EFFECT OF SOIL PARAMETER FOR MICRO-TUNELLING WORKS IN JADAF, DUBAI FOR LONG DRIVE ON LARGE SCALE PROJECTS

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EFFECT OF SOIL PARAMETER FOR MICRO-TUNELLING WORKS IN JADAF, DUBAI FOR LONG DRIVE ON LARGE SCALE PROJECTS

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Abstract. This research paper presents the effect of Soil Parameter on the long drive micro-tunelling process. There is a great amount of risk for surface and sub-structure, if soil parameters are not considered during the execution of micro-tunelling. Overcut is formed to provide space for converging ground and enables evenly distribution of surface lubrication fluid (bentonite) flow on the exterior pipes, As such, the buoyancy effects of fluid lubrication act on the pipe to lessen the drag during jacking.. Terzaghi's Silo Theory and Elastic Stress Relief Formulas are used for calculating the normal stress against the pipes.

A detailed study tabulated for Al Jadaf Area across Oud Metha Road in Dubai,United Arab Emirates to check the effect of soil parameter, such as Depth of Invert Level, Depth of Ground Water Table, SPT Value and other soil parameters which are detailed in the forthcoming study. Also, forgoing study demonstrates that long term surface settlements confirm to the design theory limit. The high ground water table, fractures within the rock and proximity of creek makes things very difficult to reduce the water table level in launching / receiving Pit and have difficulties in breaking the hard ground within the Pit.

Keywords: Overcut; Micro-tunnelling; Terzaghi's Silo Theory; Ground Water Table;Jacking; Launch Pit; SPT Value

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CASE STUDY (JADAF -DUBAI, UNITED ARAB EMIRATES)

1 - INTRODUCTION

There are greater risks involved reference to surface settlement, if soil parameters are not considered properly during micro-tunelling process. Poor geological condition (low N value[†]) can cause the surface settlement, poor and unsuitable ground tends to converge string of the pipe line. In hard rock, ground holes hold more stability and are conducive grounds to micro-tunelling process [2]. The tendency of earth at forefront of micro-tunelling to move viscously towards steel fitted in front of the pipe to be jacked. Therefore, sophisticated slurry shield[‡] are used to overcome this failure. Forces are relevant to face load depending upon the soil condition and its nature [6].

The front seal has the following advantages:

a) Safe working place for Men to enter and work

b) Mounting for face stabilized device

c) A place to observe line and level

d) Adjusting direction of the string

Seals are control remotely and most cases controlled by Computers. (Denver, 2014) In Jadaf Area where soil conditions are very poor and SPT[§] value is very low and many services are close to receiving and launching Shaft. Therefore, a proper designing is required for dewatering process and special care is required to remove water only and ensure that soil particles and other dissolved particles to minimize to avoid any the future surface settlement. Longer the length greater will be fictional force[**] and thus can affect Jacking Load [3].

Following factor can affect Jacking Load:

a) Disparity in ground condition

b) Misalignment of pipes

c) Roughness of pipe surface and joint

[†]Standard Penetration Test, measured in number of blow
[‡]Protection at the fore front of micro-tunnelling machine
[§]Standard Penetration Test, defines N -Value
[**]Resistance due to contact between soil and pipe.

d) Transient live load

e) Overcut

f) Interruption during Jacking

g) Densification of loose sandy soil due to vibration/dynamic loading

2 - SPT VALUE AND ITS EFFECT ON ACTUAL SURFACE SETTLEMENT

Figure 01 Case study area (Jadaf) in Dubai

In figure 01 case study area for Jadaf – Dubai, United Arab Emirates is shown with arrow mark near creek, which is recently connected to main sea via Dubai water canal project.

In figure 02, complete pipe line network of 1200 mm diameter GRE with micro-tunnelling references shown in the circle. Complete network is divided in three stages. Soil parameter varies from M01 to M10 and accordingly the theoretical settlement and its comparisons with actual surface settlement, which is detailed in the foregoing study of Jadaf Dubai area. The detail of the overall site plan and google map is shown in figure 02. Blue color lines are represented for pipeline and green for micro-tunnel, pipe line and micro-tunnel alignment are super imposed on the google map. Source of the supply of the water is from south side after crossing the creek.

