SPECIFYING MICROTUNNELING JOBS

by

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This paper provides an analysis of engineering issues involved in a microtunneling job. In particular, the importance of correctly specifying jacking force and jacking shaft size in order to obtain maximum value is discussed.

INTRODUCTION

Trenchless techniques, such as microtunneling, offer many benefits to the sewer jurisdiction. These include lower direct costs (bid price) when solving engineering problems such as obstacles, poor soils, deep installations, or high ground water. Lower social costs such as less traffic delays and road closures, less injuries on the job, fewer environmental headaches, and fewer citizen complaints also accrue to a district. But at the end of the day, the result of a state-of-the-art microtunneling technique is a sewer line.

In order to get a premium sewer from your microtunneling project, the specifications should be written with the object of maximizing value in mind. Simply put, the sewer line you want, as well as the techniques you need, must be specified.

PIPE SPECIFICATIONS - THE IMPORTANCE OF JACKING FORCE

The structural design of pipe installed by microtunneling takes on a different emphasis than that considered for open trench construction. For open trench work, the Engineer must consider trench width, bedding details and load factors. For microtunneling, the Engineer must consider jacking force and pit size.

Why Trench Load Is No Longer An Issue

Consider the following example:
12" NO-DIG[1] VCP (Vitrified Clay Pipe)
20' of cover
130# Sand & Gravel
ku = 0.160

Using the Marston formula[2] for load on a rigid pipe in trench conditions;

$$W_c = C_d\ W\ B_d^2$$

$$B_d = \text{O.D.} + 16" + \text{Trench Box}$$

$$= 16 + 16 + 16 = 48"$$

$$W_e = (2.49)\ (130)\ (4 \times 4) = 5{,}179\ \#/\text{Ft}$$

Using the Marston formula[3] tor load on a rigid pipe in a tunnel;

$$W_t = C_t\ B_t\ (WB_t - 2c)$$

$$B_t = \frac{\text{O.D.} + \text{Overcut}}{12}$$

$$= \frac{15.6 + 0.5}{12}$$

$$= 1.34'$$

$$W_t = (3.099)\ (1.34)(130 \times 1.34 - 2 \times 0) = 723\ \#/\text{Ft}$$

Table 1 shows comparative trench and tunnel loads for 12" NO-DIG pipe with 20' and 40' of cover. The additional 20' of cover produces no significant increase in the calculated load.

Table 1

† Cover	† Tench Load	† Tunnel Load
† 20'	† 5,179 #/Ft	723 #/Ft
† 30'	† 6,240 #/Ft	729 #/Ft

By installing a pipe via microtunneling two engineering criteria have changed drastically. First, the load on the pipe is much less.

Second, additional depth provides little, if any, additional load.

Note that the value for c in the tunnel load calculations is zero. This figure comes from the following recommended "safe values" for cohesion[4]:

Table 2

Material	Values of c (psf)
Clay, very soft	40
Clay, medium	250
Clay, hard	1,000
Sand, loose dry	0
Sand, siltly	100
Sand, dense	300
Top soil, saturated	100

For medium clay, c = 250 or silty sand, c = 100, there is no calculated load on the pipe. Clearly, conventional loads due to trench width and design are not normally a critical engineering issue when microtunneling. The issue of trench load has instead been replaced by jacking force.

Why Jacking Force Is An Issue

Pipes used for microtunneling are specialized. They must be capable of withstanding a jacking force of tens to hundreds of tons. If not, the microtunneling technique won't produce a sewer line, it will be a sprinkler system.

The jacking force required to advance the pipe results from friction due to pipe/soil contact, weight of the pipe and cutting head pressure. Friction is usually the largest contributor. The force due to pipe weight is in the magnitude of 3 or 4 percent of the force due to friction, while the force due to cutting head pressure is controllable by the operator of the microtunneling equipment.

Factors that lower jacking forces include soil type, size of overcut, bentonite lubrication, and position of pipe in the tunnel.

As shown above, frictional forces usually dominate. An empirical rule for a normal maximum jacking load is 0.04 to 0.06 tons per square foot of pipe/soil contact area.

