

Development of Environmentally-Friendly Pipe Filling Material Using Industrial Waste

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In the course of industrial construction, such as the installation of underground power transmission lines, sludge and muddy water are generated as a side product. They are usually treated as industrial waste, and currently posing a serious problem of construction pollution. For environmental protection and expense reduction, Sumitomo Densetsu Co., Ltd. has developed a pipe filling material using the sludge and muddy water. The author reports on the development process of the material and current applications.

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1. Introduction

Environmental problems have attracted worldwide attention, and the recognition of their importance has risen through the newspapers and other media every day. In the construction industry, industrial waste resulting from civil engineering work has become a big problem, termed construction pollution. Construction sludge and muddy water resulting from construction or demolition are particularly difficult to treat and hardly ever recycled except for some practical cases. We had also disposed of these materials as industrial waste after the installation of our underground power transmission lines (**Photo 1**).

To turn this situation around, Sumitomo Densetsu Co., Ltd. focused on the recycling of muddy water. We aimed to develop a material that can meet the following three requirements:

- Recyclable as a filling material of installation pipes
- Makes a contribution to environmental protection
- Decreases construction costs

This paper details the development of the filling material. An installation project of underground power line conduits in 1997 is also introduced as an example in which the material was used in response to the request from an electric power company.



Photo 1.

2. Background of the Development

Installation of underground power transmission lines is required more and more for the increasing number of objects laid underground and is often restricted by traffic congestion on the trunk roads.

Back in the 1990s, there were many possible risks in the installation of long distance lines that exceeded 600 m. The filling process of conduits, in particular, involved problems such as higher costs than those of the conventional installation process and structural risks resulting from non-uniformity in the quality of filling materials. To overcome these problems, we initiated the development of a new filling material and filling methods. Our development targets were as follows:

- Capability of unprecedented long distance power transmission over 600 m
- Recycling the construction sludge generated by installation work

3. Electric Cable Conduit Used in Installation Work

In the installation work of electric power cables, electric cable conduits (UPFP pipes) are laid in the tunnel constructed, and cementitious material is injected to fill the space. The filling material fixes the electric cable conduits, allowing them to radiate the heat from the power cables.

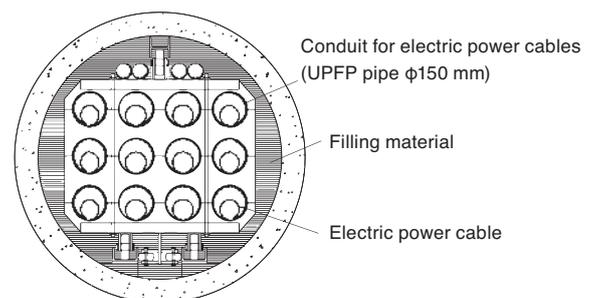


Fig. 1. Conduit cross section

4. Understanding the Muddy Water Treatment Process and Selecting Material for Filling

Generally, surplus muddy water is collected from several construction sites and accumulated in one place. The collected muddy water then undergoes the sludge treatment process through complicated classification detailed in Fig. 2. After careful consideration, we chose the dirt processed by a vibration separator (particle diameter $\leq 74 \mu\text{m}$) as the filling material. (Hereafter, the processed sludge is called slurry stock solution.)

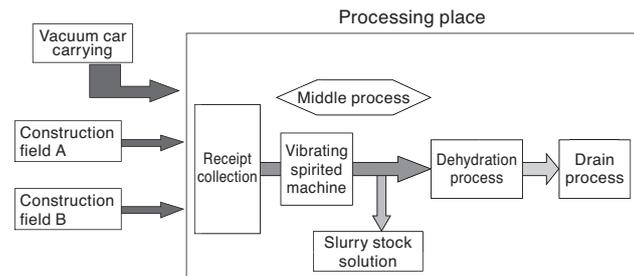


Fig. 2. Processing flow of construction sludge

5. Establishment of Quality Control Criteria for Slurry Mortar

As the slurry stock solution contains various construction sludge accumulated from different construction sites, its quality is unstable. To make the quality level of the slurry stock solution stable, we mixed the slurry stock solution with cement and evaluated the quality of the solution. We confirmed that slurry mortar can be generated with constant quality, and accordingly set criteria for the types and compositions of the additives.

6. On-site Verification Results

The results of on-site verification tests (conducted in 1999) show that the developed slurry mortar is feasible with excellent qualities and cost effectiveness. The details of the results are as below:

- (1) Force feed distance: $L = 617.5 \text{ m}$ (Force feed from one side)
- (2) Diameter and material of pipe: $D = 1,650 \text{ mm}$, Hume pipe
- (3) Amount of slurry mortar filling: $Q = 952.1 \text{ m}^3$ (bleeding 2%)
- (4) Uniaxial compression strength: $F = 0.166 \text{ N/mm}^2$ (at material age 28 days)
- (5) Cost comparison: Conventional construction unit price/new construction unit price = 100/70

7. Registration for the New Technology Information System and Patent Application

We had accumulated a wealth of experience from working with electric power companies using this industrial method. With a view to using it in public and civilian works, we applied to the Ministry of Land, Infrastructure and Transport (MLIT) in order to register for the New Technology Information System (NETIS). The application was approved in 1999 and the slurry mortar was adopted in 2003 for the first time to the waterway abandonment pipe filling construction led by the MLIT.