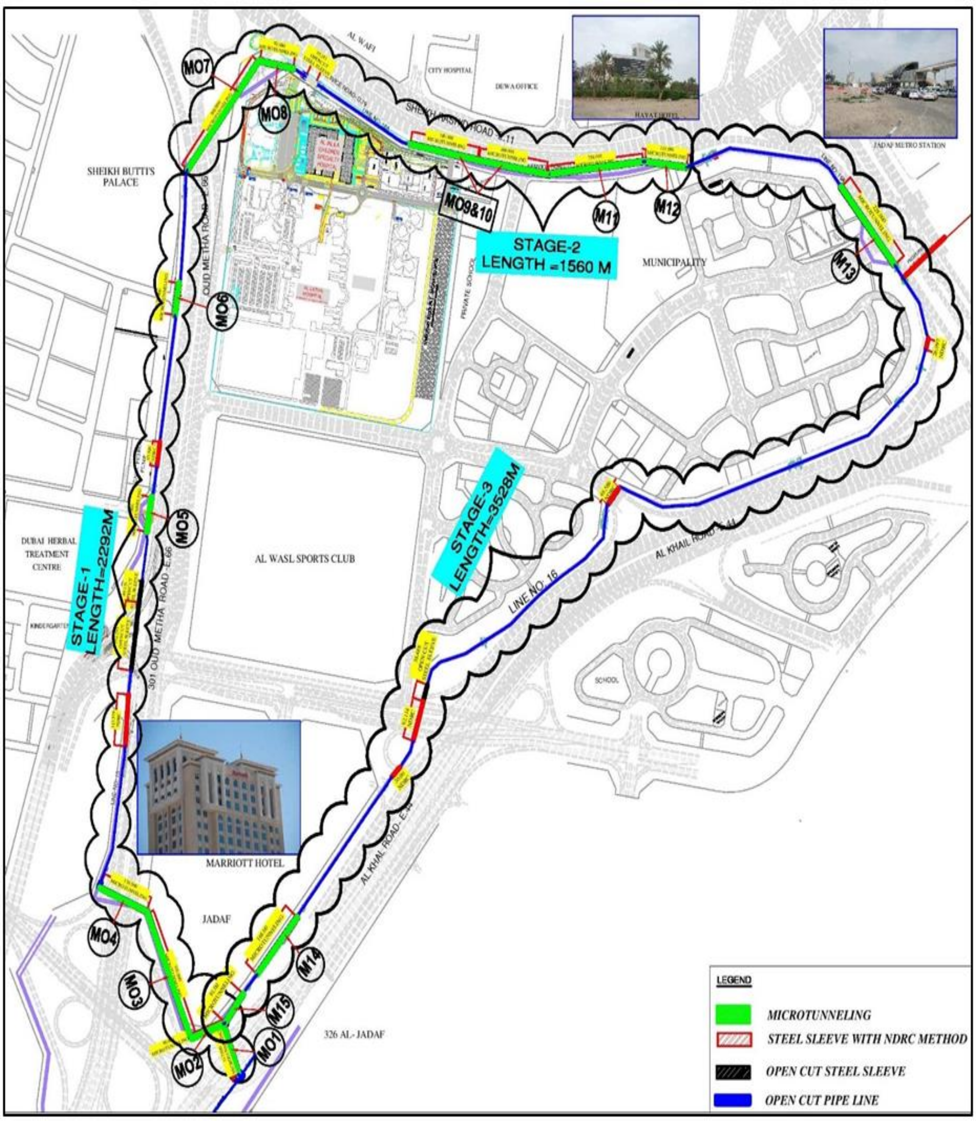
