Literature review of the benefits and obstacle of horizontal directional drilling

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Abstract. In this new era the construction industry not only need to be completed within budget, timely, at acceptable quality and safety but the stakeholders especially the local authorities and the public realises for the important need of sustainable construction method to be used for our younger generation to heritage if not better a safer world for them to live and raise up their children’s. Horizontal Directional Drilling method is the most commonly recognised trenchless utilities method as a preferred construction method in this age. Among the reasons HDD method offers less disturbance on traffic, the public, business activities and neighbourhood, lower restoration cost, less noise, dust and minimum import/export of the construction materials. In addition HDD method can drill through congested utilities areas with minimum cutting and shorter time. This paper aims to appraise the benefits and obstacle of HDD method in construction industry. It is an endeavour to fulfil the local authorities cry for alternative method that less damages to the roads, road furniture’s and public complaints compared to the conventional open cut method. In addition HDD method is seem to be in line with sustainable development requirements e.g. reduce, reuse, recycle and etc. Hence, it is important to determine the benefits and obstacle factors of HDD implementation. The factors are based on the literature review conducted by the author on the subject matters gathered from previous studies, journals, text books, guidelines, magazine articles, newspaper cutting and etc.

1. Introduction

“Horizontal Directional Drilling” which its acronym is HDD method is not a new born utilities’ installation method but was introduced since early 1970s [1]. Horizontally directional drilling was developed in California in the 1970s and was introduced in Europe in 1986 [2]. Although the first HDD river crossing across Pajaro river near Watsonville, California was carried out in 1997 only 36 successful crossings were done up to year 1979 [3]. For the first two decades the technology which was formally very difficult to operate/manage had evolved significantly to what we have today which is user friendly, well equip with hydraulics system, power source, drill frame, drilling fluids and detection guidance systems [4].
HDD method had gone through three (3) phases, in the early days it was used only in the oil and gas industry in the installation/laying of oil and gas pipelines but mostly in major crossing e.g. crossing rivers, railways and roads. Later this method was also adopted and had been very successfully accepted by the construction industries to lay/install utilities e.g. water pipes, telecommunication ducts, power cables, gas pipes, sewer pipes and etc. But its usage were limited for doing the crossing as this construction method cost is still higher compared to conventional open cut method [5]. Lastly HDD method was widely used in congested utilities area as the room for using other construction/installation method is almost impossible [6].

In the past three decades the demand in this techniques has increased tremendously and mostly was contributed by the environmentally awareness among the local authorities and the public. Among the reasons HDD method offers less disturbance on traffic, to the business activities and public, lower restoration cost in congested urban areas, less noise, dust and minimum import/export of the construction materials [7].

With the capacity to install utilities for varies sizes from 50m to 900mm in diameter and up to 1,700m in length allow HDD method to offer a clear alternative to the conventional methods with minimum surface excavation [6]. Since year 1992 up to 2016 there are about 40 thousand unit HDD machine were sold worldwide [8-10].

As illustrated in figure 1, HDD construction process starting with piloting a small pilot hole using a pilot head along the desired centre line of the proposed profile, followed with back reaming until the required drilled trench size to house the utility pipe, preparation of the product pipes and finally the pulling of pipes into the bored hole. Its major components are the drilling rig, drill pipes, slurry/bentonite, slurry recycling, survey equipment, drill bits, reamers and pipeline materials [11]. A transducer sonde is attached at behind of the cutter head during piloting and the signal is collecting by a locator carry by a person (tracker) that walk on top of the HDD alignment. The HDD operator will communicate with the tracker in order to control the pilot head drilling path.
2. Methodology
The factors determined are based on the literature review compilation from international and national journal papers, conference papers, proceedings, web pages, government’s reports and bulletins. The literature review references cover the time frame from 1998 to 2016. The review comprises the history of HDD, all types of HDD machine, its benefits, obstacles and authorities requirements.

The author used both the exploratory and refines review. At the initial exploratory review the author used the terminology or keyword searches for the review. Once sufficient literatures on topic matter are obtained the author progressed with refine review. At this stage the review involves more focused observations, analysis, specific paper references and more importantly the bibliography.

3. HDD in Malaysia
Back here in Malaysia, it was believed the Horizontal Directional Drilling (HDD) method was introduced in late 80s for some critical crossing in the construction/installation of Peninsular Gas Utilization Projects/PGU II. This project was successfully completed in 1991[12-13]. On the other hand from the information gathered from the market players, the HDD works in telecommunication and power industries were started back in 1993. Mersing Construction Sdn Bhd, one of the trenchless leader in Malaysia founded in 1980s, started their HDD division in 1995 [14].

