique suitable for pipelines, which require precision in alignment or gradient (Swift et al. 2011; Myers, 2012).

Disadvantages

On the other hand, it has its own challenges. Obstacles which can take any form (large rocks/boulders or other materials) can be a challenge for the drilling machines. This is because it would require an adjustment of the cutting head to enable it withstand the challenge posed by the obstruction. Such cases call for excavation from the surface, which not only affects the surface processes but also pollutes the soil profile by shuffling the profiles

(Swift et al. 2011; Myers, 2012). This is essentially because the obstacle has to be removed to pave way for drilling. However, the removal of the obstacle can prove to be impossible owing to different factors. For instance, it can be too large or too strong for the cutting tool used, additionally; its removal could affect the stability of other structures situated near the site. Therefore, the machine would be abandoned owing to these challenges.

The complexity in changing of phases as a result of obstacles can be very problematic. Specifically, when the support of slurry is used in the control of excavated soil, (normally below groundwater) high pressures can be a factor of concern. This is because the control of groundwater as well as slurry volumes can be a challenge with the obstacle in question. Loss of slurry/face support can lead to instability, which leads to large surface settlements and, in extreme situations, desertion of the pipe and machine. This would leave the environmental viability of the soil at great stake. Micro tunneling is generally more expensive than many of the other Non-Disruptive Road Crossing methods. Micro tunneling in its entirety costs a lot of money. Boring a 96 inch micro tunnel would cost over two million dollars. To be precise, it would cost 7826777. 31Dirhams. Boring an 84 inch micro tunnel would cost 7218777. 72 Dirham. Evidently, this is more expensive than other techniques for non-disruptive road crossing. This is because it requires relatively large entry and exit shafts as well as more advanced equipment and machines (Swift et al. 2011; Myers, 2012).

Long Term Benefits and Environmental Implications

The technology involved in micro tunneling is timeless. The technique is applicable in all soil types and conditions. Additionally, the cutting head for the equipment used can be modified in order to perform when the tunnel is faced with weak rocks. The technique is also very precise making it suitable for pipelines whose construction requires s precision in gradient or alignment. On an environmental perspective, the entry and exit shafts that are required for this technique are relatively larger compared to other techniques. This not only disrupts the soil profile but could also cause dereliction. Additionally, where the tunneling is done in under slurry conditions, the water balance of the soil above the tunnel may be disrupted due to infiltration (Maidl, B. 2012).

Pilot Pipe Jacking

Fig 6. Pilot Pipe Jacking

Figure 6 shows a setup for the pilot pipe jacking technique. Pilot pipe jacking technique unlike other non-steerable methods is very precise. This is because it is controlled using a laser guided camera that is situated on the head of the pipe. The technique installs a pilot pipe contained in an open steel pipe that also has an auger attached to the pilot pipe. It is for soil removal. The pilot pipe serves as a sleeve to contain the product pipe.

Pilot pipe jacking on the other hand is basically a variation of the non-steerable auger boring method. The only difference in this technique is that a steerable pilot pipe is initially jacked or drilled through the soil.

Additionally, the alignment of the structures is controlled by laser and a small camera situated at the head of the pipe. After the alignment and tolerances have been established, an open steel pipe coupled with an auger for the removal of the displaced soil is attached to the already installed pilot pipe and pushed through. However, the steel pipe is not part of the structure but used as a guide material for the intended pipe to be fitted afterwards. The difference between the two methods is that a reamer is attached and coupled with a plastic pipeline. This setup is then pulled in the same way as HDD.

Advantages

Also, this method has its advantages owing to its accuracy in comparison to the non-steerable auger boring method. To be precise, the pilot pipe can actually be installed within an accuracy of +/- 20 mm, additionally; the steel sleeve pipe will typically follow this accuracy with the same clearance allowing very little deviation. Moreover, the technique provides a relatively cheap alternative of achieving a pipeline to the required precision, alignment and gradient. Arguably, the method is cheaper than HDD, soil displacement and soil removal methods discussed earlier. This is supported by the fact that the machine employed is remotely controlled by one individual reducing the costs incurred in hiring personnel for the job (McFeeley, 2012; Swift et al. 2011). For every foot of tunneling that the technique is applied, it costs 363 dirham for a twelve inch pipe diameter and 15246 dirham for a 168 inch diameter pipe.

Disadvantages

On the other hand, it also has a few challenges. For instance, large rocks or differences in soil structure adjacent to the pilot pipe can pose great problems to the drilling process. Furthermore, deep drilling to the levels of groundwater will experience the same challenges described above in sections on non-steerable auger boring and micro tunneling (Swift et al. 2011; Myers, 2012).

