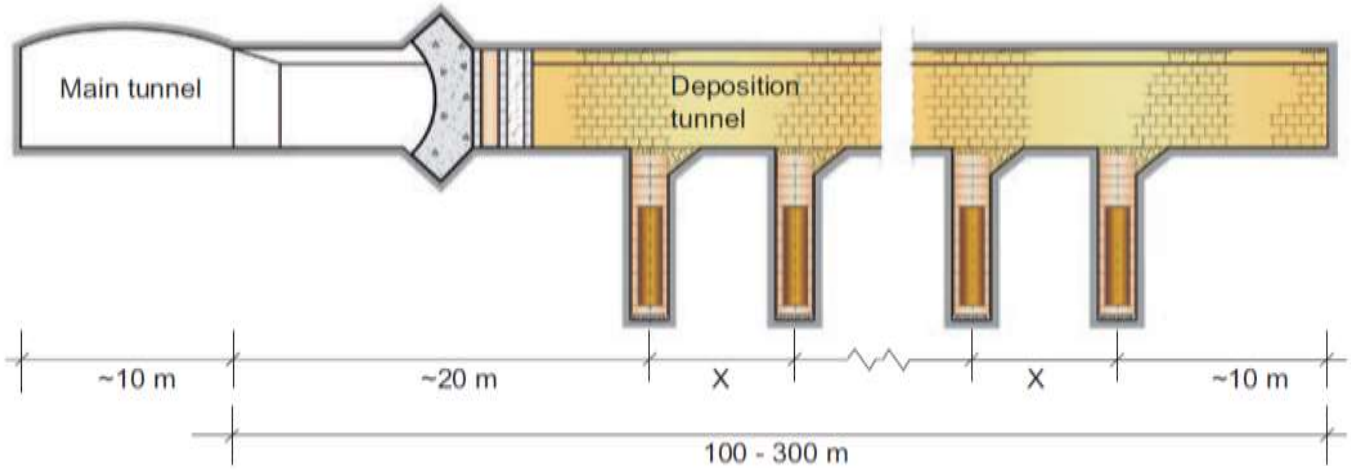
Wire sawing of KBS-3V deposition tunnels

Stig Pettersson SKB

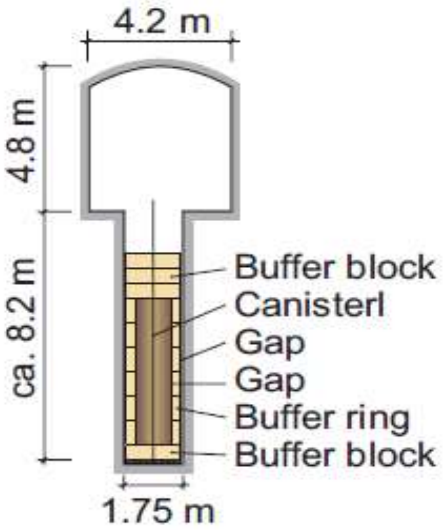
Content of the presentation

1. General information about the KBS-3V deposition tunnel
2. Different methods for deposition tunnel excavation
3. Testing of wire sawing technology in the City Line in Stockholm (SKB report R-14-08)
4. Testing of the new generation sawing equipment in a quarry in Lysekil, north of Gothenburg
5. Evaluation of the result from testing the new equipment and estimations of future production rate and costs
6. Planning for new filed testing for drilling and sawing equipment including testing of new drill plans for blasting
7. Discussions and conclusions

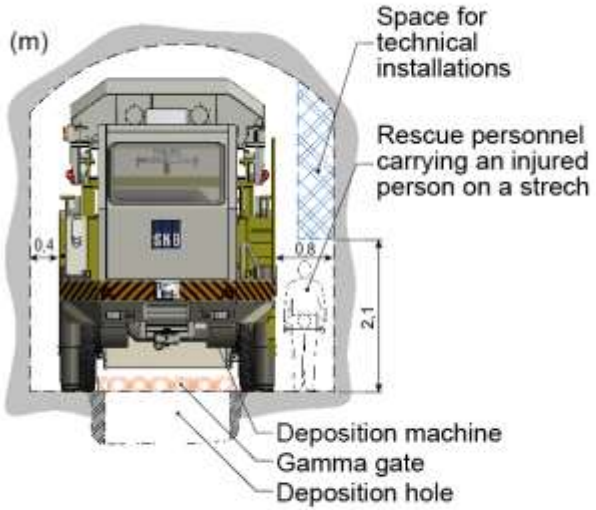
Main dimensions for KBS-3V deposition tunnel

