QUALIFICATION OF SMALL TRENCHES FILLED UP WITH SELF-COMPACTING MORTAR FOR THE INSTALLATION OF GAS DISTRIBUTION PIPES

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ABSTRACT

The research for innovative solutions which would reduce the cost of PE pipe laying and increase safety standards is a strategic point for the development of gas distribution.

Laying PE distribution networks in shallow trenches (40 to 50 cm deep and 8 cm to 20 cm wide) filled up with a self-compacting concrete allows:
- to get rid of protective sands and ramming operations,
- to decrease the volume of transported soils, to ease and narrow network cartography.

With this aim in view, Gaz de France R&D Division and its partner ETDE—subsidiary of Bouygues—have set up a qualification procedure for the shallow trenches solution to meet the requirements of natural gas distribution standards.

This procedure includes:
- resistance to heavy traffic test,
- concrete dry-time test,
- shock resistant test,
- numerical simulation of ground soil movement.

The qualification process allows:
- in the short term to implement shallow trenches on experimental sites,
- in the medium-term to obtain permanent legal authorizations,
- in the long term to encourage French Road Administration to fully approve our specifications through a French standard “Shallow Trenches.”

The first experimental sites are planned for the end of 2005.
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**CONTEXT**

In a gas production context that is coming under increasing pressure from the competition, research into new definitions and solutions for gas distribution grids is of primordial importance. It could well allow a significant reduction in the cost of investments in work and customer connections while considerably improving the network safety level.

There are many possible lines of strategic research and much interest is being prompted by civil engineering procedures, in the present case, through the techniques of grid deployment in trenches, for which there have not been any significant breakthroughs over the last thirty years (except for the mechanized equipment which has changed on a formidable scale).

Starting from a conventional geometrical trench definition (trench bottom at 90cm and width included between 50 and 80cm), we imagined a series of small trenches (thickness <20cm and depth <50cm) produced by mechanical means such as a trench mini-digger of the same type as used for certain optical fiber networks. The second major originality of the process concerns the backfilling of the trench with alternate materials such as colored self-compacting hydraulic binders whose rheology is adjusted to ensure the self-centering of the pipe in the backfilled trench.

As analyzed and defined, this new laying technique offers the potential of the following significant improvements:

- increased speed of performance,
- elimination of the need to use quarry materials (sustainable development approach)
- elimination of compacting operations gaining time and abating noise (for nearby dwellers and operators),
- substantial decrease in the volumes of excavated material to transfer to the dump (sustainable development approach),
- improved definition of the mapping of new networks.

The vocation and the heart of the profession at Gaz de France is not to be a civil engineering contractor which is why an industrial partnership has been established with the networks, electrical and mechanical company ETDE, a subsidiary of the Bouygues Construction group. ETDE is in charge of setting up the formulation of the new backfill material and the process on the basis of recommendations and functional specifications defined by the Research Division at Gaz de France.

The effective adoption of this new laying technique, patented by Gaz de France and ETDE implies the setting up and development of an innovative qualification approach with regard to mechanical, chemical and technical criteria so as to measure them up against current trench definitions.

**QUALIFICATION TEST**

The various qualifications considered should produce a higher quality, or where applicable, equivalent quality in the new trenching system compared to the traditional solution.

In particular, attention will be paid to the problems of laying under roadways, the diffusion of heat, re-excavability as well as mechanical aggression due to third parties.

Strength tests under heavy traffic in conjunction with the LCPC at Nantes, simulating 150 HGVs/day for 30 years on a fatigue circuit made it possible to measure and confirm that:

- the forces induced on the pipe are low,
- there is no deterioration in the quality of service of the roadway,
- the theoretical life direction of the pipe is maintained.
Because the network is laid at a shallow depth, it might appear that the risk of third-party aggression is higher than for conventional configurations. The facts are quite different. The various full scale tests and the digital simulations performed underline at the least the protective effect of the layer of hydraulic binder with respect to conventional backfill.

Similarly, the inclusion of yellow coloring agents throughout the volume of the trench fill serves as an outstanding warning system.

The photos in figure 2 reveal the cases of mechanical aggressions tested by the solicitation of the trench:

- **static** – the bucket or tine of the machine comes into contact with the concrete and forces against it (figure 2a real trench and 2c in the laboratory),
- **dynamic** – the bucket or the tine strikes the structure with initial velocity (figure 2b).

Using a computerized tool demonstrates the exact protective role of the binder as shown in figure 3, where impact of around 140Mpa does not spread through the remainder of the structure. The hydraulic binder acts like a fuse, dissipating much of the impact energy and thus offering far better protection of the network compared to traditional methods.
The problem of re-excavability for subsequent action on the network was also investigated. For narrow trenches, the de-structuring of the system works essentially by a bending force (unlike traditional systems that are sensitive to compression forces). The direction of the research defines the criteria and experiment plans to test re-excavability properties (figure 4 a,b).

A doctor’s thesis concerning the specific problems of re-excavability with the “Laboratoire des Ponts et Chaussées” (Roads & Bridges Laboratory) in Nantes is soon to begin.

The nearness of the network to the surface raises the question of thermal transfer. To try and evaluate the temperature of the network, a simulation of the impact of the thermal environment of a PE pipe, with self-compacting mortar backfill, was performed.

Investigation into several thermal loading cases, hot and cold, (météo France weather data coming from records covering 20 years), plus two cases representing a heat wave and a period of extreme cold spanning 5 consecutive months was undertaken.
In all these experimental situations, the hydraulic binder backfill provides total protection from cold (normal and extreme) and normal conditions of heat. Under considerable thermal loading, the temperature levels affecting the pipe can reach 37°C.

**Figure 6: Minimum & maximum temperature levels calculated for PE pipes depending on geographical location of network and time.**

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**Recapitulation of qualification tests considered for new trench geometry**

**Perspectives**

This qualification phase is going to make it possible to:

- in the short term, validate the technique of small trenches backfilled with self-compacting mortar,
- in the medium term, obtain laying authorizations from the equipment ministries,
- in the long term, transform the experimental French standard for "Micro trenches"

The first experimental sites are scheduled for mid-2006.