Manned Pipe Jacking

Fig 7: Manned Pipe Jacking

Figure 7 shows a set up for manned pipe jacking. Unlike the pipes used in micro tunneling, the pipes used in manned pipe jacking are large enough in diameter to accommodate worker working on the tunnel.

Manned pipe jacking methods are basically large enough to include operators inside the pipes who actually drive the soil displacement processes. The technique takes the same form with micro tunneling save for its size. In this technique, there are different tunneling machines with functional adjustments to handle divergent types of soils and groundwater levels. As a matter of fact, there are surfaces with the groundwater level nearer to the surface while others are far deep.

These machines are generally classified into open or closed face machines depending on the conditions of the soil in the construction site as well the structural adjustments on the design that would ensure soil stability after and during construction. Open-faced pipe jacking is actually used in soils that are stable with considerable cohesive and adhesive forces as well as the absence of groundwater inflow. This method is applied in most developing countries. It involves a tunneling machine with an open front which allows the excavation of the displaced soil. The removal of the soil is done mechanically and transported through a conveyor system out of the borehole.

When open-faced pipe jacking is used to drill pipes beyond the ground water levels, a chamber lock system may be used to apply the necessary pressure to the front. This is done to establish a pressurized front. The pressurized front is influential in the maintenance of soil stability by inhibiting groundwater infiltration during the process of excavation. However, this system is only applicable in cohesive soils or rocks because of the already existing intermolecular forces. Therefore the additional pressure is used to seal the pores that would cause groundwater infiltration. The use of this technique in loose soils would be questionable because the machines cannot produce the amount of pressure that would create temporary molecular forces between the soil particles and as well seal the air spaces (Swift et al. 2011; Myers, 2012).

Closed front or full-face excavation pipe jacking techniques are employed in loose soils and conditions with high ground water levels. As opposed to the open-faced pipe jacking method, this technique uses a closed front machine. In closed front machines, the use of the slurry shield type on micro tunneling can be influential. Alternatively, an earth pressure balance machine s normally used in its place. The principle of operation of the slurry shield-tunneling machine has already been described in the preceding methods. To be precise, a bentonite slurry suspension is mixed with the excavated soil and pumped out of the pipeline (Swift et al. 2011; Myers, 2012).

Advantages

The most recognizable advantage this method has is its quick access to the driving front. This factor makes it possible to manually remove the obstacles (larger rocks). In fact, open front machines have the most direct access into the core areas of the structure while closed front machines may need to be designed with access points to enable the shaping of its core structures within .

Disadvantages

As an environmental consequence of these processes, there are many health and safety issues associated with manned pipe jacking. Precisely, these processes expose human beings into working inside confined spaces exposing them to the danger of collapsing as a result of low air volumes or inundation due to the groundwater. Additionally, humans are endangered by the probability of the soil structures collapsing and trapping them inside the tubes. As a result of these issues, there have been constant pressures by humanitarian organizations on the use of this technique with respect to safety standards. However, it is proposed on the basis of debate that detailed and robust health and safety procedures be setup to reduce the chances of loss of lives as a result of these activities.

Other Methods

Non-Disruptive Road Crossing techniques continue to develop and new techniques are constantly in the process of trimming and implementation to trounce some of the disadvantages of conventional methods. This is done to enable or provide faster and cheaper construction techniques. For example, easy pipe and direct pipe methods are new techniques arising from test studies meant to supplement the performance the Non-Disruptive Road Crossing techniques. This method integrates conventional micro tunneling and a taste of other innovative methods of using the jacking pipes to initiate the installation of the permanent pipe.

In the effect that the tunnel is bored, the tunneling machine is withdrawn while the intended pipe is attached to the installed jacking pipes. The bolted jacking pipe segments are pulled back through the tunnel, on which the permanent pipe is coupled. In this process, the segments move together with the intended pipe. In this manner, the permanent pipe is set up quickly and easily while the jacking pipe segments can be removed and re-used for the next project. However, the process requires a micro tunneling unit to be equipped and assembled in the start pit (Swift et al. 2011; Myers, 2012).

The variation between the jacking pipes employed in the Easy Pipe as compared to conventional methods is that the extraordinary design allows their utilization as jacking pipes in the forward direction. As a matter of fact, this allows them to be retracted from the accomplished bore to pull in the installed pipe. After the cutting tool has reached the target hole in the ground, it is alienated from the jacking pipe string and replaced by a particularly designed connection pipe that also unite to the product pipe (Swift et al. 2011; Myers, 2012).

