The Important of Horizontal Directional Drilling Standard Technical Requirements

Mohd Norizam Md. Salleh¹, Nuzul Azam Haron*, Helmi Zulhaidi Mohd Shafri³, Abdul Aziz Abdullah⁴, and Nadzrol Fadzilah Ahmad⁵

¹,²,³Department of Civil Engineering, Faculty of Engineering, Universiti Putra Malaysia, 43400 - UPM Serdang, Selangor Darul Ehsan, Malaysia
⁴Centre For Continuing Education (CCE), Universiti Sultan Zainal Abidin, Gong Badak, 21300 - Kuala Terengganu, Terengganu, Malaysia
⁵Malaysian Highway Authority, Jalan Serdang - Kajang, Kawasan Institusi Bangi, 43000 - Bandar Baru Bangi, Selangor, Malaysia.

* nuzul@upm.edu.my

Abstract. Horizontal Directional Drilling (HDD) is a trenchless technology provides an installation alternative that offers a lot of benefit compared to traditional open-cut method. It’s called HDD because its steering ability to avoid existing utilities or other obstacles either horizontally, vertically and even pulled back where she got its name. HDD was developed in California in the 1970s and was introduced in Europe in 1986. Since year 1992 up to 2016 there are more than 40 thousand-unit HDD machine were sold worldwide. The aims of this study are to determine the present local authorities’ technical requirements in HDD works, to determine the factors of HDD good practices and to develop a standard HDD’s technical requirement. This research shall use mixed method in achieving the objectives. A descriptive and exploratory research design will be used for the study. The research design for this study contains the following consist of the research problem and research questions, sampling design, method of data collection, method of data analysis, validation/verification of the HDD standard technical requirements and its’ frameworks. This study shall able to produce a standard HDD technical requirement and its’ framework. With the establishment of a thorough and a standard local authority’ technical requirements it’s will able to educate the HDD contractors and assist them in carrying out their work properly, successfully and safely. It’s will also able to educate the stake holders on how important to follow the stipulated technical requirements that contributed to the project success.

1. Introduction

Compared to traditional open-cut method where open excavations were used, Horizontal Directional Drilling (HDD) method on the other hand provides an alternative installation using trenchless technology. With routing ability, it can avoid damages to any existing utility lines. HDD method minimise noise, dust, traffic disturbance, public inconvenience, business disruptions, lower renovation cost, least import/export for construction materials make this technique most favourable method among urban and sub-urban areas. In addition, this method be used to drill through high traffic

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demand areas with minimum portion of cut and fill and with minimum impact to the environment (Willoughby, 2005). HDD method can also be used for horizontal sampling where it uses to collect contaminated sampling at contaminated ground (Allouche, Ariaratnam, Biggar, & Mah, 1998).

It was first introduced in California, USA in 1971, a river crossing across Pajaro River near Watsonville and in Europe it was started in 1986 (Bayer, 2005). The HDD usage are very slow in its first decade as until 1979 only 36 successful crossings were completed since the first HDD crossing in 1971 (Sarireh, Najafi, & Slavin, 2012). Compare to past few centuries that this technology initiated, a lot of enhancement such as more user and environmentally friendly, advanced hydraulic system and power source, drill frame and drilling fluids and detection sensors has been implemented which prioritise this technology with compare to other technologies (Pipeline and Gas Technology, 2005). Most research on horizontal-directional-drilling (HDD) that conducted in the past are either concentrating more on how to improve the drilling technology, plants, tools, to make it more user friendly, easy guided, conducting experiments in developing better work procedures, user friendly guided plant, to enhance the work process, minimise possible risks, to improve on quality, to widen the HDD usage to other sectors, stability of boreholes, bentonite effect, utilities, lawsuit issues and etc.

