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ITALIAN EXPERIENCES IN MICROTUNNELLING

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1. INTRODUCTION

The use of microtunnelling, in the meaning as described below, was introduced in Italy only in the last few years (end of 1991, beginning of 1992). In this period of time it has been possible to develop a considerable weight of experience, based on the already notable optimisation of the technology acquired in other countries, so that today, in Italy as well, microtunnelling may be considered as "mature technology" for the resolution of countless problems linked to the trenchless installation of underground pipes. It was a firm from Udine, I.CO.P. S.p.A. that introduced the technology into Italy, firstly in association with the RAS (Underground Joint Crossing Venture) and then on its own. Up to now it has made over 6.000 m of sub horizontal axis crossing with the microtunnelling technology. It is still the only Italian firm that operates directly with this technology so its experience represents the total Italian experience of microtunnelling.

2. WHAT IS MEANT BY MICROTUNNELLING

Before looking at the crossing data, it would be appropriate to say what is meant by "microtunnelling". Some authors define microtunnelling as all those techniques that lay or renew underground pipes with diameters smaller than man-entry size with trenchless methods. This embraces a multiplicity of methods (steerable and non steerable methods, with or without soil removal, with or without protective pipe) and often creates confusion and misunderstanding. A modern and more precise definition of microtunnelling describes it as that technology allows the installation of underground pipes with the following methods:

- driving of the jacking pipe and simultaneous removal of material through the driving wheel;
- possibility of making steering adjustments during the driving phase;
- steering the microtunneller by remote control.

Within this definition there are different kinds of equipment that satisfy the above criteria and these can be classified as follows:

1. Equipment with auger material removal:
 - 1.1 with cutting wheel driven from outside (without bearing),
 - 1.2 with directly driven cutting wheel (driven at the shield);
2. Equipment with slurry material removal:
 - 2.1 with standard cutting head,
 - 2.2 with rock cutting head.

Equipment of type 2 is more versatile and can be used in a wider range of soils than type 1. It can also achieve greater lengths per single section of drilling, with a range of diameters, between 250 mm and 1.800 mm (internal diameter of the tube).

The experience discussed here was performed with type 2 equipment, i.e. microtunnels where the spoil is hydraulically evacuated.

3. EQUIPMENT

The equipment used to make most of the crossings consists of microtunnellers with hydraulic removal AVN1000 and AVN1500 produced by the German firm Herrenknecht. The main features of these equipments are shown in Table 1:

Equipment	AVN1000	AVN1500
OD	1405 mm - 1450 mm	1960 mm
maximum torque	80,000 Nm	180,000 Nm
RPM	0-6 rpm	0-6 rpm
slurry circuit capacity	0-180 m ³ /h	0-230 m ³ /h
diameter slurry pipe	5"	6"

Table 1: Microtunnelling equipments used in Italy.

4. CROSSINGS CARRIED OUT IN ITALY

Up to now, about 70 crossings have been carried out in Italy. Most of these has been performed for gas pipelines, only few for sewage pipelines. The Italian sites concerned have presented very different types of the ground. They therefore needed different kinds of cutting wheels, different lubrication systems and drilling methods according to the material encountered. The table 2 shows a list of the different areas in which the drilling have been performed.

CROSSING AREA	SOIL ENCOUNTERED	TOTAL LENGTH OF CROSSING [m]
Emilia Romagna (Bologna)	clay, silt, fine sand	800
Abruzzo	limestone	450
Abruzzo	various loose soils	570
Umbria (Orvieto)	clay	650
Lombardy (Milan, Pavia)	fine sands	1,500
Tuscany (Siena, Arezzo) and Lazio (Rieti, Viterbo)	various loose soils	1,000
Sicily (Messina)	rock (gneiss)	650
Alto Adige (Bolzano)	coarse alluvial soils	500
Various	limestone and quartz phylites	160

Table 2: Areas in Italy where microtunnelling crossings have been carried out.

Table 3 gives a more detailed list of the crossings carried out, with their respective length. It will be noted that the lengths are variable in a wide range, between 20 and 400 m.