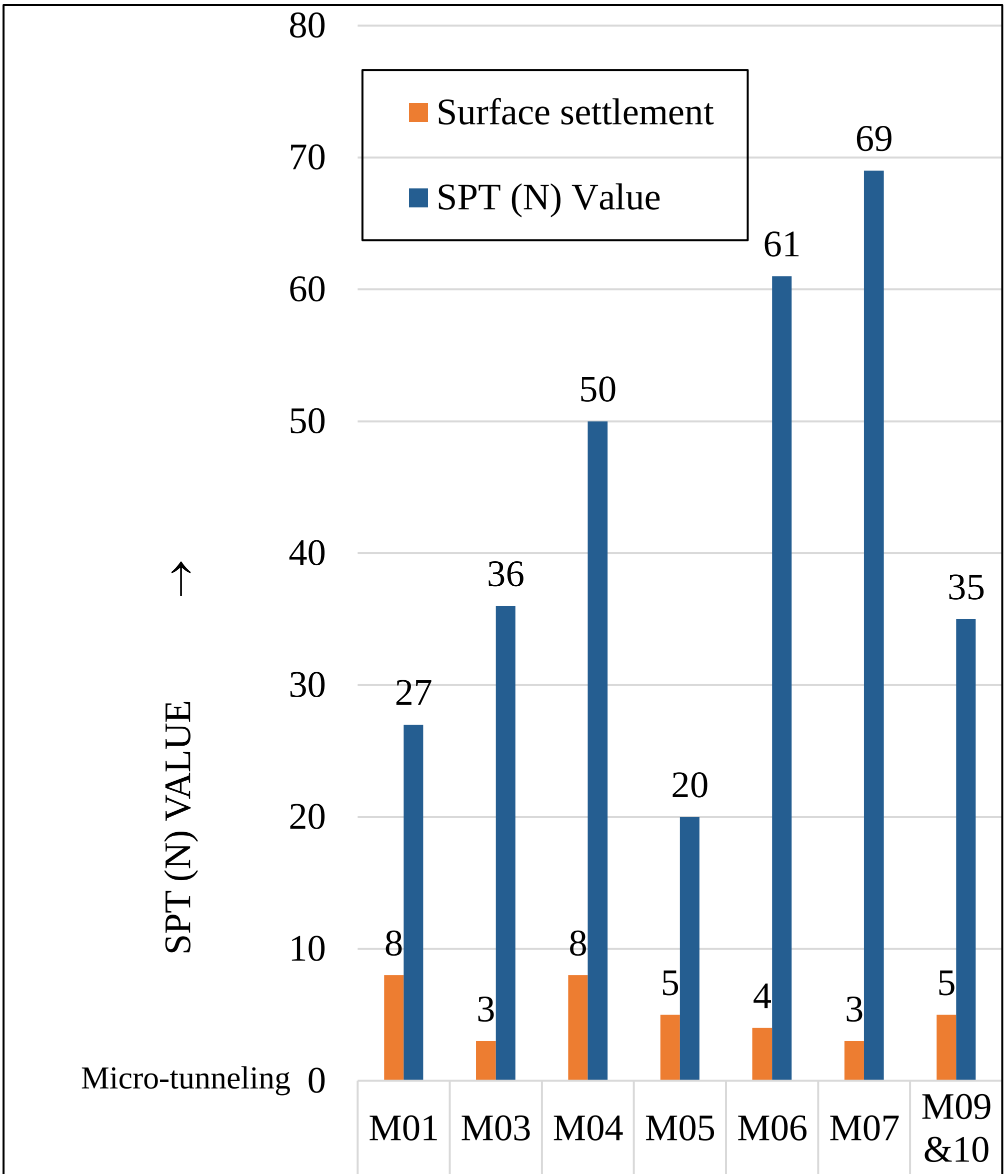