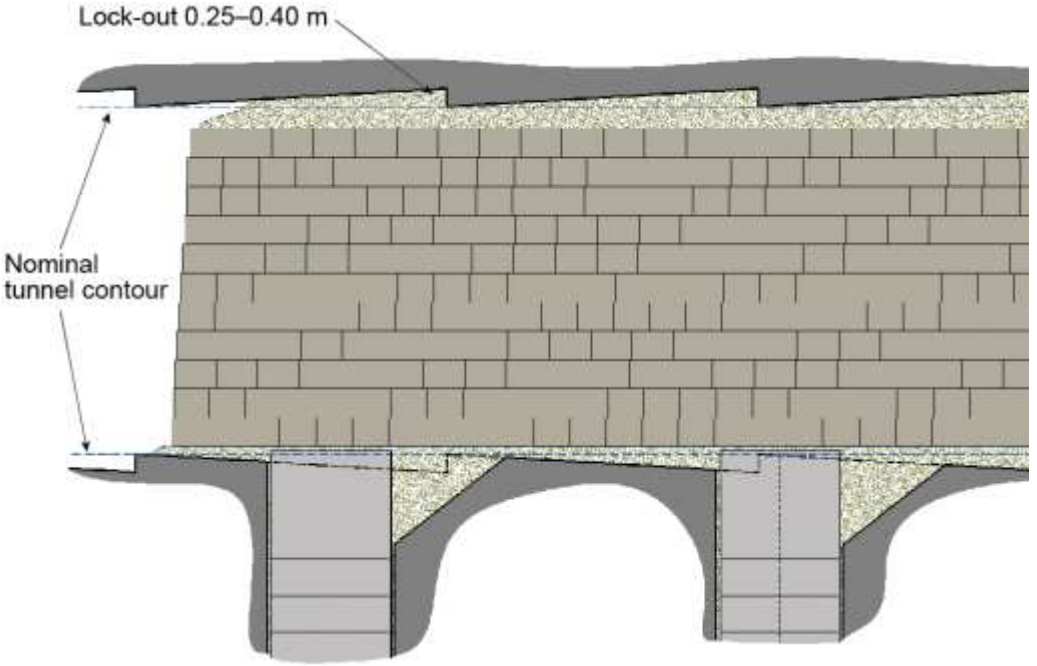


The main dimensions of the deposition tunnel are shown on this slide. In SKB reference design the distance between deposition holes is 6 m and 40 m between deposition tunnels.



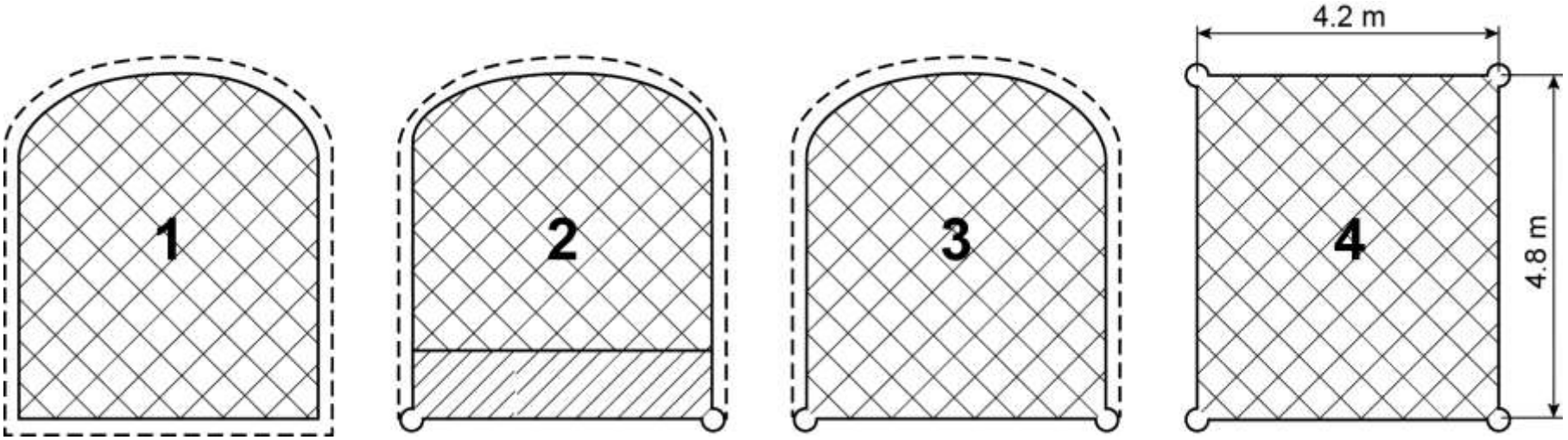
Explanations for the dimensions of the tunnel