Since year 1992 up to 2016 more than 44 thousand unit HDD rigs were sold worldwide (Carpenter, 2011; Carpenter, 2014; Carpenter, 2016). The increase of HDD usage reached its phenomenal growth, with only 12 operational unit in 1984, the numbers had increased drastically to more than 2,000 units in 1995 with a multiplying factor up to 167 times just within a decade. Since then the sales of HDD machines consistently increases about 2,000 plants a year except during 1999 and 2000 where telecommunication sectors in US reach its boom. Table 1 shows number of HDD plant manufactured worldwide from 1992 to 2016. by 2016 there are almost 45 thousand HDD machines that have been sold globally. Meanwhile in Figure 1, the pie chart shows the USA’s HDD markets according to sectors.

| Year               | Number of HDD Rigs Manufactured/Sold |
|--------------------|--------------------------------------|
| 1992–1995          | 3,435                                |
| 1996–2000          | 13,347                               |
| 2001–2005          | 5,427                                |
| 2006–2010          | 8,154                                |
| 2011–2016 (2016 projected) | 14,462                            |
| **Total**          | **44,825**                           |
As demonstrated in Figure 2, HDD technique has been executed in construction by making a appropriate trench for HDD to be inserted and small pilot head with sensors that can steer the desired route and proposed profile. This process follows until the HDD head slides through and pops from other side. Then the pipe will be insert and will be pilled back through the route that been drilled by HDD. Its major components are the drilling rig, drill pipes, slurry/bentonite, slurry recycling, survey equipment, drill bits, reamers and pipeline materials (CAPP, 2009). The HDD operator will communicate with the tracker that has been attached on HDD in order to control the pilot head drilling path. Until 2016, USA still becoming world no 1 HDD machine manufacture followed by China and India. Until 2016, USA still becoming world no 1 HDD machine manufacture followed by China and India (Ariaratnam, 2016).
With the installation of utilities using HDD method within urban and sub-urban areas becoming more famous this method may prone to accidents if it is not carried out properly and its productivity may also affected. The presence of HDD Machine from China although its can reduce the construction cost as they are cheaper, it’s may also invites those who are lacking with HDD knowledge and training to join the market. This can lead to a lot of problems e.g., non-standard and dangerous method uses, causes damage to road furniture, failure to the structures/facilities, hitting existing utilities, endanger the publics and road users, inaccurate as-built drawing and etc.

2. Research Gap
At present, Malaysia local authorities did not have a standard HDD technical requirement. Establishing a standard HDD technical requirement across all municipal will ease the stakeholders especially the contractors in fulfilling these requirements.

No studies were conducted to identify the contribution of abiding the local authorities’ HDD technical requirement to the HDD project success. This actually can assist the contractors and the HDD technical requirement is actually not to make their job difficult but is helping and assist them in carrying out their work properly, successfully not damaging third party properties and safely. The development of HDD project success framework shall proof this and the development of the proposed Local Authority’s HDD Technical Requirements on the other hand can assist the municipal and the local authorities to ensure the contractors can deliver a good job deliver on time and less damaging to the existing structures, utilities, road furniture, public properties and etc.

3. Problem Statements
In the past, researches were more concentrated their studies on how HDD method works, the stability for the bored holes, type of drill bit to be used, different type of drilled soil and what are the additive required, detection method for guiding the pilot head and etc. When the HDD topic is concern, although HDD works were introduced in Malaysia since late 80’s there are very little studies of the related topic were carried out and therefore the author felt it is the author duty fill up this research gaps. At present as well as been practiced elsewhere, different local authority in Malaysia imposes its own HDD technical requirements as there is no standard technical requirements available when the HDD method of construction is concerned. Some of the utilities concessionaires/HDD contractors may not producing the proposed HDD profile, neither engaging surveyor to do setting-out neither the as-built drawing, no thorough utilities detection/studies was carried out, soil investigation, informing other utilities concessionaires, open up existing manholes in the vicinities and joint inspection with other utilities concessionaires who have their utilities in the vicinity and etc.

At present, Malaysia local authorities did not have a standard HDD technical requirement. To install utilities across different local authorities, the contractors require following different sets of rules hence giving the ideas that the some of the technical requirement are worthless. Make it worst, some of the HDD sub-contractors are lacking of HDD knowledge and training. This can lead to a lot of problems e.g., resulting high in cost, non-standard and dangerous method, causes failure to the structure/facilities that they cross, hitting existing utilities, endanger the publics and road users, inaccurate as-built drawing and etc. as the works are carried out were based on trial and error thing. Hence a thorough and a standard local authorities’ technical requirements is not to make their job difficult but is actually helping to educate the HDD contractors and assist them in carrying out their work properly, successfully and safely.