Figure 02. Bird eye view of Jadaf Dubai with micro-tunnelling from M01 to M10



Micro-tunneling	M01	M03	M04	M05	M06	M07	M09 &10
Surface settlement	8	3	8	5	4	3	5
SPT (N) Value	27	36	50	20	61	69	35

Figure 03. SPT (N) value verses actual surface settlement

This case study proves that higher the N value lesser the surface settlement. Also, it is evident from Figure 03 that greater SPT Value provide more stability to the ground in all the cases, except for micro-tunelling M01 and M04 where actual surface settlements are extremely un-expected are required to further scrutinize the method statement for spot level difference $(S_{\max(actual)})$. Similarly, Table 01 gives the clear idea that higher the SPT value gives lower surface settlement. Higher the N Value means soil is dense and there is less chance for surface settlement [1,5,9].

Table 01. Comparison of settlement between SPT (N) and actual surface settlement

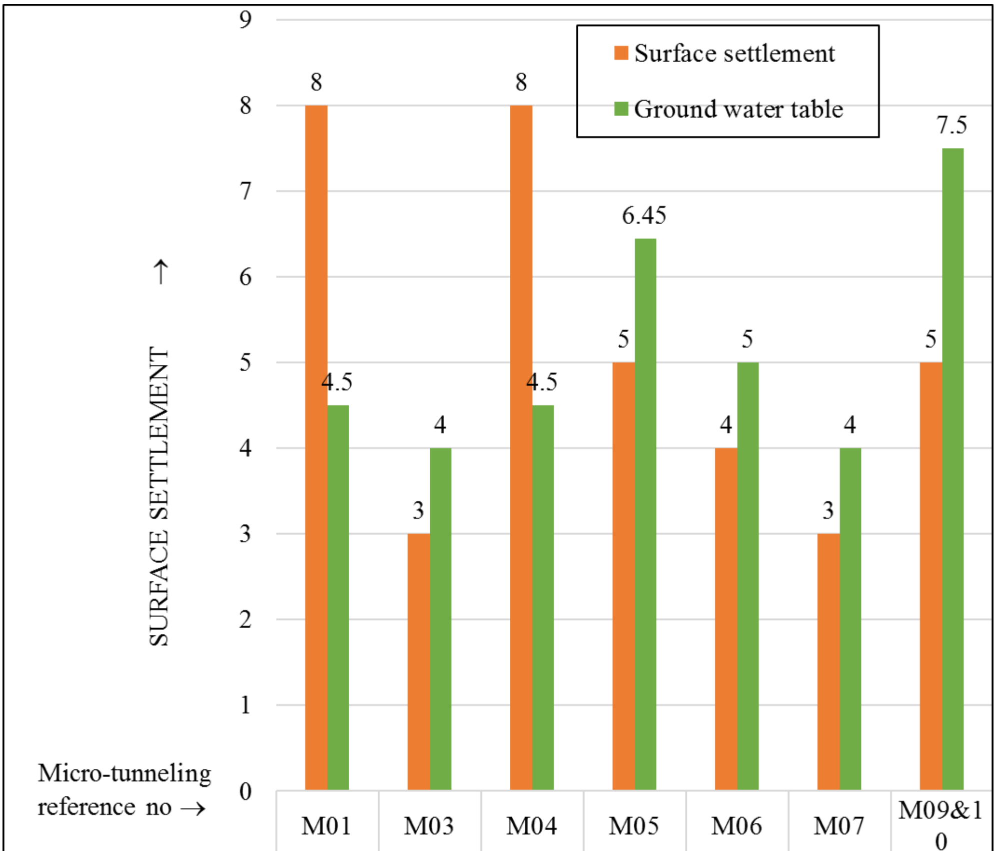
Serial Number	Micro-tunneling reference number	Maximum Settlement	SPT value
	Symbol →	$S_{max(Actual)}$	N
	Unit →	mm	Number
1	M01	8	27
2	M03	3	36
3	M04	8	50
4	M05	5	20
5	M06	4	61
6	M07	3	69
7	M09&10	5	35

3 – EFFECT OF GROUND WATER TABLE ON ACTUAL SURFACE SETTLEMENT

Under the design theory if water table is shallow then surface settlement is likely to be more and it is also reflected in the case study except for M01 and M04 where settlement is quite high (8mm) with respect to their water level table. Reasons for this discrepancy might be the way spot level has been taken. Table 02 shows the maximum actual settlement and below ground water table and confirms to design theory [7,8,10].

