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Inspection of an unlined pressure shaft – a true story

EWG Workshop Milano 03.11.2022,
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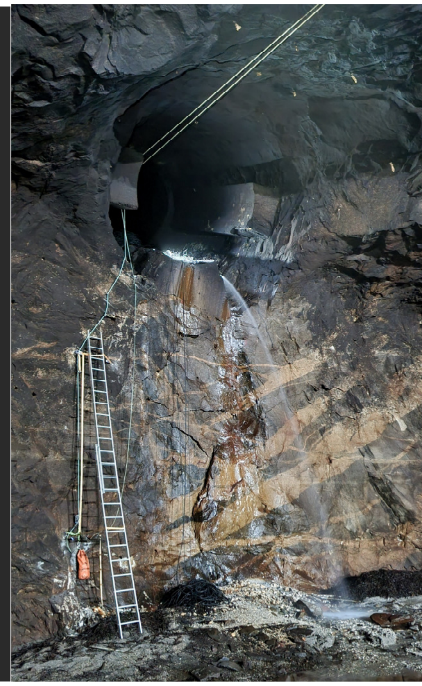
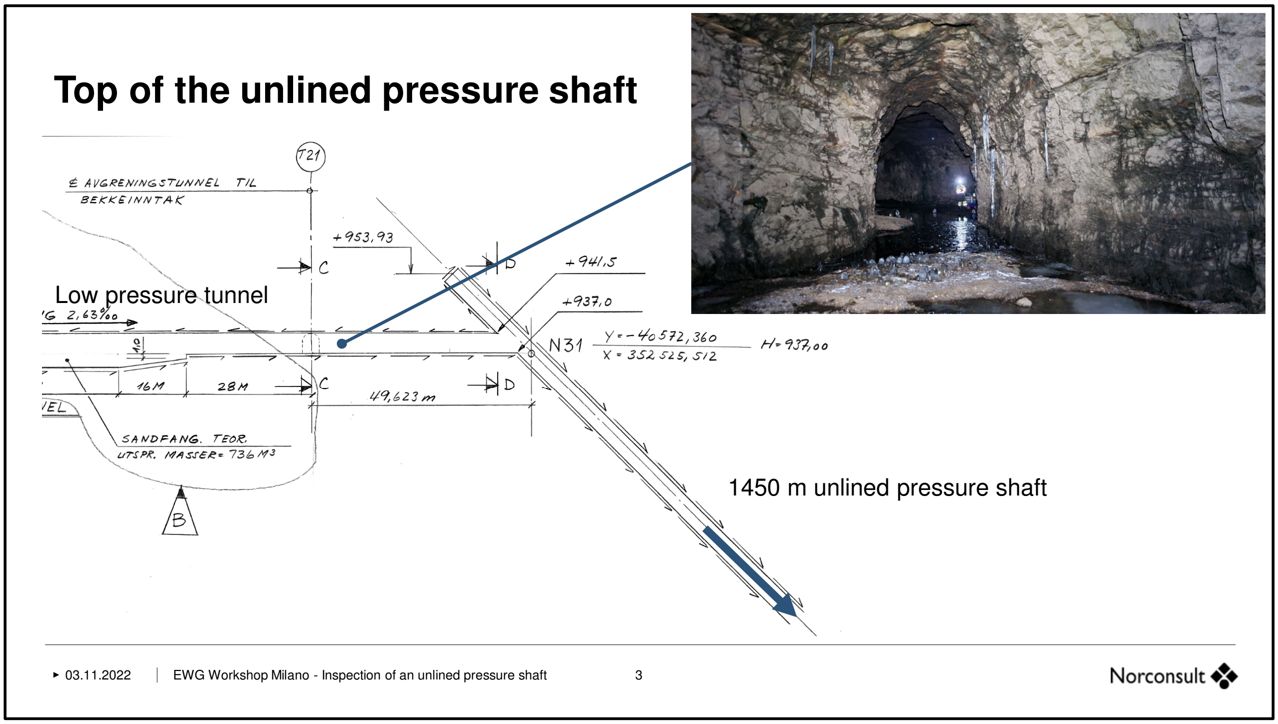
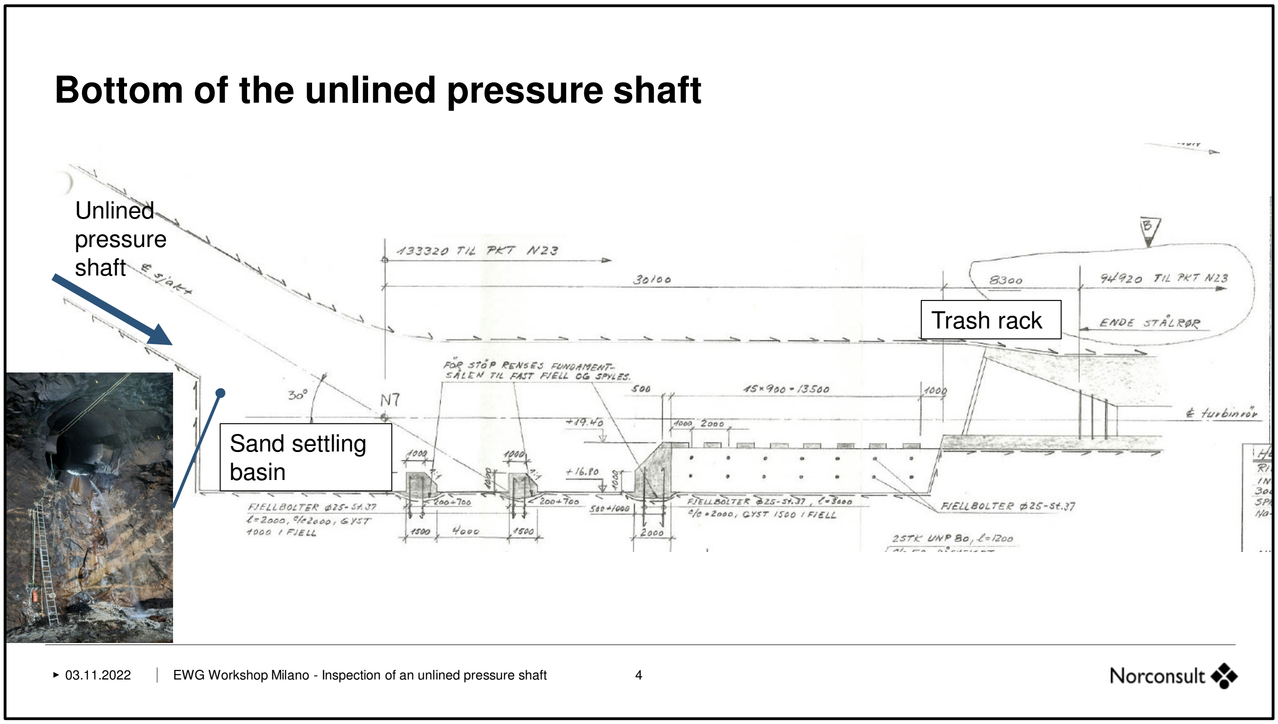