Among the problems to be addressed in this study are as follows;

i. What are the present local authorities’ technical requirements in HDD works?
ii. What are the factors for HDD good practices?
iii. What factors for standard HDD technical requirements are required?

4. Research Objectives
The aim of this research is to study the current local authorities HDD technical requirements, HDD good practices and to develop and a standard technical requirement that would assist in achieving HDD project success. The following specific objectives have been defined:

i. To determine the present local authorities’ technical requirements in HDD works.
ii. To determine the factors of HDD good practices.
iii. To develop Standard HDD technical requirements.

5. Significance of the Study

Most research that have been conducted in the past are more concentrated on the technical issues faced by the HDD methods e.g. HDD in different type of soil, the stability of the drilled/bored holes, productivities, risks, legal aspects and etc. Therefore the author felt there is a need to carry a study to identify the present local authorities technical requirements, also will concentrate in identifying whether there is any new technical input that can be used to further improve the present technical requirements and guidelines for horizontal directional drilling works. This study will also focussing in determining what are the PM body of knowledge that can assist to meet the local authorities technical requirements and whether the skill on project management body of knowledge can assist the contractors to meet the local authorities technical requirements.

With this study it is author ambition to be able to improve the current requirements/guidelines for HDD works by adapting new technologies and educate the parties involved on how important to follow the stipulated technical requirements and it's also contributed to the project success. This can also helping in upgrading the HDD pre/post work process, reporting and as well as their documentations practices in Malaysia when project management body of knowledge can be adopted. Finally complying to the local authorities requirement/guidelines can also be the aiming in avoiding damages to the existing utilities and the public safety as a whole.

Cheaper HDD machines form China since the last decade is also contributed to the drastic increases of HDD numbers, now everybody can become HDD contractor. Problem arises how to properly regulate and monitor especially the inexperienced new contractor when they carried out their drill in utilities congested urban areas. Whether the non-standard HDD technical requirement from various authorities able to legislate the HDD contractors? HDD method has becoming the preferable trenchless methods by the local authorities and municipals as fewer disturbances to the public and economy. Horizontal Directional Drilling (HDD) has made a significant impact in both the utility and pipeline installation industries over the past decade. The horizontal drilling industry in North America has grown from 12 operational units in 1984 to more than 2,000 units operating in 1995, with some experts placing the number of directional drilling rigs worldwide as high as 10,000 (Kirby, Kramer, Pittard, & Mamoun, 1996). Based from 2016 survey the number had reached more the 40, 000 units worldwide (Carpenter, 2016a).

Lack of drilling skill by contractors might cause damages to existing utilities and would cause major consequences which would ruin this technology impression among other contractors. Such damages are not only loss of time in construction but also will significantly affect the economical aspect of the project were the remediation will be over the revenue cost. (Ariaratnam & Proszek, 2006). Damage resulting from directionally drilled crossings has become a concern for municipalities and contractors due to the increased popularity of this trenchless installation method. Surface heave is one mechanism through which directionally drilled installations may damage existing surface structures such as pavements and foundations. Several factors contribute to the development of surface heave including back ream rate, borehole pressure, down hole tooling, depth of cover, annular space size, and geotechnical properties (Lueke & Ariaratnam, 2005).

