

**Titolo della tesi:** Evaluation of Jet Grouting parameters by review of production parameters, Monitoring data and Quality control" - Undercrossing Tunnel of Isarco river (BZ, Italy); Rastatt Tunnel (Germany)

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The main purpose of the thesis is the *Quality Control* of two jet grouting works, designed for the waterproofing and consolidation of two tunnels: *Undercrossing of the Isarco river* (BZ, Italy) and *Rastatt Tunnel* (Germany).

What the terms involved in the title meant?

**Production parameters:** Jet grouting parameters (air and mixture pressure, rotation and lifting speed, air and mixture flow rate), the drilling and jet grouting depth (length), jet grouting nozzle diameter, number of jet grouting nozzles; **monitoring data:** Jean Lutz Tigor data, Jean Lutz Jet grouting recorded, TEMP jet, mechanical diameter control by colored steel lances; **quality control:** analysis of the spoil and backflow quality, deviation percentage between the reference (theoretical) values and the operational, results core drilling, optical review of core boxes, overlap of jet grouting columns, Auto CAD evaluation of Tigor data, evaluation of Temp jet, theoretical calculations of jet grouting energy.

The quality control could be said is the second main step in this kind of works, because the first are the surveys in the area in order to carry out the basis on which apply the work.

**The first field trial** is divided mainly in the steps:

- **Phase I:** the purpose is to establish jet grouting parameters to be able to grout different columns diameter (10 trial field columns) and it also included the realization of the columns for the side wall and bottom plug of the foundation shaft of the west shoulder of the temporary Isarco bridge.
- **Phase II:** the aim is to test the quality of the jet grouting treatment in greater depths (where there is more dense soil, fine grained as silty sand, than in the superficial layers as it is clearly shown in the geological surveys) than those tested in the phase I. It includes the realization of three overlapped columns "a rosetta".

- **Phase III:** it was not initially provided in the executive project. As first, it was provided the execution of only one column named J4 and then, also another one was executed, named J5.

For all the columns of the different phases, the Jean Lutz parameters are calculated, coherently with the unit measures of the reference parameters: a geometrical proportion was made and the parameter was found. In particular they were deeply studied the jet parameters: *rotation and lifting speed; air and mixture flow rate; the amount of cement*. The calculation of *the deviation percentage* between the reference parameters and the operational is done in order to study how much they are corrected and, for the columns those present values over the limit (lower or higher), is explained the thought reason. It was chosen to evaluate *the energy given at the nozzles* through the theoretical equation of Croce et al. (2000). Other quality controls are reported as: *manual measurement of the diameter* (for the 10 trial field columns); *the visual inspection; core drilling* (with the measurement of the reached diameter); *"colored rods"* method with the same aim as before; *temperature method (TempJet)*, with the same aim as before.

**The second field trial** (columns made for the consolidation of the stopping block for the TBM) shows the same quality controls of the previous one, with the important addition of the *compressive strength test* and also with a *frequent check of the density and viscosity of the grout*.

The *Quality Control*, that comprehends all the previous points, may invest a major role in the evolution of the Jet Grouting technique because it is a pretty cheap solution, useful to the quality of the treatments itself and because it could lead, as in the involved two cases, to an important knowledge and improvement of the works.

*What could and should be an improvement of the quality control of the jet grouting structures?*

In the case of heterogeneity in the soil layers, as in the studied field trials, a simultaneous comparison between the final columns (by the pictures), the geological surveys and the revision of the production parameters, could lead to an **economic gain** on the high number of cores (as was done for the Phase II and III of the first case of study and the second) and also to **saving time** about the remade of the poorly executed columns, without wait the intake of the cement mixture in the soil. **The limit** of this suggestion could be that is not insured that the good quality of the production parameters are necessarily synonymous of a good treatment: in fact in the Phase II and III of the first case of study, despite the good quality of the production parameters, was carried out by the core drilling no trace of jet grouting in depth bigger than 21 m.