DELAYS IN THE OPERATION OF SUBSURFACE DRAINAGE TRENCHING MACHINES

S.D. Fisk
Member CSAE
Quebec Ministry of Agriculture and Colonization
Buckingham, Quebec

R.S. Broughton
Member CSAE
Agricultural Engineering Department
Macdonald Campus of McGill University
Ste Anne de Bellevue, Quebec

E.R. Norris
Member CSAE
Agricultural Engineering Department
Macdonald Campus of McGill University
Ste Anne de Bellevue, Quebec

INTRODUCTION

As most subsurface drainage contractors are paid on a per-foot basis, it is important that they realize the source and extent of any delays that interrupt their effective digging time. For the purpose of this study, "effective digging time" is defined as the time during which the trenching machine is moving forward while excavating on grade; "delay time" is defined as any time during the working day that is not effective digging time.

Field observations in 1950, as reported by Schwab *et al.* (2), indicated that with the machines and methods used at that time, only 34.4% of the available working season could be considered as effective digging time. The remaining 65.6% was consumed in delays. Yarnell (3) estimated that the average digging time of 15 machines operating in New York State during 1918 was only 4 h per 10-h day. The remainder of the time was spent on repairs, delays due to rocks, and frequent moving between farms.

The purpose of this study was to determine the source and extent of delays encountered by present-day trenching machines, and to indicate possible methods of improvement.

FIELD STUDY PROCEDURE

The effective digging and delay times of four, wheel-type trenching machines in Quebec and Eastern Ontario were observed during the 1969 and 1970 summers. Detailed observations were made of the delays that occurred during normal trenching operations, and the results were projected to a seasonal basis (1).

A delay was considered as any event that caused an interruption in the laying of the drains, because most contractors are paid for the actual number of feet installed. Every delay of 5 s or more was recorded. Meal breaks were not included in the analysis. Events, such as repairs, were recorded only when they occurred within normal working hours. Delays that caused the loss of a complete day were recorded as 10 h lost time.

RESULTS AND DISCUSSION

The observed delay times and effective digging times of four trenching machines are shown in Table I. Table II shows the 20 factors contributing to the total delay time, in percentage form.

Although most of these delay factors are normal and may be expected in any trenching operation, two of them, namely no supply of tiles and no plan available, are extraordinary delays that would not normally occur to the extent observed in this study. During the period of observation (summers of 1969 and 1970), there was a major shortage of clay tiles throughout Quebec and corrugated plastic drain tubing had not yet become readily available. In addition, Quebec contractors, according to the current drainage practices, are dependent on government agencies for the drainage plans and may not proceed without them. During part of the observation period, these plans were not supplied at a fast enough rate to keep all of the machines working continuously.

The durations of these two delays are not representative of the time lost on a seasonal basis, and it is not expected that these delays would normally occur in the future. Included in Table II are adjusted percentages where the effects of these two delays (no supply of tiles and no plan available) have been excluded. These adjusted values give a more representative résumé of the time consumed in delays during a complete season of operation. It can be seen that although the unadjusted percentages of total delay time are very similar for all the observed machines, this similarity is a coincidence. The adjusted percentages of total delay time range between 53.3 and 65.9%, with an average of 58.8%.

The delay due to weather ranges from 0 to about 12% for the different machines (Table II). The extent to which weather affects the operating time depends on the length of season considered. Delays due to this factor are more frequent during the spring and late fall. Weather is therefore a more apparent factor during a season extending from April to December than for one extending from June to November. This delay will also vary from year to year. The percentages shown for weather in this study are dependent upon the part of the season observed and cannot be projected to a seasonal basis for each machine. However, drainage contractors in the area estimated that 5.8%, the average for all four machines, is a close approximation

TABLE I OBSERVED MINUTES OF DELAY TIME AND EFFECTIVE DIGGING TIME FOR FOUR TRENCHING MACHINES

	Machine			
	A	B	C	D
Delay time	10271	5942	6915	3245
Effective digging time	4960	2806	3610	1692
Total	15231	8748	10525	4937