Top of the unlined pressure shaft
Water droplets gushing upwards due to leakage water into the shaft and the chimney effect



TBM drilled, unlined pressure shaft built 1987-88
Diameter Ø3,2 m, inclination 50 degrees, length 1450 m
Max water pressure at bottom almost 1000 mWc (unofficial world record at the time for unlined pressure shafts)



Trash rack in the bottom of the unlined pressure shaft.
There is also a large silt and sand settling basin.
Access to the sand settling basin is from the downstream side through the steel penstock, and a «door» in the trash rack.
Trash rack size: Height 4,5 m, width 5 m, steel, with middle support.
Steel penstock diameter Ø1,6 m, embedded in concrete.

Installed capacity of approximately 100 MW in the power station

Why inspect the pressure shaft?

- Condition assessment
  - Can the trash rack be removed?

Trash rack

- Draining the shaft is risky
  - Rockfall

- Draining the shaft:
  - Draining takes a lot of time and is vulnerable

Drainage valve

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The owner wanted to know the actual condition of all the parts of the water way to the power plant. This is important due to the availability of the plant, and insurance.

Emptying/draining the shaft increase the risk of failure every time. Draining changes the steady state of the pressure distribution in the rock surrounding the shaft. The high pore pressure in the rock acting on the empty pressure shaft pose an increased risk for rockfall and negative influence of concrete structures.
And the draining and filling procedure itself takes several days/weeks, a lot of planning, resources and people, and is vulnerable due to only one (highly strained) drainage valve.

The trash rack in the bottom of the shaft clogs up with organic debris over time. It is not dimensioned for more than 10 m pressure difference. The pressure difference measuring system is unpolite. Thus, the trash rack has been cleaned approx. every 5-10 years. The owner wanted to investigate if the trash rack could be removed, so that the inspection and cleaning intervals could be significantly increased to reduce the need for draining of the pressure shaft.

Challenges

- Remote access in the mountains
- Wintertime!
- Health and safety for inspection personell
- Preparing for the unknown
- Communication in the shaft

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The remote access up in the Norwegian coastal alpine mountains above 1000 m.a.s.l with no road access meant wide usage of helicopter, and snowmobile for local transport on the mountain. The weather turned bad during the 5 day long excercise and complicated the logistics.