Table 02. Comparison of settlement between ground water table and actual surface settlement

Serial Number	Micro-tunneling reference number	Maximum Settlement	Water table below ground level
	Symbol →	$S_{max(Actual)}$	h_w
	Unit →	mm	mm
1	M01	8	4.5
2	M03	3	4
3	M04	8	4.5
4	M05	5	6.6
5	M06	4	5
6	M07	3	4
7	M09 & 10	5	7.5



	M01	M03	M04	M05	M06	M07	M09&10
Surface settlement	8	3	8	5	4	3	5
Ground water table	4.5	4	4.5	6.45	5	4	7.5

Figure 04. Ground water table verses actual surface settlement

From figure 04, for micro-tunnelling M03 & 07, ground water table is 4 meter and actual settlement observed at site by spot level method was found as 3 mm, whereas for other's if we calculate percentage between ground water table and surface settlement, will find slight increase in the percentage as the water table depth increases.

Though percentage difference very marginal such as for M03 it is 0.75, for M05 it's 0.78 and for M06 is 0.80.

Therefore, Ground water table has an impact on the micro-tunnelling process. It is also important to consider the dewatering process shall be in such a way so that silt content remains within soil structure and does not pass through de-watering system. Also, slotted pipe or vertical screen pipe (generally PVC and in special cases deep well must be of good quality and as per the design) [11,12].

4 – MICRO-TUNELLING IN JADAF AREA

As the site area is in the city, therefore movement of heavy vehicles and noise is to be controlled accordingly. A special care is required for the summer time where cooling effect is necessary for the people working in the launching Pit. It is also necessary to control the temperature of air inside the tunnel; otherwise it can deflect laser control system and ultimately alignment of the tunnel.

In Figure 02 detail alignment of the pipeline and micro-tunnelling has been shown, to control overall movement of the traffic and other obstruction it is divided into three stages, all these are described in table 03.

Table 03. Micro-tunnelling details for 1200 diameter GRE water transmission Pipe

Sl/ No.	Microtunneling Reference	Chainage		Length in meter	Stage	Line Reference No.	Location	Road Reference
		From (L.P)	To (R.P)					
1	M-01	(-)0+025.215	0+091.785	117	Stage : 1 --- 796 Meter	18	Al Khail Road Crossing	E44
2	M-02	0+097.065	0+187.065	90		18	Existing Services Crossing(Electric trough & 800mm Irrigation Pipe)	Unmade Area
3	M-03	0+493.865	0+192.865	301		18	Near Meriot Hotel	Partially unmade area & one side service road crossing
4	M-04	0+499.510	0+637.510	138		18	Oud Metha Road	E66
5	M-05	1+450.584	1+528.584	78		18	Service Road Crossing	Before EPCO petrol pump going towards Bur- Dubai
6	M-06	2+013.688	1+941.688	72		18	Service Road Crossing	After EPCO petrol pump going towards Bur -Dubai
7	M-07	(-)0+009.943	0+304.734	309	Stage : 2 --- 1,146 Meter	18A	Oud Metha road, WFI Interchange	E66
8	M-08	0+397.734	0+304.734	93		18A	Service Road Crossing	Unmade area inside Latifa hospital
9	M-09	0+761.238	0+947.238	186		18A	Service Road Crossing in front of Emirates filling station	D79
10	M-10	1+137.313	0+951.813	186		18A		
11	M-11	1+146.205	1+404.205	258		18A	Existing Services Crossing & Parallel to Sheikh Rashid Road	D79
12	M-12	1+524.468	1+410.468	114		18A	Existing Services Crossing (Partially electric trough and land scape area)	D79
13	M-13	0+458.688	0+686.688	228	Stage - 3 --- 477 Meter	16A	Service Road Crossing	Near Jadaf Metro station
14	M-14	2+308.887	2+476.887	168		16	Service Road Crossing	Near Meriot hotel along Al Khail road towards Abu Dhabi
15	M-15	2+615.195	2+534.195	81		16	Service Road Crossing	Unmade Area
TOTAL MICROTUNNELING CUMMULATIVE LENGTH				2419				