The control measures to HDD installation-related issues could mitigate the problems e.g. 1) heaving of surface features; 2) damage to existing subsurface structures; 3) product pipe damage; and 4) surface settlement from happening. Adherence to these recommendations will better increase the likelihood of a successful horizontal directional drilling project (Ariaratnam, 2009).
Photograph 1, show heaving on road surface as the result of HDD works activities, Photograph 2, illustrated cross core of HDD dill pipes to come of sewer pipes and Photograph 3 shows a HDD drill bit went through gas line (yellow) near JJ's restaurant in USA in 2013.
Malaysian authorities are in responsibility to prevent such this damages that caused by HDD, where accidental and lack of practice of contractors became massive issue with enormous cost. Previously, HDD market was trending due to rapid growth in construction of fibre-optic backbone across the United States. However, this rapid growth have not let the contractors to be skilled in this technique before executing their job. California Department of Transportation released compulsorily training of HDD for all contractors before executing work in 1998 due to concern of underground installation damages. (D Bennett & Ariaratnam, 2011). Similar apprehensions were being raised around USA by other transportation and environmental authorities. Authorities, such as Santa Clara County, considered declaring a moratorium on all drilling operations until a standardized set of practices was established and training of operators was implemented (D Bennett & Ariaratnam, 2011). These contractors known as “cowboy contractors” have becoming a threat to USA HDD market (Griffin, 2005).

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The arising of HDD Machine from China though its can reduce the construction cost (cheaper) it may also invites HDD sub-contractors with lacking of HDD knowledge and training to join the market.

This concern has a basis with the increase of damages caused by HDD activities. From some table studies the authors had managed to gather some accidents report caused by HDD activities not only in Malaysia but as well in USA where some as gas pipeline have been stroked by HDD drill rod within the last decade. Among the damages are the fibre optic cables connected to Custom Malaysia Information System in Klang in May 2016, that had affected Westport operation (Bernama, 2016) and the power outage in Menggelebu district in Ipoh, Perak where 138 sub-station were down (Malay Mail, 2017) both were stroke by HDD activities. Similarly in 2016, American Gas Association had conducted a white paper report regarding four (4) gas pipeline stroke by HDD activities in New Albany, Indiana (November 8, 2011), in Kansas City, Missouri (February 19, 2013), in Royal Oak, Michigan (February 27, 2013) and in Ewing, New Jersey (Marc4,2014)(AGA,2016).
**Table 2: Number of Electricity Supply Interruptions – TNB Peninsular Malaysia**  
Source: (Energy Commission, 2016)

| NUMBER                | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|-----------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| Unscheduled Interruptions | 48,561 | 36,295 | 24,953 | 24,953 | 26,075 | 98,662 | 55,523 | 74,058 | 112,064 | 108,708 | 94,940 | 81,180 | 74,436 | 70,629 | 63,920 | 58,175 |
| Scheduled Interruptions |         |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| TOTAL                 |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Damaged by third parties | 8.3% | 8.4% | 11.0% | 12.3% | 8.6% | 5.5% | 8.9% | 12.6% | 15.7% | 14.6% | 15.839 | 12.1% | 6.3% | 5.6% | 5.8% | 6.7% | 5.9% |
| Interuption by unknown reasons | 4,050 | 3,045 | 2,754 | 3,199 | 4,536 | 5,380 | 6,621 | 17,904 | 14,70% | 13,56% | 14,740 | 13,956 | 22.70% | 25,439 | 3,275 | 4,166 |

Author believes the damaged caused by the HDD activities are in actual fact are quite many but they were not properly recorded. Therefore not many information can be gathered online. For example although TNB did recorded their record properly it was not stated in their annual report whether the damaged done by the third parties are due to open trench activities or HDD activities. The average third parties damages for the last 17 years for TNB (in Peninsular) alone is about 6,279 incidents, imagine if 10% is done by HDD activities. Surely the standard local authorities HDD technical requirement will contribute in reducing this figure.
6. Scope of the Study
The discussions and the results of the study should cover the research problem statement, research questions and its objectives.

On the other hand the limitations of this study shall include;

i) The study is limited to local authorities, utility companies, check consultants and contractors as the stakeholders who are involves in horizontal directional drilling works in Malaysia.

ii) The assumption is made that the contractors involves in horizontal directional drilling works are the main contractors that are listed in CIDB website under utilities categories e.g. telecommunications, water pipes, sewers, gas pipeline and etc.

iii) The project management body of knowledge spell out in this study is only limited to those that related to local authorities requirements/guidelines.

iv) The discussion on new identified technologies shall be limited to its contribution not to be discussed in detail how they are to be carried out.

v) It is limited to particular instruments.

vi) It is limited to only specific sampling builds.

vii) This study also limited on some specific data analysis and applications.