Since then and as almost happen almost everywhere in the world, HDD method becoming one of the prominent trenchless methods used to lay/install in Malaysia not only gas pipes but also for other utilities e.g. water pipes, telecommunication cables, power cables and etc.

Some local authorities in Malaysia e.g. Public of Works, DBKL (Kuala Lumpur City Hall), Malaysia Highway Authorities, highway concessionaires, railway authorities and others town council had restricted only trenchless methods can be used for road crossing especially for protocol road.

The usage of HDD in Malaysia is normally limited to obstacle crossing (e.g. highway, water ways, railways and etc.), relocation works due to road expansion or installation of new infrastructures (e.g. MRT, LRT, bridges and etc.), crossing protocol road and in congested urban areas. Among the reason the installation using HDD method is still more expensive compared to the use of conventional open cut method.

Every year many of local authorities/town councils cries for the poor repair works done by the utilities contractors due to poor reinstatement works that were carried out after the utilities installation works were carried out via conventional open cut method. Due to this and in order to reduce complaint from the road users and the public some of the local authorities had imposing for the repair works to be carried out by their panel contractors and some preferred for the utilities installation works to be carried out using HDD.

Ir Tan the former Director of DBKL’s Civil Engineering and Drainage Department had stated that DBKL would favour on HDD method due to its minimum impact to the road and road furniture’s damages but the setback is this method is 3-5 times more expensive from the open cut [5].

Figure 2, shows the photograph of a project site, plan view and the longitudinal plan where HDD works have been carried out to cross the Federal highway, railway track and river at Bt 3, Shah Alam
3.1. The Advantages of Using HDD Method

In HDD method the open excavation works are minimal. The excavation are only required at the launching and receiving pits only. For example if the HDD profile is 200m distance the excavation works are only about 2m (width) x 4m (long) x 3m (depth) X 2 locations for its launching/receiving pits. In addition these pits can be located at the suitable location with the option of avoiding the road pavement. Even if it is required to be located on the road pavement the distance on the pavement is only about 8m out of the total distance. In contrarily in conventional open cut method the total length shall be required open excavation. The following are the HDD advantages;

1. No vertical shafts required as drilling launches from the surface, small entry and reception pits [15].
2. Steering ability to avoid existing utilities or other obstacles either horizontally, vertically and even pulled back [16].
3. Requires relatively little auxiliary equipment and short set up time [15].
4. HDD provides an efficient method for crossing obstacles such as rivers, highways, rail tracks, or airfield runways [17].
5. It minimizes the negative impact on residents and businesses and eliminates the need for the removal and repositioning of expensive restoration and landscaping [7].
6. Less environmentally-damaging compared to open cut method [18].
7. The HDD method eliminates the cost and time associated with installing dewatering facilities for operations carried out below the groundwater table level [7].
8. Able to be used in congested utilities area where other construction/installation method is almost impossible [19].
9. Minimal traffic disruption and associated social costs to the public [15].
10. Ability to accommodate large diameters [19].
11. Ability to install pipes of different materials, including HDPE, PVC, steel and ductile iron [19].

Figure 2. HDD crossing Federal highway, railway track and river at Bt 3, Shah Alam
12. Compatible with a variety of soil conditions, including loose sand and solid rock [19].
13. Satisfies environmental guidelines (especially in wet lands) [19].
14. The longest single line drive installation for trenchless method up to 3km distance [21].

3.2. Obstacle of HDD Works in Malaysia
1. Poor drilling practices by some contractors may cause utility strikes that will resulted in major legal ramifications [21].
2. Lack of established good practices [22].
3. Insufficient experienced drillers [22].
4. Availability of training for HDD operators [22].
5. A through site and subsurface investigation is very important [16].
6. To establish through soil conditions [6].
7. Need to consider disposal dump area if there is no fluid recycling method. But U.S. Protection Agency (EPA) not considered bentonite and certain polymers as toxic materials [16].

4. Results and Discussion
Based on the literature review, there are fourteen (14) advantages of using HDD method and only seven (7) obstacles that that had been found may hindered the success of HDD implementation. But if these obstacles are being identified and taking care during planning and construction stages it will never be an issue. With a lot of advantages identified no doubt why HDD method becoming very famous everywhere in the world including in Malaysia. However some action need to be taken by Malaysian local authorities to avoid what have been faced by HDD market in USA in the 90s, where accidents and failures related to HDD method becoming a big issues. Back then, HDD market was exploding due to rapid growth in constructing fibre optic backbone across the United States. Unfortunately, this fast grown method caused insufficient experienced HDD drillers, inadequate geotechnical investigations and a lack of established good practices. In 1998, concern about potential damages from HDD installations beneath its roadways the California Department of Transportation (Caltrans) imposed regulations requiring training for HDD contractors when drilling under the state lands [23].

