The Snake-Mixer Method was developed as a means of recycling dredged soil. This method hardens dredged soft soil into a material ideal for land reclamation.

The mixing process is carried out during the conveyance of stabilizing agent injected into the soft soil in pipeline. The newly developed Snake-Mixer facilitates the mixing of soft soil and stabilizing agent by making use of its configuration.

Before the development of this method, the hardening of dredged soft soil required the use of special mixing-plant vessels. With the Snake-Mixer Method, however, existing pneumatic conveying vessels as well as ordinary equipment and facilities can be utilized to simplify the mixing process.

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The basic component of the Snake-Mixer is 180-degree curved pipe. By connecting a number of curved pipes and varying their diameters, curvatures, and connection angles, a variety of shapes can be obtained. Thus, the optimum configuration can be achieved for conveying soft soil over a specified distance.

Inside the pipeline, where pneumatic conveyance takes place, soil alternates with compressed air, generating a two-phase gas-liquid flow (plug flow). As the plug flow passes through the Snake-Mixer, it is forcibly agitated up and down as well as left and right, mixing the soft soil and stabilizing agent together.

**Characteristic**

The Snake-Mixer Method enables the production of homogenous hardened soil as a mean of recycling technology for dredged soil and enables dredging, hardening, conveyance, and reclamation to be combined in a single integrated piping system.

1. Enables the effective use of dredged soft soil.
2. Enables the production of homogenous hardened soil and enables faster use of reclaimed land, because it does not require any improvement of the ground after reclamation.
3. Can be used with existing pneumatic conveying vessels and ordinary equipment such as concrete pumps.
4. Can be used for small-scale works as well as massive works and long-distance conveyance.

**Practical example**

**Operation on Water**

**Operation on Land**

**Actual result of works**

1. **Conveying Field Test of Dredged Soil**

   In order to verify the long-distance (1000m) conveying capabilities of the pneumatic tube mixing methods and the possibility of obtaining improved soil of uniform low strength (qu28 = 30 KN/m^2 or above) by adding a small quantity of stabilizing agent, a field test was conducted using three such methods including the *Snake-Mixer* Method. In this test, it reveals that mixing capability was satisfactory for all cases and soil was successfully conveyed over a distance of 1000m. (1998, Jun.~1998, Sept)

   - Type of soil : Silt & clay content 70 % (natural moisture content : 110 %)
   - Stabilizing agent volumes : 50, 60, 80 kg/m^3

2. **Fushiki Toyama Port (Fushiki District) Dredged Waterway (-2.1~−10.0m)**

   Based on the result of the pre-test, the main project was carried out. Soft dredged soil was loaded from the quay, was to mix and harden by the *Snake-Mixer* Method, temporarily retained on a disposal land 1000m away. (1998, Sept. ~ 1999, Mar.)

   - Type of soil : Soft clay & clay with sand (natural moisture content : 120 %)
   - Stabilizing agent volumes : 60 kg/m^3
   - Volume of cement treated dredged soil : App. 27,000 m^3
Target unconfined compression strength: $qu_{28} = 30$ KN/m² or above

3. Covering the back side of a stone embankment foundation in the 3rd Island of the Nagoya Port.

The purpose was to prevent any outward leakage of muddy water contained in the soft dredged soil used to fill the backside of the embankment of a disposal pond. (1999, June 11–1999, Oct.)

- Type of soil: Clay (silt & clay content: 85%, natural moisture content: 120%)
- Stabilizing agent volumes: 80 kg/m³
- Target unconfined compression strength: $qu_{7} = 400$ KN/m² or above
- Execution extension: 570 m
- Volume of cement treated dredged soil: App. 23,500 m³

**Improvement effect of the Snake Mixer Method**

We examined the improvement effect of the Snake Mixer Method in divers ways the Snake Mixer was used, the improved effect was satisfactory.

The intended effect was confirmed by comparing the unconfined compression strength of this mixture with that of samples that had been fully mixed in a laboratory. We found that, strength rose by more 30% when the Snake Mixer was used.

Also, we found that, strength rose by more than 30% when the Snake-Mixer was used; and that the mixing effect was satisfactory irrespective of the volume of stabilizing agent added. (1997: The result of experiment conducted to confirm the method)

**Mixing Effect of the Snake Mixer**

<table>
<thead>
<tr>
<th>Without Mixer</th>
<th>With Mixer 50kg/m³</th>
<th>With Mixer 100kg/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strength ratio (%)</td>
<td>68%</td>
<td>101%</td>
</tr>
<tr>
<td>Average strength (%)</td>
<td>98%</td>
<td></td>
</tr>
</tbody>
</table>

**Deviation strength of stabilized soil**

It reveals that mixing capability was satisfactory and the strength distribution was small, when the stabilizing agent volume added changes. (1998: The result from field test using carrying vessel of dredged soil.)

**Deviation strength of ground depth direction**

A cone-penetration test (conducted to assess changes in the depth strength with time of the treated soil) indicated that strength rose at a certain rate over time, and that a good mixing effect was attained with no partial change of strength.