Wintertime operation and inspection was decided due to the power plant’s production planning. The whole water way had to be drained and emptied due to rehabilitation of the main inlet valve inside the power house, so the shaft was empty and available for inspection

A video camera was sent down the unlined pressure shaft first. The video did not show anything due to moist conditions in the shaft. Thus, the personell entering the shaft did not know what to expect. In addition, the drawings of the water way system was inconsistent.

How to inspect the pressure shaft?

- Manual vs camera inspection

- Quote from the engineering geologist:
- *«Video inspection may discover if you have a problem.*
- *If you cannot see any issues by video inspection this does not prove that you do not have a problem»*

Manual inspection was chosen, with experienced Engineering geologist; Rope access with rockfall guard was chosen, because this is possible to excecute within reasonable limits and measures. Steel wire and proper personnel carriage requires lifting equipment certification and CE.

An experienced access specialist company called Vertikal Service was used for access.

The personell carrier was manuevered from the brink at the top of the pressure shaft. Communication from the shaft to the top was chalenging, several technologies was used (Yagi, VHF radio, telephone with cable).

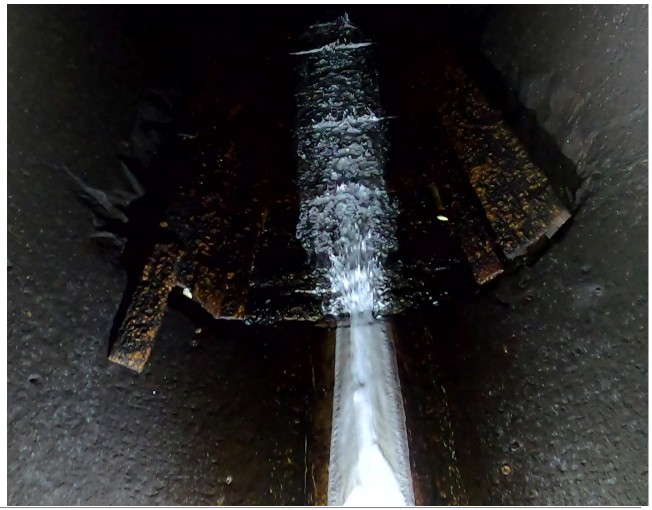
Findings from the manned inspection

450-500 down the shaft

Approx. 450-500 m down the unlined pressure shaft the personnel carrier got stuck in a weakness zone/large crack. The crack exhibited loose rocks and silt. The Engineering geologist managed to loosen some of the rocks, and took silt samples for further studies in the lab. It was a crack in the upper part of the shaft as well.

It was decided not to enter further due to the risk of falling rocks, so the mission was aborted and the personell returned to top shaft.
In addition, the communication was challenging.

Findings from video inspection



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After the manned inspection was aborted, a second round of inspections was performed. A camera was again sent down the whole shaft, on wheels. The video quality was highly improved as compared to the first camera inspection by closing the air inlet at the bottom (reduced the moist in the air significantly), and installing 11000 lumens of light and four go-pro cameras to a tripod centered in the shaft. This inspection was only possible because the narrow path in the bottom of the shafts diameter was relatively smooth and free from major weakness zones/cracks.

The picture of the water flowing over steel bars is taken by the camera at approx. 1000 m down the shaft. The steel bars cover a hole/niche in the shaft made due to maintenance (gear breakdown) on the TBM during excavation. The hole/niche was known before all inspections started, but it was unknown how or if it was covered.

In the remaining part of the shaft, the video inspection did not reveal any visible challenging areas of importance

Conclusion

- The combination of manual- and video inspection was valuable
- The power plant owner now know the condition of the shaft
- The upper half of the trash rack was removed
- The intervals for inspection and cleaning of the trash rack can now be much longer than before

The combination of manual and video inspection proved valuable for this particular condition assessment. The engineering geologist got a good overview of the situation due to the manual inspection for approx. 1/3 of the unlined pressure shaft. And got to investigate on site the most (and only) severe weakness/crack observed.

The video inspection of the remaining 2/3 of the shaft did not show weakness zones or cracks of substantial size, thus it was concluded by the Engineering geologist that the whole shaft was in an adequate condition. Possible minor rockfall will settle in the sand settling basin. The owner now know the condition of the shaft.

The bottom half part of the trash rack was left as an additional safety measure in the unlikely event of large rock fall from the shaft filling up the sand settling basin. Even if this part of the trash rack clogs up with debris, the open upper half ensure that the pressure difference over the trash rack will not be an issue. This means that the power plant owner can significantly increase the time interval between draining of the shaft (anticipated to possibly 20-25 year intervals instead of 5-10…)

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Hver dag forbedrer vi hverdagen