Pipe/soil contact area is equivalent to 3.1416 x pipe O.D. (Ft) x pipe line length (Ft)

Example

240' line length, 12" NO-DIG pipe
Maxie Road, Houston, Texas
Empirical Maximum Jacking Force

(0.06)(3.1416)(1.30)(240) = 60 Tons

The recorded maximum force at the Maxie Road job was 60 tons, which occured after a 3 day work stoppage†

Note on line length. Clay pipe is extremely strong in compression, thus the limiting factor for the length of a microtunneling run is the guidance system and required accuracy for line and grade.

Pipe strength is NOT a Limiting Factor

As the laser target moves farther from the light source, the beam spreads, making precise steering more difficult. Manufacturers of microtunneling equipment therefore usually recommend a run length of 300 feet for pipe 24" I.D. and under.

As mentioned above, to be certain that a good sewer line is installed, all pipe used must be able to safely take a load greater than that expected on the job.

Two options are offered for specifying maximum safe jacking force. They may be used separately or in conjunction.

Option A. Material Specification.

Calculate the empirical jacking loads using a factor of 0.06. Multiply the result by a selected safety factor (2.5, 3.0, or 3.5). This value represents the minimum pipe strength required.

Example

18" NO-DIG, 300' run length, S.F. = 3.0
(0.06)(3.1416)(2.041)(300) = 116 Tons using a S.F. of 3.0
Minimum pipe strength required = 346 Tons/Ft

option B. Performance Specifications

Using the published strength of the pipe, divide by a selected safety factor. The resulting value equals the maximum allowable jacking force to be used on the job

Example

Published strength of 18" NO-DIG = 546 Tons/Ft
Divide by S.F. = 3.0
Maximum allowable jacking force = 182 Tons/Ft

JACKING SHAFT SPECIFICATIONS - THE IMPORTANCE OF PIT SIZE

In open trench work, the width is a crucial engineering issue.

Direct cost issues of pipe strength, depth of line, bedding, shoring and bracing are all keyed to the width. Furthermore, the bulk of the social cost comes from the width and length of the

trench. How much it costs to repair the street, how much traffic is diverted, how much soil, often treated as contaminated, must be disposed of, whether the street must be closed, and the potential for accidents basically all come from how big a hole has to be dug in the ground.

In microtunneling, much less digging must take place. same issues appear as jacking shaft, or pit, size.

Direct Cost Issues

In direct cost, a new tradeoff exists. Smaller shafts costs less, since less excavation must take place. However, a small pit means smaller lengths of pipe, thus labor productivity decreases.

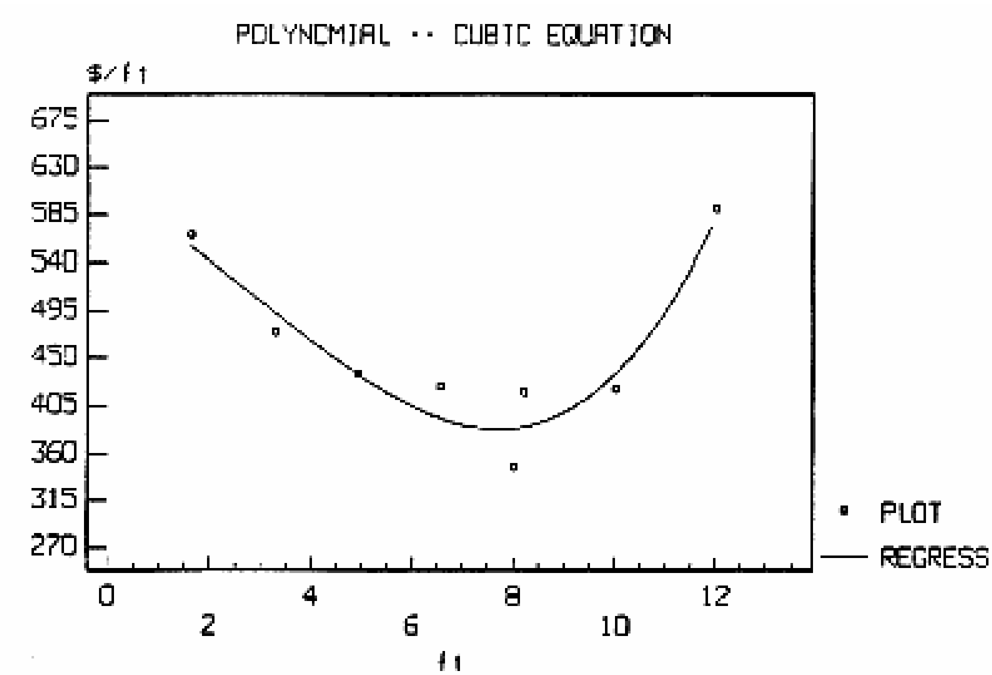


Figure 1 is a graph of bid price versus pipe length.

