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Article abstract

Land drainage technology remained static from the days of the Pharaohs to 1900. Practical drain installation machinery was introduced just prior to 1900 and was gradually improved to the 1960s. From 1850, clay drain tile were manufactured in hundreds of small rural plants in Ontario. These tile were installed by hand or by open trench machinery. In the late 1960s land drainage technology advanced rapidly with the introduction of plow-in equipment and the parallel development of corrugated plastic drainage tubing. Laser technology was introduced to make the operation efficient. The design, construction, and world-wide sale of this new equipment began in Ontario and has developed major side industries such as the production of tubing for veins and arteries of humans. The paper discusses the development of the technology using four time periods.

LAND DRAINAGE TECHNOLOGY - CANADA'S LEADERSHIP ROLE

Ross W. Irwin[1]

ABSTRACT

Land drainage technology remained static from the days of the Pharaohs to 1900. Practical drain installation machinery was introduced just prior to 1900 and was gradually improved to the 1960s. From 1850, clay drain tile were manufactured in hundreds of small rural plants in Ontario. These tile were installed by hand or by open trench machinery. In the late 1960s land drainage technology advanced rapidly with the introduction of plow-in equipment and the parallel development of corrugated plastic drainage tubing. Laser technology was introduced to make the operation efficient. The design, construction, and world-wide sale of this new equipment began in Ontario and has developed major side industries such as the production of tubing for veins and arteries of humans. The paper discusses the development of the technology using four time periods.

RESUME

Cet article retrace les quatre grandes périodes de développement de la technologie du drainage des terres, restée statique de l'époque des Pharaons jusqu'à 1900. Des machines facilitant la pose des drains ont fait leur apparition au tournant de 1900 et ont été perfectionnées graduellement jusqu'en 1960. Au milieu du 19e siècle, des drains formés de tuiles d'argile étaient produits dans des centaines de petites manufactures rurales en Ontario. Les tuiles étaient installées à la main ou à l'aide de machines servant à creuser des tranchées. A la fin des années 1960, la technologie du drainage avança rapidement grâce à l'utilisation des techniques de labourage et au développement de tuyaux de plastique ondulé. L'utilisation de lasers a rendu les équipements de drainage plus efficaces. En Ontario, la conception, la construction et la vente de ces équipements à l'échelle mondiale a donné naissance à des industries de pointe comme celles spécialisées dans la production de tuyaux utilisés dans les veines et artères humaines.

Land drainage, as an age-old technology, has played an important role in the development of the Canadian agricultural industry. The agricultural land base of Ontario is about 5,649,000 hectares (ha), of which 3,460,000 ha are under crop. The area of

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agricultural land in Canada now improved through tile drainage is 2,222,843 ha, of which 1,584,050 ha is in Ontario.2

Surface drainage removes surface water. These were the water furrows plowed each fall by the farmer. It is a land improvement practice as old as man. Subsurface drainage (tile drainage) also removes excess water from the soil profile to permit the entry of oxygen for the growing plant. Soil organism development and fertility transfer to plants are important benefits. Subsurface drainage also dries the soil surface for better machinery working conditions and reduces soil compaction and soil deterioration.

Subsurface drainage is the installation of a system of parallel lateral drains at a depth of 0.75 m in the soil, and spaced about 12 m apart. Water flows by gravity to the lateral drains. The collected water then flows through larger main drains to an outlet, generally an open ditch.

The first reference to the installation of subsurface drains in Ontario is 1844 when clay drain tile, manufactured at the Bowmanville Pottery by hand, were installed on the farm of John Smart at Port Darlington.3

Early agricultural literature contains many references to land drainage technology;4however, few were installed in the field. It was only after most of the land had been cleared did the farmer find time to improve the drainage of his farm. Horseshoe-shaped drain tile were common in this period, some having a sole tile, others were laid on wood. By the end of the 19th Century drain tile were round in shape and were usually 50 to 75 mm in diameter.5. The few that were installed were done so by hand. Drainers dug about 15 m a day at 0.9 m depth. At $2.00 a day for wages, this worked out to 13 cents a metre, which was very expensive for the time. The Canada Farmer related that three drainers had installed drains in five acres at a cost of $99.96 an acre. They stated 'many farmers think it dear, but most consider one or two acres a year.'6 It is obvious that land drainage was not used to improve extensive areas of land during this period.