Similar concerns were being raised around USA by other transportation and environmental agencies. Agencies, 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 [23]. In addition poor drilling practices by some contractors have caused utility strikes that have resulted in major legal ramifications and subsequent negative image of the technique. The damage claims are normally huge as it is not only the utility repairing cost but also include “loss of revenue” where insurance company are normally not covered [22]. Table 1, summarised the advantages/disadvantages between HDD method and conventional open cut method.
Table 1. Comparison summary between HDD and conventional Open Cut method.

| No | HDD Method | Traditional Open Cut |
|----|------------|----------------------|
| 1  | **Rapid Deployment**  
✓ Easy setup & minimum machineries  
✓ Open trench only at launching and receiving pits | **Slow Deployment**  
✓ Involve a lot of machineries for excavation & import/export materials  
✓ Open Excavation all the way |
| 2  | **Flexible Installation**  
✓ Drill from surface  
✓ Can re-engineer the alignment vertically/horizontally to avoid utilities/obstacles  
✓ Installation not necessary straight | **Rigid Installation**  
✓ Open Excavation all the way  
✓ Difficult to change direction once meet utilities and obstacles.  
✓ Difficult to change alignment |
| 3  | **Environmental Friendly Process**  
✓ Minimum open excavation  
✓ Less noise and dust. Fewer amounts of debris & waste generation.  
✓ Reduce construction materials (For road repairs).  
✓ Bentonite can be recycle and chemically not harmful | **Non-environmental Friendly Process**  
✓ 100% open excavation  
✓ Large dumping of excavated materials, import/export at site, large noise and dust pollution.  
✓ Huge quantity of waste, required heavy machinery to export/import materials  
✓ A lot import/export sand, crusher run requires for road repairs |
| 4  | **Better Quality reinstatement**  
✓ Less excavation easier to repair and control reinstatement quality | **Poor Quality reinstatement**  
✓ 100% Open excavation difficult to repair and control reinstatement quality |
| 5  | **Avoid Traffic Congestion**  
✓ No road closure  
✓ Less construction machineries  
✓ Less import/export construction material | **Causes Traffic Congestion**  
✓ Road closure  
✓ Many Construction machineries  
✓ Major import/export construction material |

HDD method comes with some sustainable construction criteria’s e.g. reduce, reuse and recycle of the construction materials and bentonite, less noise, less impact to the environment and the public however the disposal of bentonite upon completion if not being managed properly may attract ecological issues e.g. turbidity and contamination to our water source [24].

5. Conclusions
No doubt HDD method is a good alternative method when compared to the conventional open cut method but it also a better option to most other trenchless method. Among the reasons the HDD method offers less disturbance on traffic, the public, business activities and neighbourhood, lower restoration cost, less noise, dust and minimum import/export of the construction materials, easy to setup, minimum support machineries/truck, can manoeuvre in between utilities/obstacles, not restricted to straight alignment drilling, reduce, reuse, recycle and etc.
However HDD method requires well trained operators, good soil/geological information, accurate utilities mapping, and good drilling practices. Therefore with the intensity of utilities are getting congested the local authorities/clients requires to ensure only trained and experience contractors are allowed to undertake the job. To safe guard the facilities/asset from get damage by poor HDD works, the time has come for the local authorities to enhance their technical condition for HDD works e.g. to ensure the HDD operator are well trained, HDD machines are in good shape, soil investigation report and utilities mapping were carried out, a good drilling practices is adopted in contractors’ drilling procedure and etc.

With the present of cheaper HDD Machine from China although this can reduce the construction cost but it’s also invites HDD sub-contractors with lacking of HDD knowledge and training to join the market. This can lead to the above problems. Moreover the rapid growth in using HDD drills method in the last two decade make some areas are almost saturated with utilities and any activities by inexperienced HDD contractors can invite catastrophic. To proof the concern on this issue is valid the damage to fibre optic cables of Custom Malaysia Information System in Klang in May 2016, that had affected Westport operation [25] and the power outage in Menggelebu district in Ipoh, Perak where 138 sub-station were down [26] both were strike by HDD activities. The numbers of accidents are actually getting bigger but the question now is how to get the statistic? Therefore more interviews to the stakeholders' e.g. local authorities, insurances, utilities companies, design consultant, project owners and etc. need be conducted to establish information and data.

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