While non-linear least squares regressions shows a small minimia near 8', in general the bid price is fairly flat for 4' lengths through 10' lengths. This is due to the shaft size/productivity tradeoff. Since pit size corresponds to pipe length + equipment; and the equipment normally takes up about 4', we conclude that direct cost is statistically the same (within 1 standard error) for 8' through about 14.5' pits.

Social Cost Issues

In social cost, unlike direct costs, there is no tradeoff. A smaller pit size lowers all social costs. Social costs are difficult to quantify so we will use anecdotal data.

The Manual of Improved Practice prepared for the the Federal Highway Administration provides guidelines for the placement of pipelines within the rights of way of urban streets.

Figure 2 shows an example of a 100' R/W, 16' median.

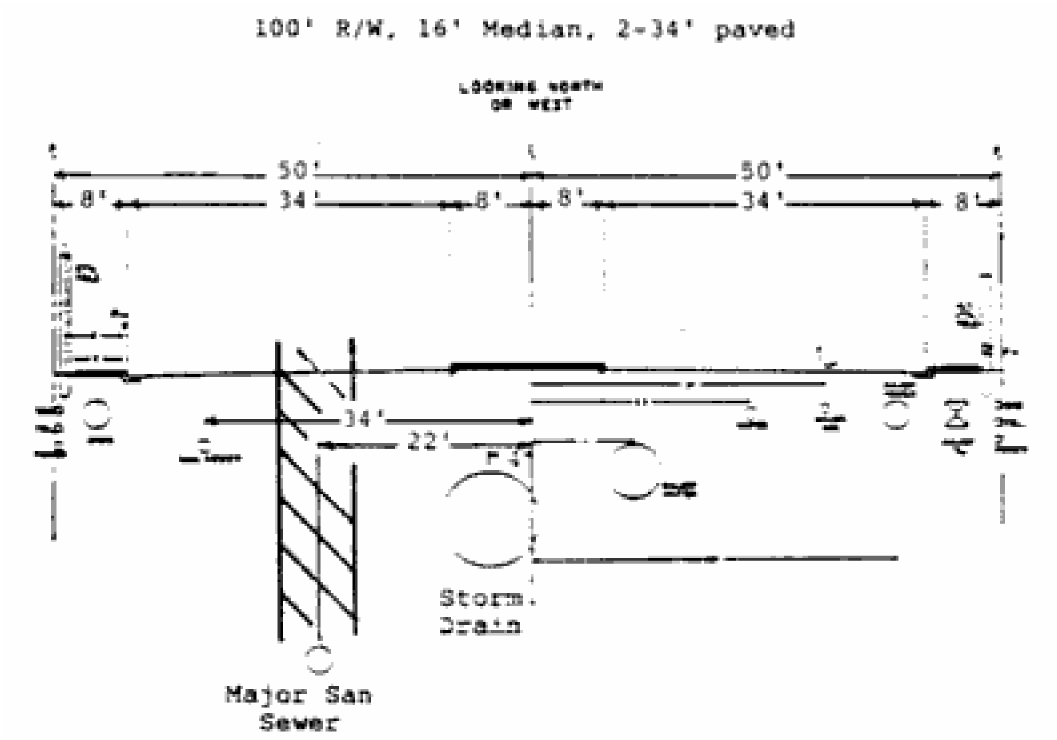


Figure 2

With an 8' diameter jacking pit, a 10' (safe) traffic lane can be accomodated on each side of the pit. If the bottom portion of the shoring is left in place, it will not encroach upon the corridor of other utilities.

Figure 3 illustrates that a 14' jacking pit will eliminate one traffic lane.