The data for the crossings can be shown in various ways. To achieve a synthetic and easily readable identification of the activity, the following diagrams are presented. These illustrate, in percentages, the crossings in relation to the under-crossed works, the ground encountered during the drillings, the diameters used and, lastly, the temporal distribution, from 1991 until now of the crossings carried out. (figs. 1,2,3,4).

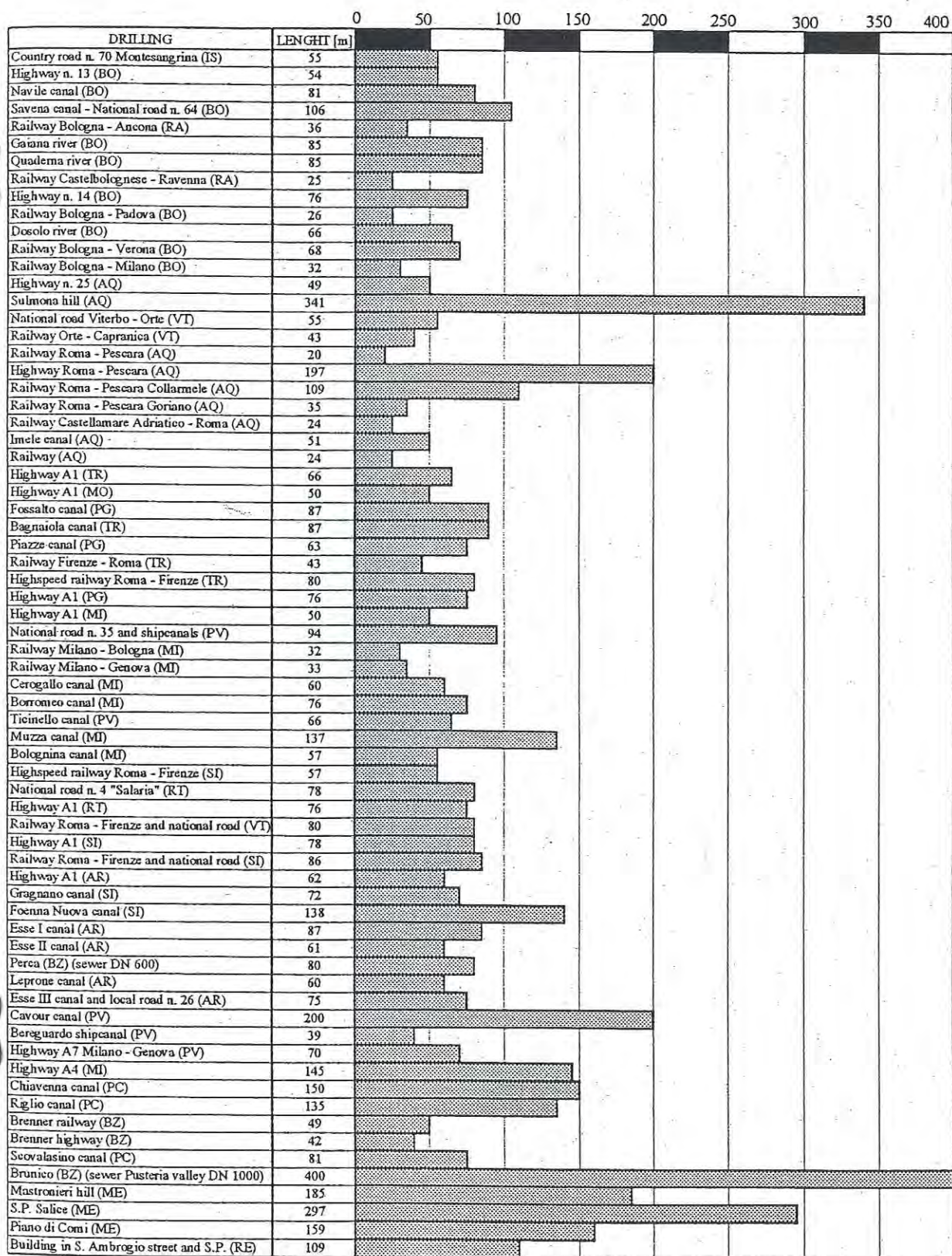


Table 3: List of crossings in Italy with respective length.