7. Literature Review
The literatures studies involved journal articles, conference papers, authorities’ technical requirements, books, guidelines and etc.
| Subsurface conditions | (Allouche et al., 2000) | (Adel & Zayed, 2009) | (Ali, Zayed, & Hegab, 2007) | (Zayed, Amer, Dubey, & Gupta, 2007) | (Sarireh et al., 2012; Sarireh et al., 2013) | (Zayed & Mahmoud, 2013; Zayed & Mahmoud, 2014) |
|-----------------------|------------------------|----------------------|-----------------------------|---------------------------------|--------------------------------|-----------------------------------|
| Job and mgmt conditions | Management Conditions | Managing Env. Cond. | Managing Env. Cond. | Managing Env. Cond. | Managing Env. Cond. | Management Conditions |
|                       | -Managerial skills | -Rig Size | -Buried Obstacles | -Cont. Experience | -Operator Exp. | -Crew/operator skill |
|                       | -Operator’s efficiency | -Site * weather | -Operator & crew skill | -Operator Exp. | -Rig size | -Rig size |
|                       | -Safety Reg. | -Operator & crew skill | -Rig size | -Operator Exp. | -Rig size | -Operator Exp. |
|                       | -Mechanical cond. | -Rig size | -Operator Exp. | -Operator Exp. | -Operator Exp. | -Operator Exp. |
| Physical Conditions | Physical Conditions | Pipe Mechan. Cond. | Pipe Mechan. Cond. | Pipe Mechan. Cond. | Pipe Mechan. Cond. | Pipe Mechan. Cond. |
|                       | -Pipe size | -Length | -Diameter | -Diameter | -Diameter | -Diameter |
|                       | -Pipe length | -Pipe length | -Pipe length | -Pipe length | -Pipe length | -Pipe length |
|                       | -Pipe usage | -Pipe usage | -Pipe usage | -Pipe usage | -Pipe usage | -Pipe usage |
|                       | -Pipe depth | -Pipe depth | -Pipe depth | -Pipe depth | -Pipe depth | -Pipe depth |
| Environ. Conditions | Environ. Conditions | Soil Type | Soil Type | Soil Type | Soil Type | Soil Type |
|                       | -Unseen soil cond. | -Clay | -Clay | -Clay | -Clay | -Clay |
|                       | -Water table level | -Sand | -Sand | -Sand | -Sand | -Sand |
|                       | -Soil cond. | -Rock | -Rock | -Rock | -Rock | -Rock |
| Pipe diam. & material etc. | Rig Size | Pipe Mech. Cond. | Pipe Mech. Cond. | Pipe Mech. Cond. | Pipe Mech. Cond. | Pipe Mech. Cond. |
|                       | -Pipe diameter | -Length | -Diameter | -Diameter | -Diameter | -Diameter |
|                       | -Pipe Length | -Pipe Length | -Pipe Length | -Pipe Length | -Pipe Length | -Pipe Length |
|                       | -Pipe Depth | -Pipe Depth | -Pipe Depth | -Pipe Depth | -Pipe Depth | -Pipe Depth |
|                       | -Pipe Type | -Pipe Type | -Pipe Type | -Pipe Type | -Pipe Type | -Pipe Type |
| Site conditions | Site conditions | Environmental Conditions | Environmental Conditions | Environmental Conditions | Environmental Conditions | Environmental Conditions |
|                       | -Soil Type | -Soil Type | -Soil Type | -Soil Type | -Soil Type | -Soil Type |
|                       | -Ground Water | -Ground Water | -Ground Water | -Ground Water | -Ground Water | -Ground Water |
|                       | -Obstructions | -Obstructions | -Obstructions | -Obstructions | -Obstructions | -Obstructions |
| Weather | Weather | Weather | Weather | Weather | Weather | Weather |
|                       | -Pipe Length | -Pipe Length | -Pipe Length | -Pipe Length | -Pipe Length | -Pipe Length |
|                       | -Pipe Diameter | -Pipe Diameter | -Pipe Diameter | -Pipe Diameter | -Pipe Diameter | -Pipe Diameter |
|                       | -Pipe Depth | -Pipe Depth | -Pipe Depth | -Pipe Depth | -Pipe Depth | -Pipe Depth |
|                       | -Pipe Type | -Pipe Type | -Pipe Type | -Pipe Type | -Pipe Type | -Pipe Type |
|                       | -Mechanical Conditions | -Mechanical Conditions | -Mechanical Conditions | -Mechanical Conditions | -Mechanical Conditions | -Mechanical Conditions |
|                       | -Machine Condition | -Machine Condition | -Machine Condition | -Machine Condition | -Machine Condition | -Machine Condition |
|                       | -Slurry Flow Rate | -Slurry Flow Rate | -Slurry Flow Rate | -Slurry Flow Rate | -Slurry Flow Rate | -Slurry Flow Rate |
|                       | -Steering Problem | -Steering Problem | -Steering Problem | -Steering Problem | -Steering Problem | -Steering Problem |
|                       | -Pipe Conditions | -Pipe Conditions | -Pipe Conditions | -Pipe Conditions | -Pipe Conditions | -Pipe Conditions |
|                       | -Pipe diameter | -Pipe diameter | -Pipe diameter | -Pipe diameter | -Pipe diameter | -Pipe diameter |
|                       | -Pipe Length | -Pipe Length | -Pipe Length | -Pipe Length | -Pipe Length | -Pipe Length |
|                       | -Pipe depth | -Pipe depth | -Pipe depth | -Pipe depth | -Pipe depth | -Pipe depth |
|                       | -Pipe type | -Pipe type | -Pipe type | -Pipe type | -Pipe type | -Pipe type |
|                       | -Environmental Conditions | -Environmental Conditions | -Environmental Conditions | -Environmental Conditions | -Environmental Conditions | -Environmental Conditions |
|                       | -Soil Type | -Soil Type | -Soil Type | -Soil Type | -Soil Type | -Soil Type |
|                       | -Unseen buried obstacles | -Unseen buried obstacles | -Unseen buried obstacles | -Unseen buried obstacles | -Unseen buried obstacles | -Unseen buried obstacles |
|                       | -Site & Weather Conditions | -Site & Weather Conditions | -Site & Weather Conditions | -Site & Weather Conditions | -Site & Weather Conditions | -Site & Weather Conditions |
The local authority’s technical requirements, some foreign local authorities, HDD good practices, productivity factors and HDD risk factors will be studied in order to identify what are the best factors that will be used in the propose standard local authorities’ technical requirements.