Attempts were made to mechanize the installation operation. Carter and Rennie both marketed Canadian made wheel-type trenching machinery from 1860s. These machines were advertised to dig 500 m of 0.9 m deep trench, 200 mm wide, in a day. The fact these machines fell into disuse is the best indicator they were not a real success. In 1892, the Buckeye Trenching Machine Company in Findlay, Ohio, produced the first

2 Statistics Canada, *Selected Agriculture Highlights. Census of Canada*, 1986.

3 R.W. Irwin, *A Review of Land Drainage in Ontario*, Ontario Agricultural College Technical Publication 7 (Guelph, 1961).

4 Kenneth Kelly, 1975.'The Artificial Drainage of Land in Nineteenth Century Southern Ontario,' *Canadian Geographer* 19:4 (1975), 279-98.

5 Irwin, op. cit.

6 *Canada Farmer*, 15 April 1876.

acceptable trenching machine; however, only thirty-six were sold in the next decade. This company monopolized the Canadian business to 1955.

The first Buckeye trenching machine imported to Canada was a 1902 model at Pontiac, Quebec. Jacob Schihl of Woodslee, Ontario, bought a 1905 model. The third trencher was imported in 1909. By 1910 there were eleven in the province, and 130 by 1916. The rapid growth was associated with a promotion programme of the Ontario Department of Agriculture from 1905.

The period 1910 to 1945 witnessed an expansion in interest in land drainage due to the farmer changing emphasis from general farming to cash crops. There was also a modest improvement in the machinery. By 1920 there were 147 trenching machines in Essex, Kent and Lambton Counties, with only seventy-seven in the balance of the province. These numbers had not changed much by 1945.

Clay drain tile were used throughout the period, along with a small quantity of concrete drain tile, generally of a larger diameter, in the later years. Table I compares the number and size of drain tile production plants in Ontario in 1910 and in 1970.

Table I

Clay Drain Tile Production in Ontario

Annual Production (m)	**No of Drain TilePlants**	
	1910	1970
0 - 30,480	15	1
30,480 - 152,400	47	2
152,400 - 304,800	6	3
304,800 - 609,600		7
609,600 - 914,400		5
914,400 -1,219,200		8
1,219,200 -1,524,000		4
1,219,200 +		3

Drain tile production was seasonal in 1910. The kilns did not hold many drain tile and most of the sixty-eight plants produced less than 250,000 m. In 1920 there were eleven tile plants in Kent County.

Trenching machines were originally powered by a steam engine which required another man, horse, water cart and fuel. Gasoline engines soon replaced steam. Round wheels were replaced by half- tracks for improved traction in wet soil conditions. Loose joints on the equipment, and poor operators, forced the Department of Agriculture to increase drain tile diameter from 75 mm to 100 mm for lateral drains. In 1945, the Buckeye Model 301 was introduced. This wheel-type trencher was smaller, lighter and more efficient. It was the first major advance in thirty years. Daily production was still limited to 1,000 m a day, or 140,000 m a year.

The full-time drainage contractor after emerged after 1945, replacing the farmer who installed tile during slow farming periods. There was a steady improvement in machinery, all of it imported. Grain corn was being adopted as a major crop outside south-western Ontario, and good drainage was needed to grow corn.

Clay drain tile production increased from 1945 to 1967. By 1967, the production was 18,288,000 m a year, only 457,200 m being installed in the nine eastern counties of Ontario. Six of the thirty-three plants in operation produced half the drain tile.

Speicher Trencher Company of Celina, Ohio, built a rubber-tired, wheel-type trencher of automotive parts and introduced it into Canada in 1956. It was an instant success and competitor to the Buckeye models 301 and 302. Rapidly, other new models developed having hydraulic control systems, improving drain laying capability. The maximum speed was still 9 m a minute, because of the limitation of the hand process of moving drain tile from the tile buggy to the trenching machine. It was a growth period and from 1964 to 1968: ten Barber Greene, sixty-five Speicher and thirty-five Buckeye trenching machines were sold. Specialized trench backfilling equipment was introduced in 1961.

By the 1960s grain corn was grown in most counties of Ontario and new soybean hybrids made its production feasible outside southwestern Ontario. The demand for improved farm drainage was high. In 1967 less than 5 percent of the drainage work was in eastern Ontario. The Ontario cabinet approved the Agricultural Rehabilitation Development Act (ARDA) 1 April 1966, to assist agricultural production in the eleven eastern counties. The programme was extended to the balance of the province the following year. A very major problem developed. The Department of Agriculture's December, 1967, survey showed 22,765 farmers in Ontario wanted to instal tile drains within the next three years. This represented 807,717 ha, 62% in southwestern Ontario. This crisis was solved by the drainage industry.