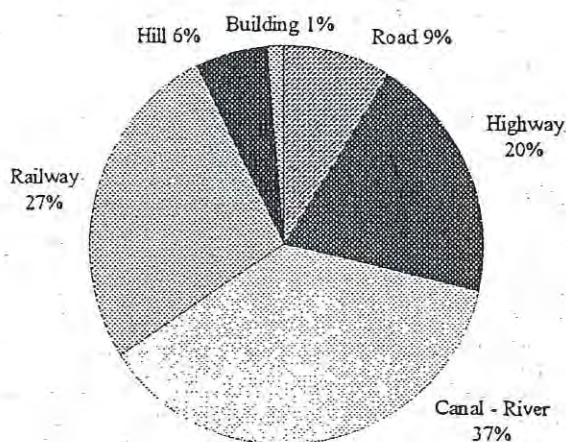


Figure 1. Distribution of microtunnelling crossings carried out in Italy in relation to the under-crossed works.

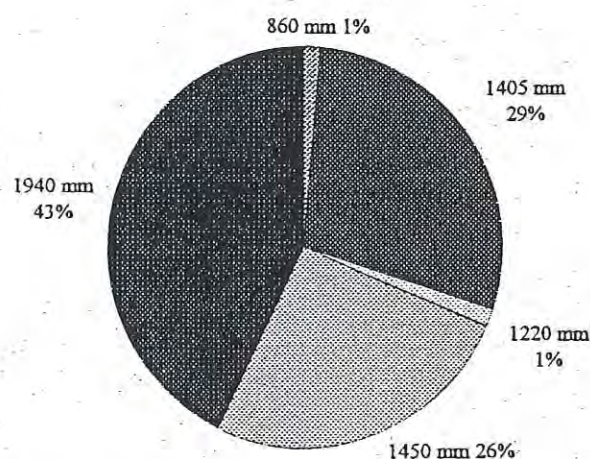


Figure 3. Distribution of the microtunnelling crossings carried out in Italy in relation to the drilling diameters.

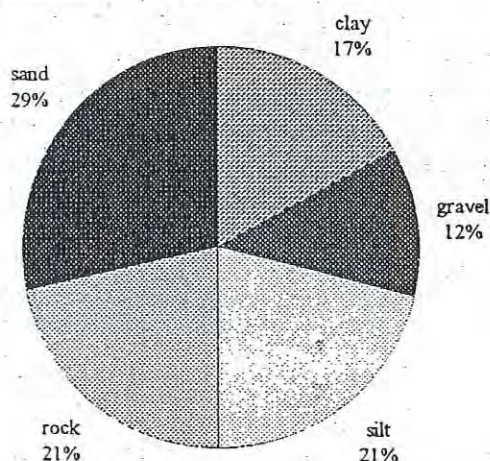


Figure 2. Distribution of the microtunnelling crossings carried out in Italy in relation to the ground encountered.

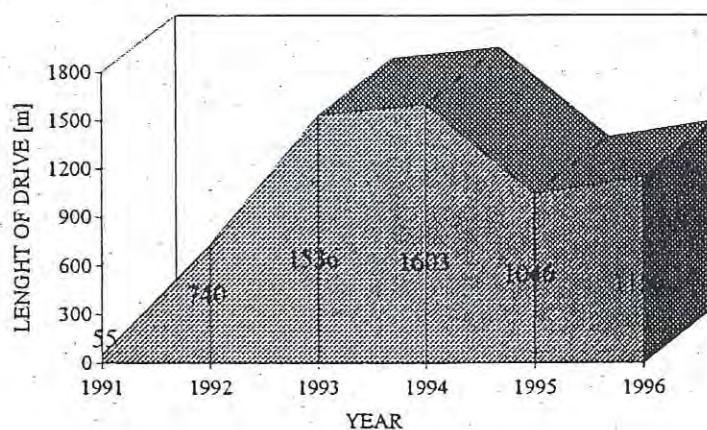


Figure 4. Time distribution of the microtunnelling crossings carried out in Italy starting from 1991.