This study also will taking into consideration the factors suggested in NASTT Horizontal Directional Drilling (HDD) Good Practices Guidelines (David Bennett & Ariatnam, 2017), CALTRANS Encroachment Permits; Guidelines and Specifications for Trenchless Technology Projects (Caltrans, 2015), Implementing quality control in HDD projects—a North American prospective (Allouche, 2001), Implementing quality control in HDD projects—a North American prospective (Allouche, 2001), Guidelines for Preventing Underground Utility Damage as a Result of Horizontal Directional Drilling (Puckett, 2011), Avoiding Damages to Facilities When Using Horizontal Directional Drilling (Ariaratnam, 2009a), Damage to Surface Facilities (Ariaratnam, 2009a), Guidelines for installing PE gas pipes using HDD (Popelar & Kuhlman, 1997) and etc.
| Table 4. Summary of HDD Risk Factors |
|-------------------------------------|
| **(Allouche, 2001)** | **(Woodroffe & Ariaratnam, 2008)** | **(Woodroffe & Ariaratnam, 2009)** | **(Murray, Osbak, & Bayat, 2013)** | **(Onsarigo, Adamtey, & Atalah, 2014)** | **(Gierczak, 2014a)** | **(Gierczak, 2014b)** |
| **Damage to pipe column** | **Geological conditions** | **Subsurface Risk** | **Hydrofracture** | **Mgmt. Problem** | **Human** |
| **Utilities** | **Existing Utilities** | **Hydraulic fracturing** | **Loss of circulation** | **Wrong cal/design, br radius, pipe coating** | **Inexperience, insufficient education, Lack of skills** |
| **Environmental damage** | **HDD rigs** | **Collapsing soil** | **Loss of depth** | **Downtime no equip.** | **Fatigue** |
| **Damage to surface improvement & adjacent structures** | **Tracking device** | **Loss of annular pressure** | **Mixed soil condition** | **Contractor error** | **Misreading** |
| **Non-conforming installation** | **Drilling fluids** | **Abnormally slow production** | **Heave** | **Supply & quality** | **Equipment** |
| **Site investigation** | **Site access** | **Surface subsidence** | **Surface subsidence** | **Drill tools fatigue** | **- Drill rig, mud motor, Mud cleaning Side crane, ballast system b/down** |
| **Project detail** | **Storage areas** | **Hitting unknown existing utilities and structures** | **Surface subsidence** | **Roller block, cradle failure** | **Drill rig b/down** |
| **Client specification** | **Site Layout** | **Loss of formation/collapse of borehole** | **Surface subsidence** | **Roller block, cradle failure** | **Mud motor** |
| **Existing utilities** | **Location** | **Collapse of product pipe** | **Surface subsidence** | **Ground Problem** | **Mud cleaning Side crane, ballast system b/down** |
| **Environmental impact** | **Set up area** | **Drill string stuck in hole** | **Weather related risks** | **Man/made u/g obstacle** | **Roller block, cradle failure** |
| **Restoration** | **Project detail** | **Surface equipment damage** | **Obstructions** | **Borehole collapse** | **Ground Problem** |
| **Product spec.** | **Client specification** | **Iron water line damaged** | **Inability to maintain line and grade** | **Blockage swelling clay/silt** | **Borehole collapse** |
| **Safety** | | **Surface equipment damage** | **Safety** | **Drilling fluid seepage** | **Borehole collapse** |
| **Cost** | | **Borehole collapse** | **Environmental risks** | **Environ. Problem** | **Borehole collapse** |
| **Weather** | | **Flow to exits** | **Bypass related risks** | - Legal problem | **Borehole collapse** |
| **Traffic** | | **Drilling fluid solids control work** | | - Severe weather cond. | |
### REQUIREMENTS