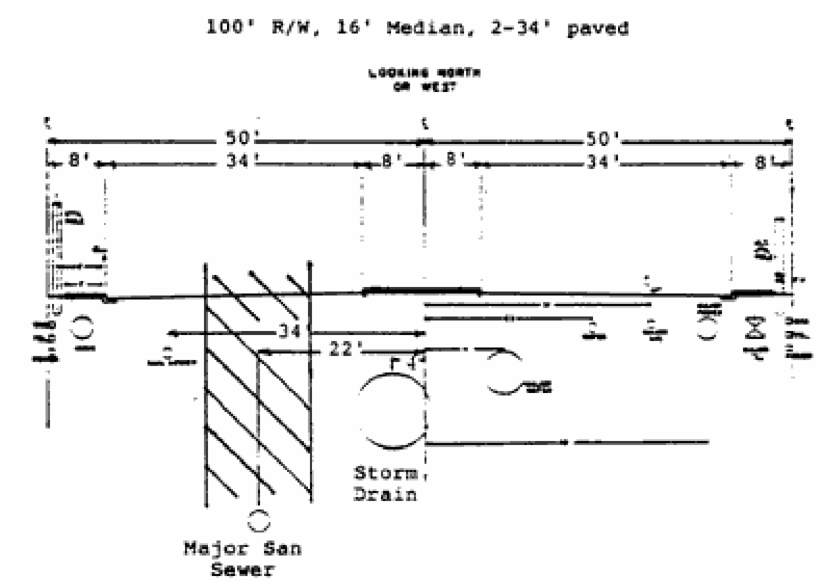
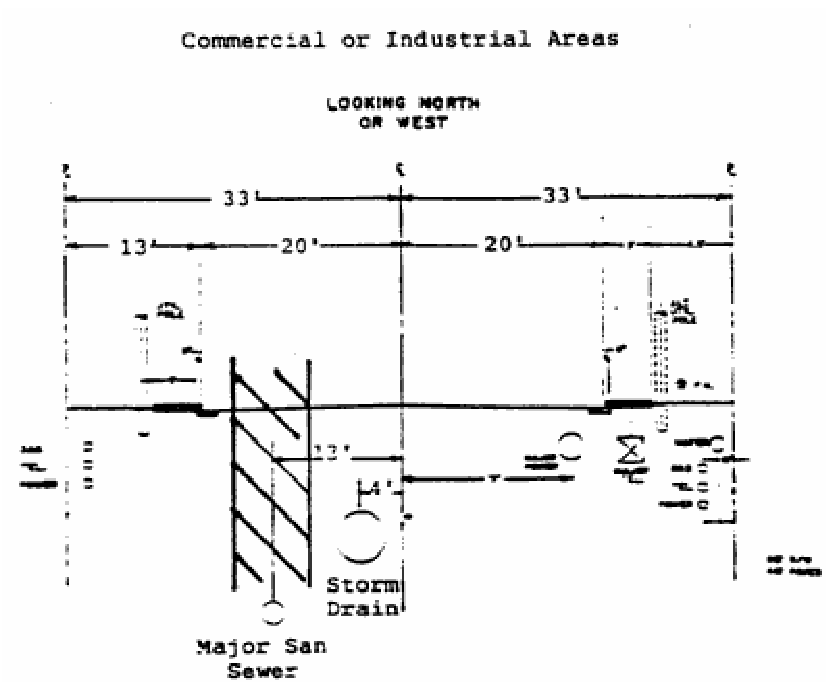
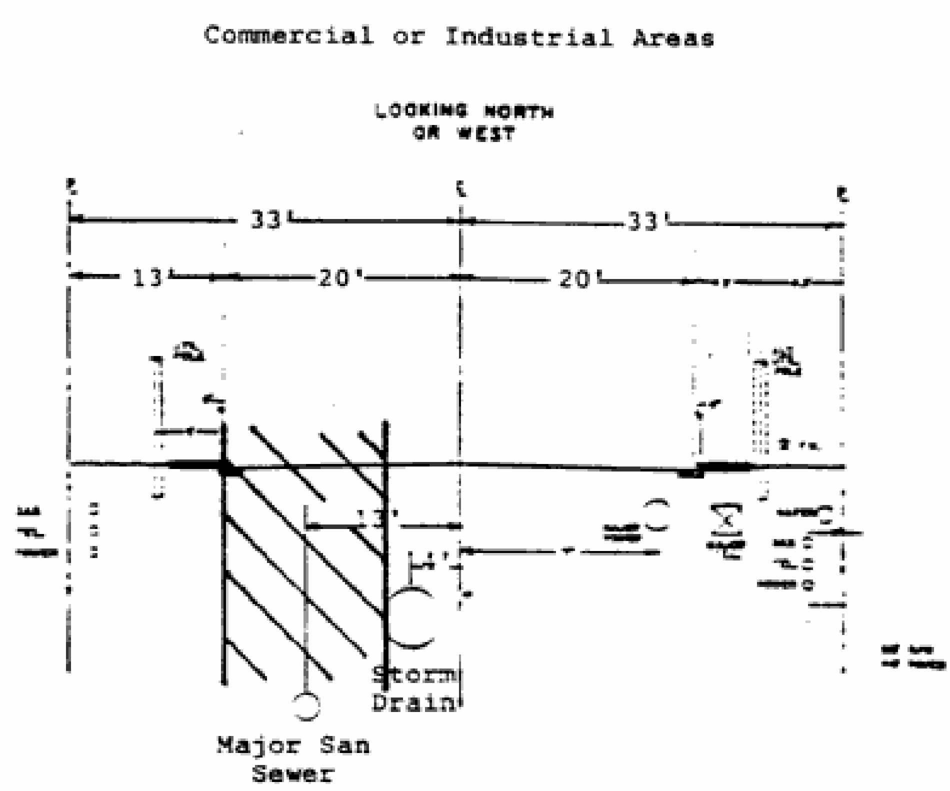


