Title:

Efficient crossing of traffic routes and waterways using the dynamic ramming technique

Speakers:

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Abstract:

The installation of pipelines in densely populated areas, like for example along the NEL Northern European Gas Pipeline in Northern Germany, requires numerous crossing underneath federal roads, motorways und railway tracks. For the required installation lengths between 30 - 60 metres the dynamic ramming technique is perfectly suitable.

The paper presents the technical application aspects in principle - also in comparison to the auger boring technique - the wide application range plus the combination with other trenchless techniques. Using the example of a street crossing for the NEL pipeline, project planning, installation process and removal of the soil from the pipe are described in detail. The daily installation performance is impressive. The Ruhrgas AG rates the dynamic ramming technique as “very recomendable”: In addition examples of alternative ramming applications, e.g. HDD assist techniques or pipe roofing, are given.
1. The dynamic ramming technique

Pneumatic ramming machines are used for the dynamic installation of steel pipes, either as protection or product pipes, up to 4,000 mm diameter in lengths of up to 80m in the soil classes 1 - 5 (partially even in class 6 - easily removable rock) beneath traffic routes and water ways.

Altogether, there are 14 machine types with up to 40,000 kN thrust force available. The induced impact energy is transferred to the complete pipe string in the best way possible, providing maximum directional stability during ramming. The average installation speed is approx. 10 m/hour. The firm connection between pipe and machine is achieved with conical add-on cones and/or multipart cotter segments. The special soil removal cones have two holes for releasing part of the soil carried along, thus causing relief.

The technical and economical advantages, in comparison with other installation methods, result from the fact that abutments (in the rear, front or underneath) are not required, thus shortening the set-up times. A further advantage is that the working pits are comparably small in widths and depths, thus only little cover is required. The technique also grants that the pipe string is stably embedded in the ground. The structure of the surrounding soil is not loosened but packed smoothly to enclose the steel pipe securely and protectively, which also makes pipe installation in water-bearing and rocky soils possible. Due to its very small displacement volume in the area around the cutting shoe, heave of the ground or street surface can be ruled out even with little cover. After the ramming works have been concluded, the soil is removed using water and/or compressed air.
2. Application range of the dynamic ramming technique

2.1. Horizontal ramming
The main application of the dynamic ramming technique is the horizontal installation of longitudinally or spirally welded as well as seamless steel pipes underneath roads, motorways, railway embankments, rivers and buildings up to 80 m length without pressing abutments. The steel pipes are used as product pipes, e.g. in pipeline construction or as protection pipes for supply and drainage pipe bundles. Additionally the ramming technique is applied horizontally for building underpasses or small culverts.

2.2. Vertical application
The dynamic ramming technique can also be used in vertical direction, e.g. for building foundations. With special adapters the ramming machines can also be used for installing sheet piles.
2.3 Pipe renewal

With additional accessories, damaged gas, water and sewage pipes of almost any kind of material can be replaced. The new HD-PE pipe (long or short) can have a larger diameter than the old pipe. House connections have to be laid open.

3. Alternative ramming applications

In addition to the above mentioned common forms of use, the dynamic ramming technique is quite often used in combination with HDD bores (so-called HDD Assist methods), e.g. to loosen stuck HDD drill rods, to install casing pipes for HDD crossings, to overcome hydrolock with a pipe or to rescue / remove product pipes.

A further alternative application is the installation of pipe roofs for tunnel construction.
4. The dynamic ramming technique in pipeline construction

There are several aspects which make the dynamic ramming technique rather suitable for pipeline construction than auger boring. The main advantages are:

- Easy adaption to multiple sizes of casing, less accessories required, i.e. less total investment
- No press abutments required
- Easy accommodation of changing soil types
- Less safety concerns – no rotating equipment to injure operator
- Requires smaller truck to transport equipment on site
- The complete pipe string can be welded together prior to installation, thus downtimes are avoided and costs are reduced

5. The North European Natural Gas Pipeline NEL

The NEL North European Natural Gas Pipeline belonging to WinGas in Kassel, Germany distributes natural gas arriving from Russia to Germany and the rest of Northwest Europe. The natural gas storage unit in Rheden is the final arrival point for the gas pipeline, which runs all the way from Lubmin at the coast of the Baltic Sea. Stretching over a 440 km route from the North of Germany, the pipeline has to cross beneath countless roads, rivers and railway tracks.

The red line marks the NEL pipeline from Lubmin to Rheden in Germany.

5.1. Ramming application for NEL Pipeline near Perdöhl / Germany
The contract for 2 construction packages with a length of over 120 km was won by the contractor Bonatti S.p.A. of Parma, Italy. Within this framework, subcontractor DALCAI HORIZONTALE WEGBORINGEN BV was the highly recommended specialist company for horizontal bore techniques. The company, based in Nijverdal in the Netherlands, carried out three road crossings using the dynamic ramming method.

DALCAI has been specialising in the dynamic ramming technique for pipeline constructions since 1999. Over the past 2 years alone, DALCAI has carried out more than 11 km of pipeline installation using the technique to ram steel pipes with a compressed air operated steel pipe rammer, manufactured by TRACTO-TECHNIK of Lennestadt, Germany, which has enabled it to gain extensive experience and the relevant know how, as well as the necessary routine to complete this type of bore task. DALCAI’s managing director, Jan-Willem Dalvoorde commented: “The success of the task depends on the machine technology. The rammers must be able to withstand enormous strains, if you consider, that the strongest rammer worldwide, the APOLLO can produce a single impact energy of up to 40,500 Nm.”