RECEIVED FOR PUBLICATION OCT. 18, 1971

TABLE II PERCENTAGE DELAYS FOR FOUR TRENCHING MACHINES†

Delay factor	Observed % A	Observed % B	Observed % C	Observed % D	Observed % Avg	Adjusted‡ % A	Adjusted‡ % B	Adjusted‡ % C	Adjusted‡ % D	Adjusted‡ % Avg
Maintenance (fuel, etc.)	1.1	0.3	1.1	1.6	1.0	1.3	0.4	1.4	1.6	1.2
Adjustments - minor repairs	1.6	2.1	2.9	3.4	2.5	1.8	3.1	3.9	3.4	3.1
Major repairs	6.1	2.9	4.7	2.4	4.0	7.2	4.1	6.3	2.4	5.0
Poor tile flow into trench	1.3	2.0	2.5	0.4	1.6	1.6	2.9	3.4	0.4	2.1
Waiting for tile wagon	2.7	1.5	3.7	2.1	2.5	3.2	2.2	5.0	2.1	3.1
Commencing laterals	3.7	2.9	3.7	4.1	3.6	4.3	4.1	5.0	4.1	4.4
Making junctions	6.6	3.9	0.2	1.5	3.1	7.8	5.6	0.3	1.5	3.8
Cleaning machine	0.4	0.6	5.2	8.0	3.5	0.5	0.9	7.1	8.0	4.1
Moving machine in field	4.3	2.3	5.0	4.8	4.1	5.1	3.3	6.8	4.8	5.0
Moving to new job site	2.0	2.1	1.5	7.3	3.2	2.3	3.0	2.1	7.3	3.7
Setting grade targets	8.3	3.3	3.1	4.1	4.7	9.8	4.7	4.2	4.1	5.7
Digging out rocks	3.1	2.7	3.7	7.0	4.1	3.7	3.9	5.0	7.0	4.9
Short coffee breaks, etc.	1.0	0.1	1.0	1.4	0.9	1.2	0.1	1.4	1.4	1.0
Discussion on site	1.4	1.5	0.2	0.0	0.8	1.7	2.2	0.2	0.0	1.0
Removing grade targets	0.2	0.0	0.1	0.2	0.1	0.2	0.0	0.1	0.2	0.1
Backfilling over collector	0.5	0.2	0.2	0.3	0.3	0.6	0.3	0.3	0.3	0.4
Weather	6.4	2.4	0.0	12.2	5.2	7.6	3.5	0.0	12.2	5.8
No supply of tiles	13.4	4.6	20.6	0.0	9.7	0.0	0.0	0.0	0.0	0.0
No plan available	2.0	26.1	5.7	0.0	8.5	0.0	0.0	0.0	0.0	0.0
Other	1.5	6.6	0.8	5.1	3.5	1.8	9.5	1.0	5.1	4.4
Total % delay	67.6	68.1	65.9	65.9	66.9	61.7	53.8	53.5	65.9	58.8

† 1% delay represents 15 h of potential digging time in a 1500-h season.
‡ Adjusted values are based on the actual total observed time minus delays due to no supply of tiles and no plan available.

of the seasonal delay due to weather conditions.

Delays due to major repairs are affected by the age and condition of the machine and the digging conditions encountered. The delays for major repairs presumably occur randomly during the season. It is possible, therefore, that figures based on observations of a partial season do not represent the delay over the complete season for a particular machine. However, the average value of 5.0% for major repairs agrees closely with the opinions of contractors in the area. This takes into consideration that many repairs are performed after normal working hours or during a period of rain, and are not considered as working-day delays.

The remaining delay factors (Table II) may be expected to occur during the normal digging operation. The variation between machines is due mainly to differences in the operating procedures of each contractor and the efficiency with which his field crew executes each phase of the total operation. Most of these delays cannot be eliminated completely. By reducing them to a minimum, a contractor can realize the maximum production within the time available.

The length of the working season varies from year to year and depends largely on the climatic and soil conditions of the area in which the machine is operating. Additional variation occurs because some contractors work 5 d per week and others work 5-1/2 or 6 d per week. Also, some contractors work more hours per day than others.

The 1970 working season, based on the four machines under study, began about May 4 and continued until approximately December 12, or a total of 223 days. Considering a 5-1/2 d workweek, and allowing for two holidays, 174 working days were available (Figure 1).

By applying the average adjusted delay factors shown in Table II to the 174 available working days, the equivalent of 10.1 d would be lost because of weather, 8.7 d because of major repairs, and 83.2 d because of other delays. The 72 d remaining would be the period of effective digging time.