The lock-out is needed for the drill and blast method and will make the tunnel contour uneven. This will create problems for the different machines used during the installation of buffer, emplacement of the canister and final backfilling of the tunnel. The deposition holes are not in centre of the tunnel as shown. The cut-out at the top of the deposition holes is preliminary 1.6 m long and 1.25 m deep. The cut-out make it possible to reduce the height of the deposition tunnel.

Excavation methods under discussion



The following four alternative for production of deposition tunnels has been discussed:

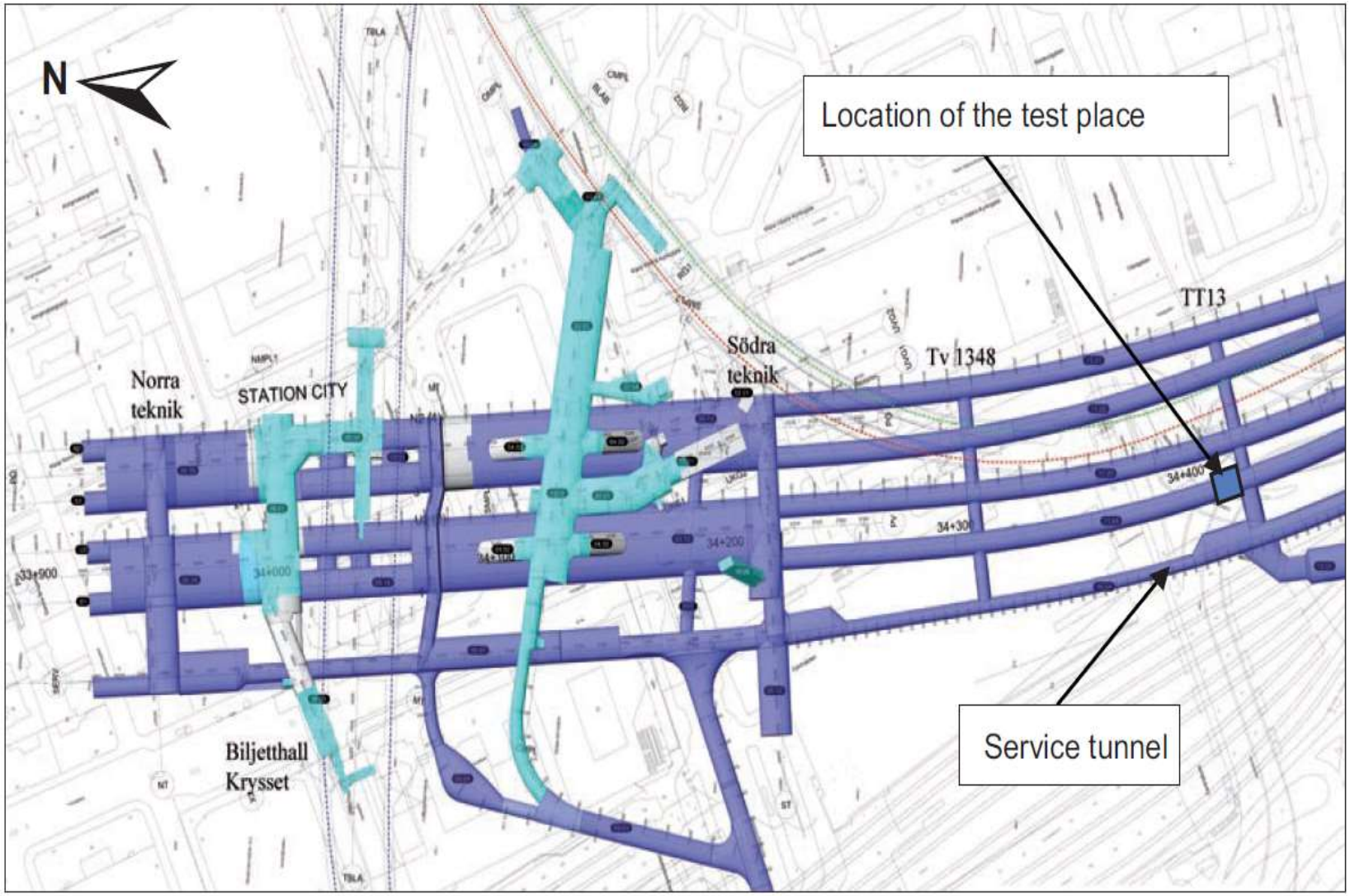
Alt.1: Drill-and-blast the full tunnel area. This i SKB reference method at present.