#### PRE-CONSTRUCTION:

1. To submit designed profile endorsed by E.S and F.E. **√**
2. To submit 5.1 report. **√**
3. To submit worksite status mapping. **√**
4. To submit Method of Statement. **√**
5. To submit works program. **√**
6. To submit insurance and work form deposits. **√**
7. Traffic management plan **√**
8. To submit contractors personnel list that possess sound knowledge and experiences. **√**
9. To submit Instrument/plant lists. **√**
10. To submit Settlement analysis. **√**
11. Utilities Mapping. **√**
12. To submit works programme. **√**
13. To submit Method of Statement. **√**
14. To submit designed profile endorsed by local authorities **√**
15. To conduct worksite final joint inspection. **√**
16. To reinstate all road/railway track/waterway furniture's to original condition. **√**
17. To commission the utilities only when the construction Completion Certificate is secured. **√**
18. To comply with safety requirements. **√**
19. To conduct permanent marker survey. **√**
20. To have contingency plan for emergency. **√**
21. Not allow to stockpile construction materials within ROW. **√**
22. Not allow to block/divert drains without consent. **√**
23. Manholes should be closed to ROW boundary. **√**
24. Min. cover/depth for the new utilities from finished level/utilities to be followed. **√**
25. All pits should be outside the ROW. **√**
26. Stray current study. **√**
27. Monitoring programme. **√**
28. To submit contractors' personnel list that possess sound knowledge and experiences. **√**
29. To submit as-built drawing. **√**
30. To conduct permanent marker survey. **√**
31. To have contingency plan for emergency. **√**
32. Not allow to works during raining. **√**
33. To conduct permanent marker survey. **√**
34. To reinstate all road/railway track/waterway furniture's to original condition. **√**
35. To conduct worksite final joint inspection. **√**
36. To submit as-built drawing. **√**