8. Shift in Usage of the Filling Material

Since the registration of NETIS, we have received increased inquiries from consultant companies. In their line of work, the material we developed is used to fill in unused water supply pipes and drainage pipes to prevent ground subsidence. This is different from the purpose for which the material was originally intended.

As shown in Fig. 3, we initially received a lot of orders from electric power companies who conducted filling construction work for the installation of electric power conduits. However, due to the reduction in capital investments by electric power companies to power supply constructions and the effects of the NETIS registration, orders from consultant companies increased, and accordingly the ratio of public construction increased (Fig. 4) Along with the shift in purchasers from electric power companies to local governments, the usage increased for filling water supply pipes and drainage pipes.

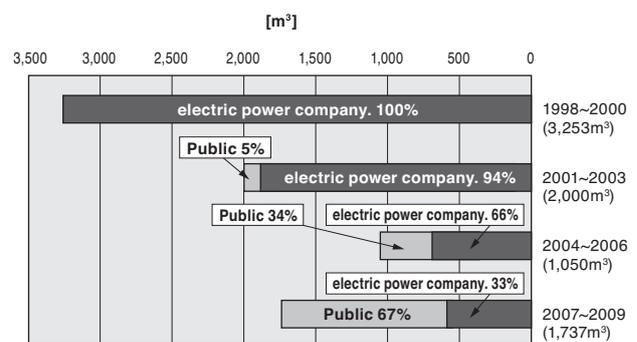


Fig. 3. Ratio of order source

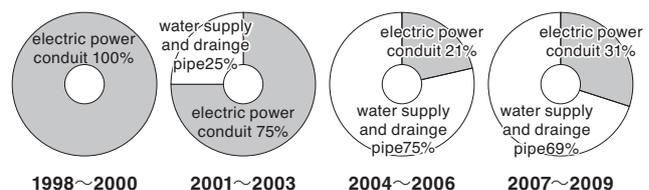


Fig. 4. Shift in ratio of construction types

The shift in the use of the slurry mortar is attributed to the following features of the material.

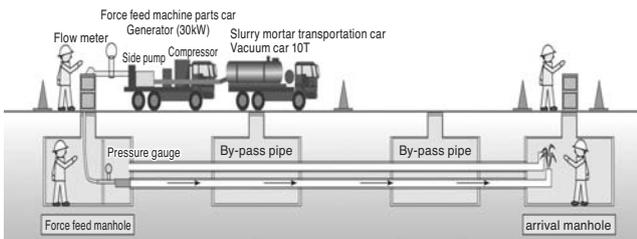
- (1) The force feed distance is longer than that of conventional filling materials.
- (2) Decrease of ancillary work due to the reduction in number of middle length holes
- (3) Decrease of manhole (middle part) installation
- (4) The ability of filling a day increased by 3-4 times
- (5) Ideal as filling material, showing less bleeding

With the above-mentioned features, construction budgets are reduced and work schedules are shortened. Accordingly, traffic jams are reduced and traffic environments in the resident areas are improved. Moreover, as the slurry mortar is recyclable, it can contribute to the environmental conservation, which has been a key idea in modern society.

9. Establishment of Filling Method

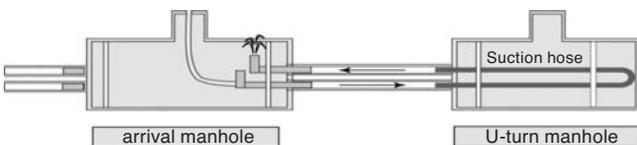
Taking advantage of the fluidity of the slurry mortar, we established a filling method to meet the customer needs for reducing construction loss.

(1) Continuous filling method



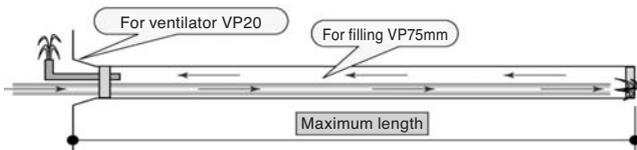
The method requires a small construction area, and is therefore suitable for roads where traffic is heavy and manholes cannot be left open.

(2) U-turn filling method



The method fills a conduit with two or more holes at a time, and is therefore used for places which cannot be closed.

(3) Back filling method



The filling method used when the conduit is blocked.

10. Conclusion

Since the development of slurry mortar, 12 years have passed. Although the approach of recycling construction sludge was not common at that time, a lot of industrial methods and materials have been established since then for recycling the sludge and are used effectively in various fields. The slurry mortar has only limited use, such as filling water supply pipes and drainage pipes. However, we will continue improving the material and industrial methods thereof to find new applications.

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