Clay drain tile production increased but could not keep up to the demand. The tile companies could not finance a massive expansion, so alternatives were sought. One group of sixteen drainage contractors decided to construct a concrete drain tile plant.

Before actual construction they learned of the first production of corrugated plastic drainage tubing by Advanced Drainage Systems Inc. in Delaware. In October, 1967, 460 m of tubing were imported to Ontario and installed at several sites for observation. The group saw the future of this alternative product and formed the Big O Drain Tile Company at Hensall. In 1968 about 1,219,000 m of plastic drainage tubing were made by the Big O plant. By 1980, drain tubing production had risen to 39,624,000 m from eleven plants.

Corrugated plastic drainage tubing is produced on a standard pipe extruder that feeds a special forming mandrel where compressed air forces high-density polyethylene into a corrugated mould. The technology originated in Europe but has been greatly modified and expanded for Canadian conditions.

Corrugated plastic drainage tubing had the advantage of light weight, about fifteen times lighter than clay drain tile. It was originally sold in 76 m long coils and could mechanize the installation of drainage pipe.

The Big O Drain Tile Company had begun production in September 1968. Daymond Ltd in Chatham and United Extrusions in Orangeville, began production in 1969. Other smaller plants were formed in local communities to service drainage contractors. By 1977 corrugated plastic drainage tubing commanded seventy-five percent of the market. Today it is ninety-eight percent.

Corma Inc. in Concord began the manufacture of corrugated forming mandrels for drainage tubing in 1975. This company has expanded and exports world-wide the tooling to produce materials for the medical profession, automotive trade and all other corrugated tubing applications.

Figure 1 shows the use of drain pipe since 1965. Over this period the use of pipe product has tripled as farmers strive to maximize their return on investment. Financial pressure encouraged farmers to drain land which in former years would have been left in pasture. Many of these soils were fine sands which plugged drains. About 1957, Globe Glass Saturators Co., Petrolia, developed a fibreglass mesh product for the protection of drains. It was named 'Tile Guard.' The product was reasonably successful in keeping sand out of drains when properly applied in the field. About 500,000 m were used in 1962.

Tile Guard was not suited to the installation of corrugated plastic drainage tubing, nor the newer rapid methods of installation. By 1973 it had been replaced by several materials such as Cerex and Remay, which were heat welded around the tubing at the factory. These products were easily torn through handling. In 1973, the Big O Co. purchased knitting machines to produce a polyester 'sock' which was extruded on the tubing. In 1977, 610,000 m of pipe protection was used in Ontario.

Dr A.N. Ede, in Silsoe, England, researched the design of the floating-beam mole plow. The patents were sold to Hudswell Yates Development Ltd and Ede was contracted