**Jobsite specifications:**

**Client:** WinGas, EON Rurgas, GasUnie  
**Main contractor (2 x 60 km):** Bonatti S.p.A. Parma / Italy  
**Subcontractor:** DALCAI Horizontale Wegboringen B.V, 7440 AA Nijverdal / Netherlands  
Tel. +31(0) 5486 18382  
www.dalcai.nl  
**Installation lengths:** 3 crossings under streets using the ramming technique  
- in Perdöhl „An der Chaussee“, 34 m long  
- in Albertinenhof „Wittenburgerstraße, 40 m long  
- in Schwartow „Zarrentinerstraße, 44 m long  
**Soil conditions:** compact, sandy soil  
**Characteristics:** Trenchless method for reasons of tree protection (old oak alley). Decision in favour of ramming technique because it's faster and cheaper than auger boring.

5.2 Detailed description of the pipe installation project for NEL near Perdöhl
The three road crossings were situated close to the A24 motorway in Mecklenburg-Vorpommern approximately 80 km east of Hamburg. The crossing included a 34 m length in Perdöhl, a 40 m length in Albertinenhof as well as a length of 44 m in Schwartow.

A decision was made to apply the dynamic ramming method because it is possible to work quicker and at less expense than with the auger boring method combined with a spiral conveyor. The ramming process does not require any thrust wall for resistance or heavy jacking frames. The technique offers a stable directional control and is also applicable to lower ground cover limits. The pipe string, which is welded together beforehand, can be pushed forward with an installation speed of up to 10 m/h, which means that road crossings can be completed within one working day. With the auger boring method, where only single pipe sections can be jacked forward, up to 5 to 7 working days would have to be allowed to complete the same task.

Contrary to the open trench installation of steel pipes, which are normally coated by PE (at 1,420 mm diameter x 22.7 mm wall thickness), steel pipes sheathed with glass-fibre were applied on the rammed road crossings. Three individual pipe strings, each with a length of 18 m, were welded together to make up the complete crossing length. An initial pressure test was carried out and then the pipe was placed on the prepared ramming base on site.

At the first crossing site, DALCAI utilised the APOLLO rammer model with an impact energy of 40,500 Nm. The compressed air was supplied by two compressors with 63 m³ and 45 m³ air flow rates respectively. Cotter segments are generally applied for these tasks, which prevent the product pipe from flaring during the ramming process, so that the pipes can be welded perfectly together face to face. Furthermore, the form of the cotter segments allows the strike energy to be transferred evenly into the pipe string. The four-part segments can be quickly installed and fixed in place. At the same time two HDPE pipes of ND125 were fixed into an appliance on the steel pipe. These pipes were pushed in with the steel pipe and used as a spare empty pipe and also for control cabling.
Above: Start of the ramming process.

Left: The installation process continues at a ramming speed of 40 m in 2,5 h.

The APOLLO ramming hammer was then placed in position and the compressed air supply set up to enable installation of the pipe string. A cutting shoe on the first pipe leading edge strengthens and protects the pipe wall during the installation process and minimises any casing friction occurring on the pipe surface. In the compact sandy soils of the site the casing friction was very high for certain periods during the ramming process. This did not however prevent a smooth pipe installation. The pipe string leading edge arrived on the other side of the road, surrounded by an alleyway of oak trees after only 2½ hours. The installation process was complete.

The site set up was then dismantled for transport to the next jobsite. This included the use of a high pressure jetting vehicle with 20 m³ volume capacity in order to remove the spoil from the ramming run out of the pipe. A jetting head bored through the soil in two steps, rinsing the sandy soil out of the pipe.

Soil removal using water. Final cleaning with flushing jets.

With an additional pressure test of the installed pipe string, which followed the ramming and cleaning, the bore installation was completed.

The ramming work was carried out in the following working steps:
- Welding the pipes together to produce one pipe string plus a first pressure test.
- Starting to operate the water container in a 4 m deep trench situated in groundwater.
- Installing the steel pipe, coated with glass-fibre inside the prepared trench.
- Preparing the pipe string by attaching the cutting shoe at the front of the pipe.
- Attaching retainer device for the carriage of two empty HDPE pipes of ND 125 (retaining control lines).
- Application of the 4 cotter segments for the even force induction and to prevent the pipe from flaring.
- Positioning the rammer with a base and connection of the compressed air via two compressed air hoses.
- Rinsing out the soil over 4 hours with 120 m³ water, pumped out of a nearby river and transported to the site on a trailer.
- After the complete pumping process and disposal of the rinsed out soil a final pressure test of the installed pipe string was carried out, which was then welded to the steel pipes in the open trench either side of the crossing.

The clean and pressure-tested steel pipe with accompanying pipes ready for being connected to the pipeline

All three installations were carried out in 3 successive working days, as the working sequence was co-ordinated in an exemplary manner and despite the multi-lingual team-work (Italian, German and Dutch) the work was carried out and completed in a routine manner.