5 - COMPARATION ON DIFFERENT SOIL PARAMETER THEOROTICAL AND ACTUAL SURFACE SETTLEMENT

Table 04. Comparison of settlement between theoretical and actual with respect to soil parameter

S.Nr	Micro-tunnelling referance number	Maximum Settlement		Length (m)	Depth of invert	Depth of axis of pipe	Water table below ground level	SPT value	Friction angle of soil	Duration between spot level on same cordinate
	Symbol →	S_{max}	$S_{max(Actual)}$	L_t	h_i	z	h_w	N	ϕ	Δ
	Unit →	mm	mm	m	m	m	m	Nr	Degree (°)	day
		Theortical	Actual							
1	M01	4.4	8	117	12.67	11.93	4.5	27	40	338
2	M03	4.2	3	301	13.04	12.3	4	36	40	404
3	M04	4.4	8	138	12.64	11.9	4.5	50	40	400
4	M05	5.7	5	78	9.91	9.17	6.45	20	40	863
5	M06	6.4	4	72	9.01	8.27	5	61	40	639
6	M07	5.4	3	309	10.51	9.76	4	69	40	211
7	M09&10	5.1	5	372	11.1	10.36	7.5	35	40	515

Table 04 summarizes, soil parameter being used in this case study and overall summary of the result obtain from spot level difference with other details such as difference in the theoretical & actual surface settlement. We can also conclude from this chapter that depth of micro-tunneling – of the soil, ground water table, nature of soil, particle size distribution, diameter of the bore hole, has major effect on the surface settlement, whereas other soil parameter such as chloride, sulphate and has only minor affect [15].

Figure 05 is a typical cross-section at launching pit, where depth of invert level of the micro-tunnelling pipe is 11.1 meter and depth of the axis of the pipe is 10.36 meter, these are also reflected in table 04, these data are required to work out surface settlement, which is 5.1 mm in this case.