METHODS OF REDUCING DELAY TIME

The adjusted figures in Table II show a range of total delay times between 53.3 and 65.9% for the different machines. This indicates that some contractors are experiencing greater delays than others while doing the same basic operations.

Much of the delay time is unavoidable as it is an integral part of the drain installation operation. A contractor who can attain over 50% efficiency is doing exceptionally well. However, many of the observed delays may be reduced by good management and careful planning.

The largest single delay factor shown in Table II is weather. Although this loss is generally unavoidable, the time can often be used to good advantage by performing preventative maintenance and planning new work. The time required for major repairs may be reduced by maintaining the machine in good condition and by overhauling the machine thoroughly during the winter months. Further repair delays may be prevented by keeping a good supply of spare parts

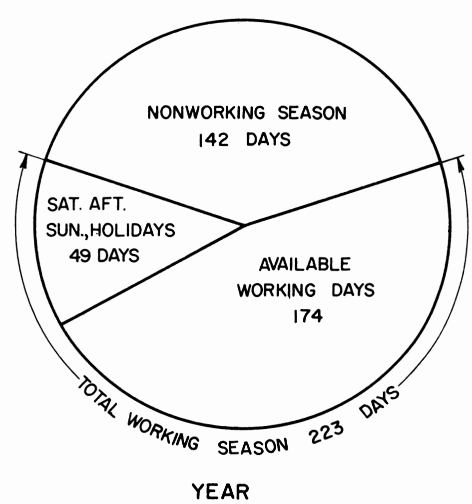

Figure 1. Average time distribution for four trenching machines in 1970.

on hand and by owning a complete set of tools and a portable welder.

One of the largest differences between delay times of machines was that for making junctions. This delay was practically eliminated by one contractor, whereas another had a delay of almost 8%. It is not necessary to stop the machine while making junctions, as some contractors do, except perhaps during very wet conditions. The machine may continue to work while one man completes the junction. A portable tile-cutting machine is essential for maximum efficiency in this operation. The number of junctions can also be minimized by planning long laterals. The use of prefabricated junctions, when available, also saves field time.

Poor flow of tiles into the trench caused misalignment and uneven spacing between tiles, resulting in an average delay of 2%. This was especially evident at high digging speeds. By proper adjustment or alteration of the design of the tile chute this delay can be reduced. It was noted that Machine D, which was installing corrugated plastic tubing, experienced very little delay from this factor.

Machine A experienced excessive delay in setting grade targets. The machine was delayed frequently while the crew set the targets for each lateral after the machine was in position ready to dig. Although it is sometimes difficult to keep ahead of the machine when working with only a three-man crew, careful planning of the time available can reduce this delay. Some unavoidable delays, such as maintenance, repairs, and moving to a new job site, may require the attention of only one man while the other two set targets. Use of the laser system of grade control may help to reduce this delay.

Other methods of minimizing the delays include scheduling of jobs close together to reduce the moving time, and installing tile on the lands with the poorest drainage conditions during the driest part of the year.

SUMMARY

There are many factors that cause delays in subsurface drainage trenching operations. Some of these, such as weather, are unavoidable, but many of the others may be reduced by careful planning and good management. Observations of four, wheel-type, subsurface drainage trenching machines showed that delays accounted for 53.3-65.9 percent of total working-day time. The delays that appear to be most easily reduced include setting targets (5.7 percent time loss), making junctions (3.8 percent time loss), and moving to new job sites (3.7 percent time loss). Based on 174 available working days, the average effective digging time was an equivalent of only 72 days. By decreasing these time losses, the operational efficiency of subdrainage trenching can be improved and considerable savings can be made.

REFERENCES

1. Fisk, S. D. 1971. A study of the performance and cost of operation of wheel-type drainage trenching machines. M.Sc. Thesis. Dep. Agr. Eng., McGill University, Montreal, Quebec.

2. Schwab, G.O., R.K. Frevert, and L.L. DeVries. 1956. Tile-trenching machine performance. Agr. Eng. 37: 469-472.

3. Yarnell, D.L. 1920. Tile trenching machinery. U.S. Dep. Agr. Farmers Bull. 1131, Washington, D.C.