Figure 3

Piqure 4 illustrates that an 8' jacking shaft can be accomodatedin a typic al commercial or industrial street.



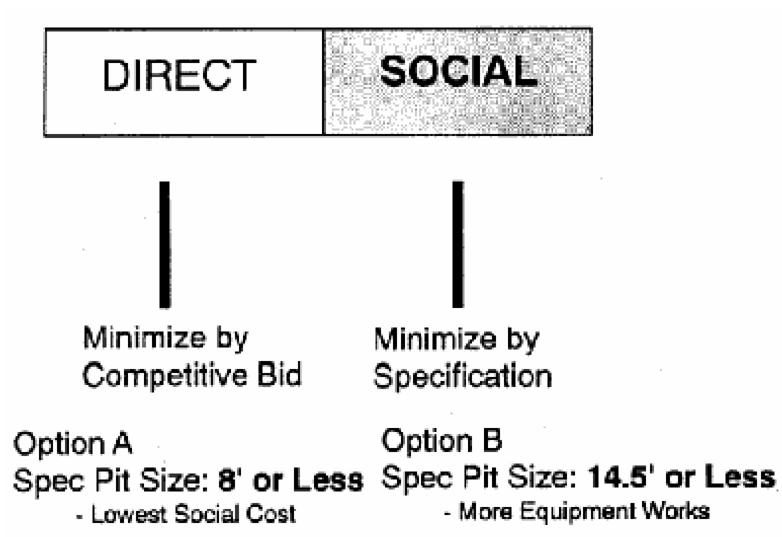
However, Figure 5 shows that a 14' jacking pit encroaches upon the storm drain corridor.



Fiqure 5

In qeneral, then, a smaller pit lowers social costs & saves the community money.

To achieve this social cost savinqs, however, pit size must be specified. As diaqrammed in Fiqure 6, direct cost can be minimized by competitive bid, but social cost can only be minimized by specification.



We suggest two options. Option A represents the lowest availables social cost without sacrificing direct cost. Option B allows more types of microtunneling equipment on the job and is useful when social cost is just not an issue.

SUMMARY

While a good specification for microtunneling includes more than jacking force and pit size, they must appear in the spec. Toogether, they help a sewer jurisdiction achieve full value on a microtunneling project.

REFERENCES

Author to Whom Correspondence Should be Addressed

[1]NO-DIG Pipe is the tradename of Mission Clay Products' microtunneling pipe.

[2]WPCF Manual of Practice No.9 (ASCE Manuals and Reports on Engineering Practice No. 37) Design and Construction of Sanitary and Storm Sewers, p. 187.

[3]WPCF Manual of Practice No.9, p. 201.

[4]WPCF Manual of Practice No.9, p. 203.

[5]Refinement performed using GB-STAT (Dynamic Microsystems). r^2 = .9134, std error of estimate = 31.7 $/Ft.