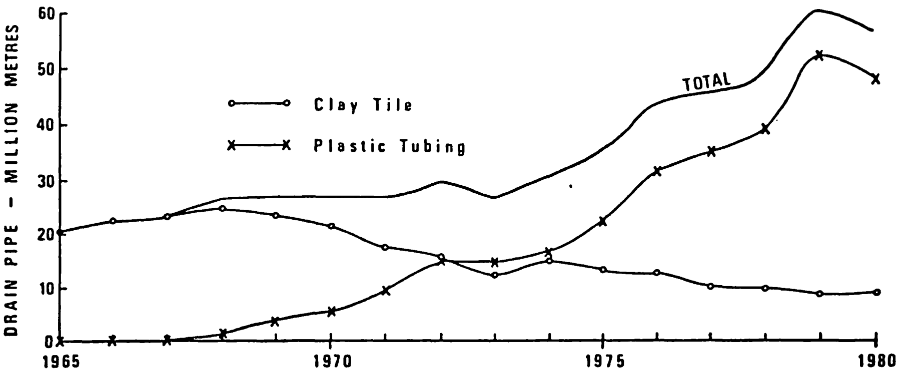

Fig.1 DRAIN TILE PRODUCTION IN ONTARIO, 1965 – 1980*

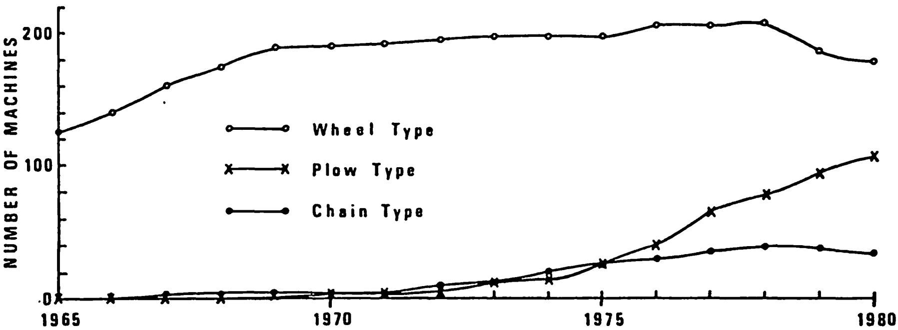

Fig.2 DRAINAGE MACHINES IN ONTARIO, 1965 – 1980*

to refine the design for drainage plowing. The company produced their first machine in 1966. It produced two Badger Majors, and twelve Badger Minors by 1971, four of them being shipped to Canada.

The Badger Minor consisted of a 45 degree angle drainage plow point which could lay 100 mm drainage tubing at a depth of 2 m. The grade was maintained by a special linkage having 'free roller' bearings.

At that time, the Ontario sugar beet industry was in decline. C and D Sugar Company closed their plant at Wallaceburg in 1959 and their plant at Chatham the end of 1967. The year before, the company, to diversify, had bought Daymonds Ltd of Chatham, an aluminum and plastics extrusion business. In May 1969, company representatives became aware of the Badger plow and were appointed Canadian representative in September 1969. Badger Systems (later Trenchless Pipe Systems), a division of C and D Sugar Company, awarded the rights for the United States to Certain-Teed Daymond.

Arthur Eddy, a Woodstock drainage contractor, wanted to buy a Badger plow in 1970. He found it could only be leased from Daymond Ltd. Eddy enlisted local friends and the design for a different drainage plow evolved. The double parallel link system of grade maintenance was developed and tested in a soil tank. The Zor Company in Woodstock built their first drainage plow based upon this design in 1971. It was a popular design and by 1978 129 were produced. Several models were added and the basic machine was modified over the period. The design was licensed in the United Kingdom where Mastenbrook Zor plow found a fine market.

The prime designer was Robert G. Elms, who in 1976 also designed a new drainage plow, 'The Wedge,' for the Kitchener firm Canteco Ltd. The plows were manufactured at Embro. Another Canadian- designed and manufactured plow was the Krac Charrue, originally made in Quebec. These were 'add-on' types where the drainage plow was carried by a large bulldozer tractor.

About 1979 a series of self-propelled type drainage plows were designed and built in Ontario. Such plows include the powerful Tait Manufacturing Company (of Grand Valley) Model 325, used on CIDA projects in Pakistan, and the drainage plows developed by Wolfe Ltd, Melbourne, and Eddy Oxford Ltd, Woodstock. These plows tend to be designed with a parallelogram linkage for grade maintenance. Figure 2 shows the number of drain installation machines in Ontario.

Drainage plows have few moving parts and low operating expenses, about one-fifth that of a wheel-type trenching machine. The first Badger plow required one man operating a radio-controlled sighting level to maintain grade. Such a system did not speed the installation and was prone to human error.

The laser was developed in 1960 and by 1966 had been adapted to grade control of road building machinery. The Laserplane system was introduced for grade control to the drainage industry in Canada in 1969. It was a system for establishing a reference plane of laser light over a work area 600 m in diameter.

The decade from 1967 to 1977 was one of innovative design in land drainage. There was greater progress in this period than the previous 2000 years of drainage use. The impetus was the farmers' demand for improved land drainage. The price of agricultural products permitted farmers to finance the improvement, and creative government policies fostered the work.

In 1967, clay drain tile was installed using a wheel-type trenching machine at a maximum rate of 9 m a minute. A few European chain-type drainage machines were imported in the period 1967 to 1972. These machines increased production but were only efficient in stone-free ground. The introduction of corrugated plastic drainage tubing, the drainage plow and laser grade control, completely changed the industry. The rate of work increased to 30 m a minute. While drainage tubing is still sold in 75 m long coils, the bulk of it is now marketed in the drainage industry in 'maxi' rolls of 1100, 1770 and 6100 m lengths.

The introduction of laser grade control combined with well-designed installation machinery and corrugated plastic drainage tubing have given the land drainage industry of Canada a high technology base at no increase in cost to the farmers. Canadians developed, improved, and exported this technology.

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