### REQUIREMENTS

#### POST-DURING:

- To secure work permit.
- To provide briefing/kick off mtg.
- Engaged check consultants (panel to authorities)
- Risk Analysis
- Crossing alignment is to be discussed on site visit.
- Specialist contractor to be approved by local authorities
- To submit settlement analysis.
- To submit Instrument/plant lists.
- Traffic management plan
- To submit works programme.
- To submit Method of Statement
- To submit worksite utilities mapping.
- To submit S.I. report.
- To submit designed profile endorsed by local authorities
- To conduct worksite final joint inspection.
- To conduct permanent marker survey
- To have contingency plan for emergency.
- Not allow to works during raining.
- Not allow to stockpile construction materials within ROW.
- Min. cover/depth for the new utilities from river bed is to be followed.
- Min. cover/depth for the new utilities from finished level/utilities to be followed.
- All pits should be outside the ROW.
- Stray current study.
- Monitoring programme.

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### Table 5: Present Local Authorities/Concessionaires HDD Technical Requirements

| Requirement | LLM | PLUS | DBKL | JKR | SPAD | PN | KTMB | JPS | PGB |
|-------------|-----|------|------|-----|------|----|------|-----|-----|
| i. To submit designed profile endorsed by E.S and F.E. | **√** | | | | | | | | |
| ii. To submit 5.1 report. | **√** | | | | | | | | |
| iii. To submit worksite status mapping. | **√** | | | | | | | | |
| iv. To submit Method of Statement. | **√** | | | | | | | | |
| v. To submit works program. | **√** | | | | | | | | |
| vi. To submit insurance and work form deposits. | **√** | | | | | | | | |
| vii. Traffic management plan | **√** | | | | | | | | |
| viii. To submit contractors personnel list that possess sound knowledge and experiences. | **√** | | | | | | | | |
| ix. To submit Instrument/plant lists. | **√** | | | | | | | | |

### Table 5: Local Authorities/Concessionaires Technical Requirements (continued).

| Requirement | LLM | PLUS | DBKL | JKR | SPAD | PN | KTMB | JPS | PGB |
|-------------|-----|------|------|-----|------|----|------|-----|-----|
| i. To perform traffic management plan. | | | | | | | | | |
| ii. To conduct permanent marker survey. | | | | | | | | | |
| iii. To have contingency plan for emergency. | | | | | | | | | |
| iv. Monitoring programme. | | | | | | | | | |

#### Notes:

- Requirement impose by local authorities/concessionaires - **√**
- Requirement prohibit by local authorities/concessionaires - **x**
8. Methodology
This research aims to determine the present local authorities’ technical requirements in HDD works, to determine the factors of HDD good practices and to develop standard HDD technical requirements the new framework for HDD technical requirements. This will be achieved through the processes in Figure 3 and Figure 4. The analysis of the data obtained will be done using SPSS 23, to give accurate results which will be interpreted objectively.

![Figure 6. Frame works to develop HDD Standard Technical Requirements.](image)

![Figure 7. Research framework](image)
This research shall use mixed method in achieving the objectives. A descriptive and exploratory research design will be used for the study. The research design for this study contains the following:

- The research problem and research questions.
- Sampling design.
- Method of data collection.
- Method of data analysis.
- Validation/verification.

9. Conclusions
This study shall able to produce a standard HDD technical requirement and its’ framework. With the establishment of a thorough and a standard local authority’ technical requirements will able to educate the HDD contractors and assist them in carrying out their work properly, successfully and safely. It’s will also able to educate the stake holders on how important to follow the stipulated technical requirements that contributed to the project success. This can also helping in upgrading the HDD pre/post work process, reporting and as well as their documentations practices in Malaysia when project management body of knowledge can be adopted. Finally complying to the standard local authorities requirement/guidelines can also assist in avoiding damages to the existing utilities, road furniture’s, public properties and the public safety as a whole. With minimising the construction risk the HDD productivity can be increased and this can also contribute to the project success. At the end of the study some suggestion for future studies will also be proposed.

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