



HCI PUIF Method

The PUIF is a method to grout the chemical material to improve the ground condition in a weak and fracture geology. Normally, there are two kinds of improvement could be achieved. First is to increase the unconfined compressive strength (q_u) of the soil by occupying the space of the gap after congealed. Second is to decrease leakage of the soil layer by disturbing the channel of water flow and thus obtaining the water proof effectiveness.

The broad area water leakage in tunnel during excavating will lead to the ground soften and cause a deflection or as a worst result of collapsing. The PUIF method is designed and developed to cope with situation which the cement or silicate grouting is still not able to deal with. The method can effectively improve the ground condition and prevent the possible interruption of the follow-up work due to the unstable geology.

Depending on the ground condition, it's chemical material can be grouted through the pre-poling steel pipe or the self-drilling rock bolt.

- **When borehole collapsing is unlikely to happen and a borehole is pre-drilled**
 - Grouted through pre-poling steel pipe with external diameter 1" and wall thickness 2.8mm, material standard according CNS 2056 G3030 (Medium) and test proved by CNS 2111 and CNS10006.
 - Grouted through the PVC pipe. The front end with closed sharp cover of steel pipe, 4 hole with 8mm diameter drilled on the pipe body, 1st hole is located 8cm from the front of pipe, and drilled one hole with 90 degree rotation for each 25cm.
- **When borehole collapsing is likely to happen**
 - The chemical material is grouted through the self-drilling rock bolt so as to reduce the failure rate of installation and save the processing time. The length of the self-drilling rock bolt is 3 meter and the body of the bolt needs to be pre-drilled with 13 holes. The first hole is located 30 cm from the bolt head and the other 12 holes will be drilled with the interval of 20cm from the first hole. No hole allowed to be drilled within 50cm from the bolt end to avoid leakage when grouting.
- **The mostly used grouting material in PUIF method is PU or Silica resin, both of them contain solution A and B**

- **PU resin**

Introduction

The grouted PU resin can offer a strong confined force between the rock layers and increase the internal stress within the rock layers. Therefore, the rock layer can be kept in stable status and the tunnel can be protect from possible collapsing.

The coagulating time of the PU resin could be easily adjusted to meet the requirement of different areas where the ground condition needed to be improve. This is the advantage which the regular cement grouting doesn't possess.



Main Advantages

- Rapid coagulating time allowing the follow-up excavation can be progressed without interruption
- Grouting as needed, can solve the leakage problem immediately
- Can be grouted effectively in the area needs to be improved
- Function well even if it is working in the water
- Completely comply with environmental regulation and has better endurance than other grouting material

| Technical Data | | |
|-------------------------------|----------------------------|--------------|
| Appearance | A liquid | Light yellow |
| | B liquid | Dark brown |
| Viscosity (at 20°C) | A liquid | 900±100cps |
| | B liquid | 150±20cps |
| Specific Gravity (at 20°C) | A liquid | 1.052±0.03 |
| | B liquid | 1.236±0.03 |
| Reaction time (at 20°C) | 10 seconds±5 seconds | |
| O3 | N/A | |
| Flammability | N/A | |
| Expansion | 15 times | |
| Reacting temperature | 100°C | |
| Uniaxial Compression strength | 42kg/cm2 | |
| Mixed ratio | 1 : 1~1.2 (weight ratio) | |

■ **Silicate Resin**

Introduction

In tunnel construction, it is normally to encounter some worse geology conditions such as high groundwater, leakage in tunnel, sand layer with bad cohesion, sand leakage with water layer, fracture layer and etc. When the regular supporting methods like rock bolt, shotcrete, and etc. couldn't provide a effective support, the Silicate Resin, with high penetrability and well water interruption capability, can be used to heal the loosen geology and stabilize the excavating area to allow the follow-up activity to be continued.

| Technical Data | | |
|-----------------------|---------------|------------|
| Viscosity (at 20°C) | A liquid | 60±10 cps |
| | B liquid | 140±20 cps |
| Time of hardening | 40 sec±25 sec | |
| Expansion | 15 times | |
| Mixed ratio | 1 : 1 | |

■ Resin Injection Pump

| WILLICH 2KB Mobile | | |
|--------------------|--|---|
| Power | Air compression mobile | |
| Specification | Air flow power | air compression 7N/m ³ /min, 8 kw |
| Weight | weight | 125 kg |
| Volume | A&B liquid | 30 d m ³ |
| Grouting ability | flow pressure | Max 20 d m ³ /min Max 180 bar |
| Property | Using the flow switch to tune the flow rate, therefore the inject velocity can be controlled. When inject pressure is too over, it could slow down the flow rate and get well accuracy control. | |

■ Selection of grouting material

| Comparison of function of grouting material | | | | | |
|---|--------------------------------|---------------------------|---|---------------------------------|---------------------------|
| Material | HCI-FCU PU | Cement Bentonite | Quickly hard Cement combination material | Special quickly hard cement | |
| Permeability | Excellent 80 MPa.s 25°C | Good W/C=100% | Excellent 14 MPa.s | Worse 1800 MPa.s W/C=100% | Worse W/C=100% |
| Combination reaction time | Adjustable 10~15sec | Fixed | Adjustable 30~300sec | Adjustable 60~120min | Adjustable 90~120min |
| Single compression stress (kg/cm ²) | 42 (5 min) | 0.3 (1day) 1.0 (3days) | 1.3 (1day) 2.0 (3days) | 0.9 (1day) 3.0 (3days) | 1.0 (1day) 3.0 (3days) |
| Work ability | Tunnel working team | Tunnel working tem | T Tunnel working team | Tunnel working team | Tunnel working team |
| Application in water | Yes | No | No By condition | No By condition | No By condition |
| Grouting management | Yes By interval grouting | No | Yes By interval grouting | No | No |
| Flow scope | Small | Large | Medium | Medium- large | Medium- large |
| Limitation of Improvement | Yes | No | Yes (partial) | No | No |