5. CROSSINGS OF PARTICULAR INTEREST

It is worth drawing attention to a drilling of particular interest, which crossed the Sulmona mountains Sulmona (Abruzzo) in 1993, where a single 341,5 m section of drilling (o.d. 1940 mm) was carried out for client Snam, Italy's organisation for the supply and distribution of gas. This required crossing hard, poorly to highly fractured limestone of uniaxial compressive strength averaging about 70 N/mm². The entire crossing was carried out with a rock cutting wheel, taking approximately two months of work.

At the beginning of 1996 a crossing of 400 m (two sections from a central shaft), in a variable ground of sand and gravel with coarse pebbles to build the Val Pusteria sewage pipe was carried out near Brunico (Bolzano).

The recent crossing of about 300 m in one section in Milazzo (Messina) is also worth mentioning. The pipe had a slope of 30% and was drilled entirely through gneiss 80 m under the terrain top (fig 5). This was also for a Snam gas pipeline.

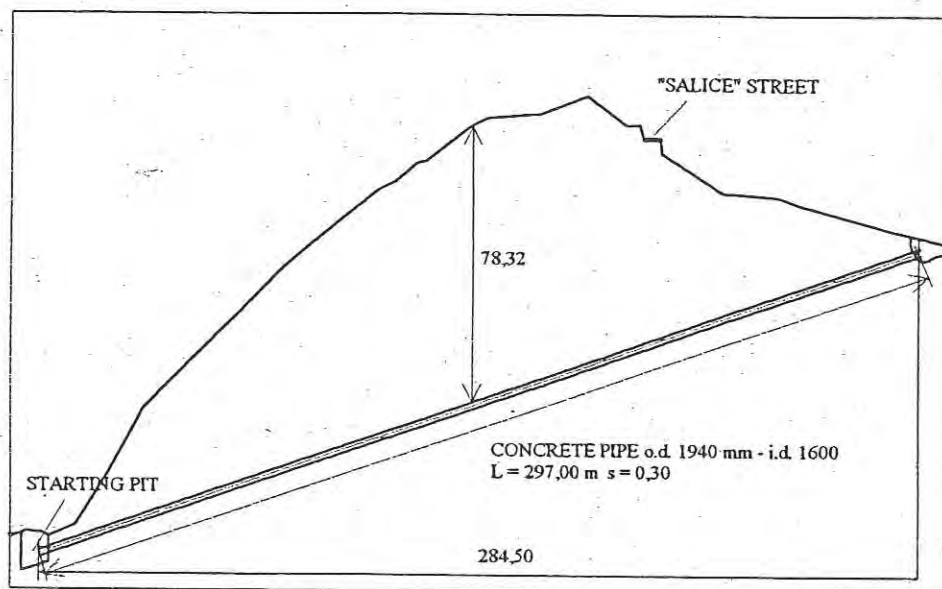


Figure 5. Schematic profile for the "Salice" crossing at Milazzo (Messina) totally performed in gneiss.

6. CONCLUSIONS

Almost all of the Italian microtunnel have been performed for gas pipelines. Although microtunnelling for sewage pipes and urban works is highly developed in other European countries, in Italy the use of this method in this field had a slow development, this because the technology is not widely known among designers and public administrators. The first uses, however, have been made. For example the construction of the main sewage collector in the town centre is being carried out in Pordenone. Recently other tenders considering the use of microtunnelling in an urban context have been called for. The experience of a wide range of conditions for tunnelling in these first five years of microtunnelling usage in Italy, and the reputation that the technology is acquiring, give hope that it will be used more, even in urban environments, in the solving of problems that are linked to the laying of pipelines in the subsurface with trenchless techniques.