The jacking pipes are then pulled back using the bi-directional jacking frame, concurrently pulling the product pipe into the right spot. In the initiate pit the individual jacking pipes are sequentially removed along with all other equipment until the product pipe reaches the intended launch shaft. The bond pipe and jacking frame are detached from the ditch leaving the product duct in place to be finally connected to the remainder of the conduit on either side of the hindrance crossed. This will actually depend on the number of obstructions passed by the piping. As a matter of fact, this technique can be termed as a hybrid of the HDD and micro tunneling methods (Swift et al. 2011; Myers, 2012).

Advantages

This method has its own advantages owing to its single-step process, which leads to rapid installation of pipes. It is easier and the processes involved are instant. It actually saves time, as no time is required for the coupling of pipes in micro tunneling as well as the formation of drilling rods as for the HDD case. In this technique, the design of complex shapes and designs is easier as pre-welded and already tested pipes can be fixed.

Additionally, the construction of shafts is eliminated, as the technique only requires the construction simplified surface entry and exit pits. This technique is actually design to initiate the displacement of soil and setting of the intended pipes simultaneously. Moreover, inclines, gradients, and curved surfaces can be successfully created with this method. To be precise, this technique is an ideal method for sea outfalls, which have an access from one side only. Actually, the use of Pipe Thruster enables both tunneling machine and pipeline to be inhibited (Department of Transport, 2013; Municipality of Abu Dhabi City, 2012).

Disadvantages

This method also has several disadvantages, first, since it is a combination of several methods discussed here in like the HDD method and the micro tunneling method it also poises the disadvantages associated with the two methods especially with regard to pollution in the case of HDD method and dangers of instability when digging where underground water table is reached. Further, the cost implications with regard to the expenses incurred in this method are as well directly proportional to the level of application in combining elements of the other NDRC methods discussed in excavation. Thus, this method proves to be the most expensive method among the ones discussed. In addition, the method has not fully been proven to be efficient and hence further research and studies on its application and effects are required to ensure that it is applied efficiently and effectively in future.

Conclusion

Generally, the NDRC method that would best suit Dubai out of the ones discussed herein is the Horizontal Directional Drilling. Bearing in mind that Dubai is an expansive desert with a soil profile that is largely composed of sand, it would be prudent to propose that HDD is the best method to ensure NDRC principles are met. In addition, much of Dubai has established infrastructure that calls for precision in NDRC techniques such that a considerable part of these infrastructure are not destroyed. In essence, HDD is the only NDRC technique that would ensure minimal if any disruption to the infrastructure of Dubai which if left unchecked may result into financial losses due to the disruption caused to social political and economic activities.

The paper has presented several NDRC techniques that can be employed in laying down underground crossings that ensure that the roads are not destroyed. First, the paper has discussed Non steerable soil displacement methods followed by Non steerable soil removal methods. Subsequently, the paper analyzed the horizontal directional drilling, micro tunneling, manned pipe jacking and pilot pipe jacking NDR techniques. Further, alternative methods to the ones mentioned were also discussed in the paper. All these techniques can be useful in the ensuring that NDRC principles are observed during underground road crossings. However, as mentioned in the preceding paragraph the best NDRC method that would best suit Dubai is HDD due to its advantages associated with excavation on sandy soils which is predominant in the landscape of Dubai as discussed herein.

This notwithstanding, the choice of the best technique to be used in Dubai from the various examples discussed above would be governed by an analysis of the soil structure as well as the various landforms. For example, the building of the famous Palm Islands development, off the coast of Dubai is one example in which Non-Disruptive Road Crossing techniques have been of great use. Excavation in sand presents difficulties, especially near the coast and below the water table. These are essentially characteristics of the soil profile in Dubai and hence worth consideration when choosing an appropriate NDRC method to employ. The services of geologists are therefore important and necessary in determining the soil composition and structure before commencing on any of the NDRC techniques discussed. Non-steering soil displacement, non-steering soil removal and pipe pilot pipe jacking are the cost-effective techniques. On the other hand, horizontal directional drilling is the most expensive since it is very sophisticated.

Manned pipe jacking technique is more costly when compared to pilot pipe jacking and other conventional techniques due to the mere fact that it requires that personnel be stationed inside the pipes as operators.

It is also worth noting that some of the technologies listed above might become obsolete with time after more cutting edge technologies for the same purpose have been discovered. The rate of constructions in the urban space is increasingly exponentially. With time this will result in reduced vast space. Additionally, the space for installation of pipelines will be increasingly limited and sandwiched between buildings or other installations. As such, the installation of pipelines will require precision in terms of alignment. Owing to this, any methods that do not have accuracy will be less used because of the potential for catastrophes, especially because tunneling using such methods could encroach into buildings and weaken their foundations. I anticipate that techniques like nonsteerable soil displacement methods and nonsteerable soil removal methods will become obsolete and get replaced by other technologies (Maidl, 2012).

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