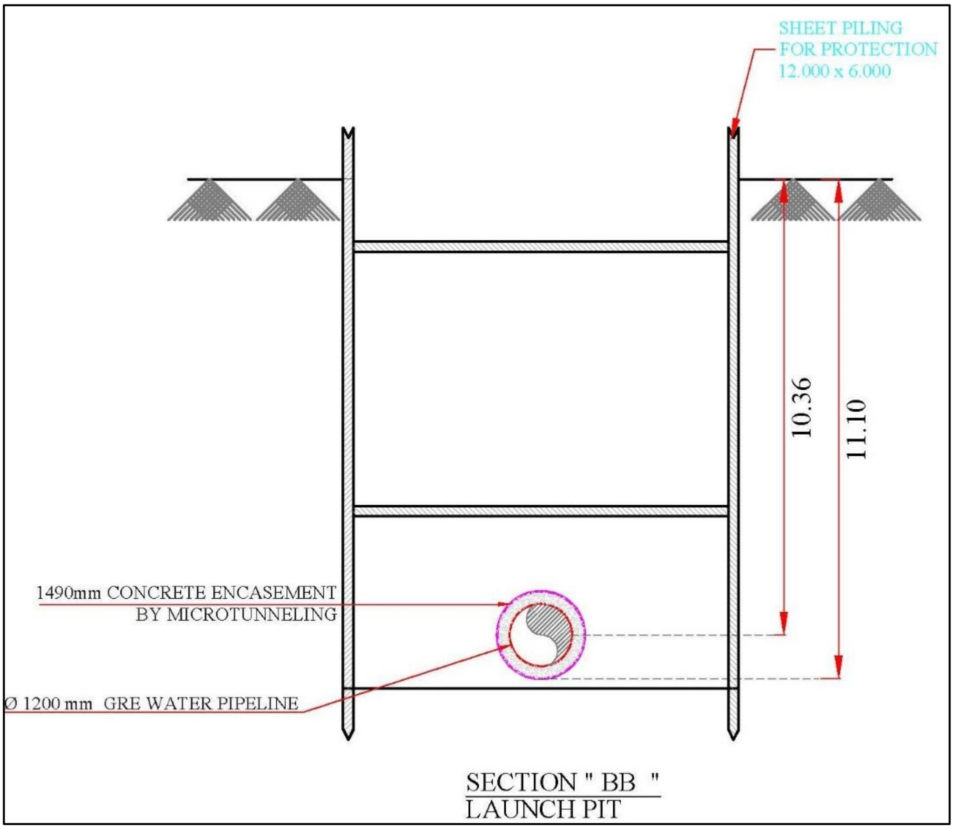


Figure 05. Section at launching pit for micro-tunnelling M09 &10

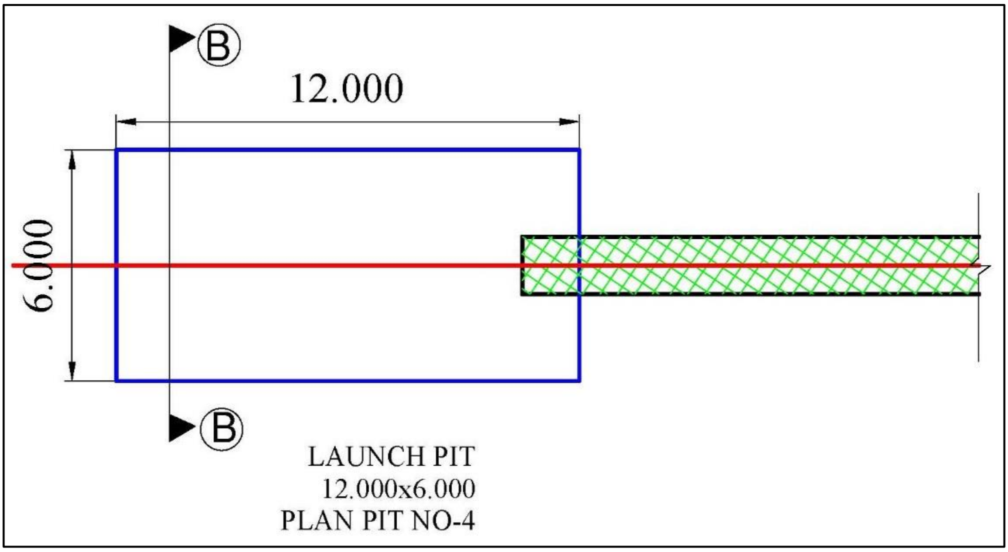


Figure 06. Plan at launching pit for micro-tunnelling M09 &10

Figure 06 is the plan of the launching pit of M09 & 10, in which blue line represents sheet piling and red line is the centre of the micro-tunnelling longitudinally. Section B-B is shown in figure 05.

6 – CONCLUSION

Therefore, we can conclude from this study that depth of micro-tunelling, ground water depth, nature of soil, particle size distribution and Diameter of Borehole has a major effect for surface settlement whereas other soil parameters like chloride and sulphate has only minor effect. Chemical analysis is required for more detailing to understand its effect on surface settlement. The present study has focused exclusively on the Jadaf area in Dubai, United Arab Emirates, in a particular pattern of the soil with specific parameter for a given O.D[††] (1490 mm composite pipe with concrete encashment – for I.D[‡‡] 1200 mm[§§] diameter GRE[***] pipe for main water transmission pipe line for DEWA) of the bore and accordingly the micro-tunnelling machine has been selected for typical soil parameter , surrounded by existing underground services and various future proposal of infrastructure. There are further regions such as crossing of water ways (canal / filled up areas etc.) and proximity of the important structure for instance hospital, hotels, educational institute etc, in a different kind of soil parameter. Similar case study is required for other parameter of the soil structure and sub-soil geological condition such as detailed particle size distribution, rock strength, sulphite and chloride content etc to ascertain challenges faced during construction and the amount of surface settlement within the range predicted in theory and after effect of the micro-tunneling.

†† Outer diameter of the pipeline completed by micro-tunnelling method
‡‡ Internal Diameter
§§ Millimeter
*** Glass Reinforce Epoxy pipe

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