TamPur Injection System for Handling Water Ingress in Tunnel and for Soil Stabilisation

In drill & blast tunnel excavation contract of the face many unknown challenges, which affect badly the overall safety and progress of tunnel excavation projects. One of the largest problems in tunnels is uncontrolled water ingress.

Two of the biggest risks are:

- Immediate flooding of tunnel
- Ground collapse associated with water ingress

Such incident can be avoided by doing pre-injection in tunnel using appropriate Polyurethane or other injection grouting system. Pre injection is always safe and less costly and can be planned and done in advance if One has prior information on the presence of water bound strata along the tunnel axis of excavation.

Pre-injection is done from the tunnel face and for a specific distance ahead of excavation face into the soil along the tunnel axis and into its overburden to stabilise the soil and to create an impervious layer so as to block the easy passage of ground water ingress into tunnel.

The main goal is to seal overburden soil, rock mass before excavation

- Secondary effect is stabilization
- Pre grouting is mainly used in conventional tunneling (drill & blast)

Post-injection in necessary to handle any water ingress or for soil stabilisation and it is done somewhere behind the tunnel face or at face , location after any collapse. Post injection is more costly than Pre Injection .

Situations in which pre-injection is particularly cost-effective:-

- Planned water ingress elimination/ reduction in water bearing rock or strata
- Ground zones with fractured or weathered rock as well as unconsolidated soil or sand

Situations in which post-injection are widely in use (and planned for):-

- Rehabilitation injection (improvement of old or collapsed underground structures)

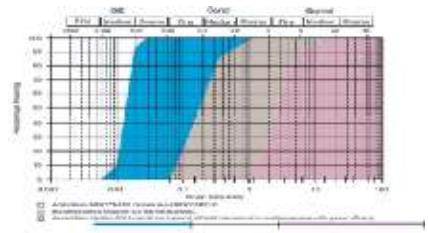
Situations in which post-injection become a necessity due to unforseen circumstances:-

- Uncontrolled water ingress due to the lack of probe - drilling & pre-injection

Post Injection is usually between 10-50 times more expensive than Pre – Injection!!

Selection of any Injection materials governs by the following ground conditions in any Tunnel :-

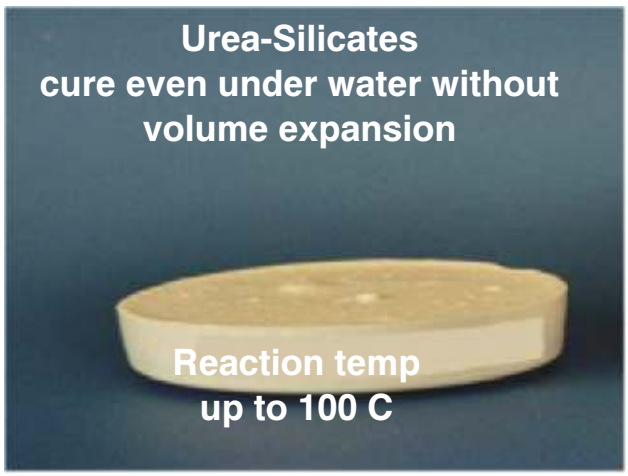
- Permeability of soil and its capacity to intake grout materials
- Fractures content and width of fracture
- Grain size distribution of soil
- Water content inside soil and flow or discharge of water



- Water pressure at which it is leaking
- Temperature inside tunnel or temperature of water

Based on the above criterias any injection product has to be selected. However, grouting materials should be judged after knowing its following important properties.

- Injection materials - its generic name and type
- Mixed viscosity, flow for both chemical and cement based grout
- Hardening time or gel time specially for post injection to seal any water ingress
- Expansion in contact with water specially for PU injection system
- Adhesion properties with soil, rock
- Grain size (just for cement, d_{95})



Grouting materials available for use in such situations are:

- Microfine cements
- Polyurethane (PUR) resins
- Acrylic resins
- Colloidal silica

PU Injection resin (selected type) can have following uses in UG construction and for other geo technical problem solving:

- Stabilisation of all rock, coal, sand, gravel and concrete materials
- Stabilisation of convergence
- Stabilisation of caved material
- Pre injection into faulted zones to secure before advancement
- Primary and secondary support injection of any type of cable bolt, spiling bar or Irma bolt etc
- Anchoring and securing
- Slab jacking/lifting
- Stopping water ingress

TamPur 100/120/122/125/130 (Pure PU) are such material which has following technical properties and recommended for use in rock, soil stabilisation in Tunnel

- A flexible or rigid material that may foam to fill larger cracks and voids and achieves a good bond strength
- When pumped under pressure a migration of up to 10m can occur
- Foaming rates of between 1-30 times its volume can be achieved to suit specific applications
- Foams in contact with water ideal for large water stopping projects
- Ability to inject through any style of bore hole packer or bolt
- Variable reaction time from 30 seconds to 1 hour
- Can be made fire resistant

All PUR-based system produce effect of self-injection but only for 2-component systems this behaviour can be effectively utilized. Carbon dioxide can generate pressure of up to 20 bars, therefore PU choice must be for use in weak rock and structures.

Injected liquid resin expands further under CO_2 pressure. A closed cell foam is formed securing penetration and mechanical strength.

There is another variety of Polyurethane resin system which is a silicate modified solvent free rapid hardening and strength gaining PU resin which is used for soil, rock stabilisation and thus can ensure rapid stabilisation of overburden mass in tunnels during excavation.

Its Major Benefits:

- Water does not influence curing reaction
- Reaction temperature mostly below 100°C
- Does not readily decompose in soil & water
- Void free solid PUR can stand compression up to 70 MPa
- Liquidsandsolidsfireretardant
- Suitable as cavity filler in foamy state
- Suitable as rapid anchor in gresin
- Adhesion under water only under pressure min. 2 bar
- Plasticity starts at 90°C
- Bolt fixed by grouting TamPur 116 PU injection resin
- Simple mix ratio 1:1 by volume
- Flexible deforms under compression and recovers
- Can penetrates cracks of 0.1mm up (very low viscosity)
- Good adhesion to dry or wet substrates
- Fast reaction of 30 -180 seconds even under water
- Lower exothermic $<$100oC
- Fire resistant. Does not propagate fire
- Environmental and user friendly

Use of the above said PU Injection in under ground tunnelling & mining is aimed at specific problem solving and it can be used in any tunnel both for Pre Injection and for Post injection . The Hybrid variety is not so costly than pure PU and thus it can save time and money for tunnel construction by solving specific geotechnical problem . □

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