Alt. 2: Drill-and-blast the tunnel gallery, wire sawing the floor and remove the bench by drill-and-blast.

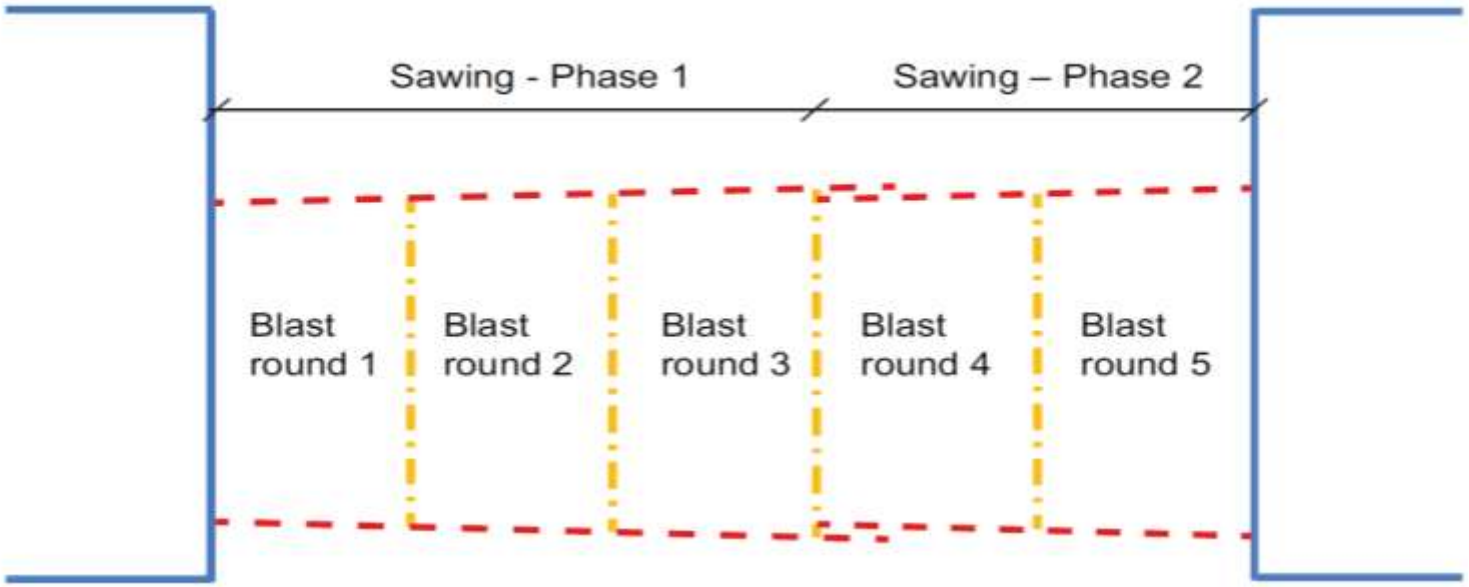
Alt. 3: Wire sawing of the tunnel floor, drill and blast the full tunnel area.

Alt. 4: Wire sawing of all sides, drill and blast the rock. This method was tested for a short deposition tunnel in the City Line.

Plan view of the City Line tunnel system

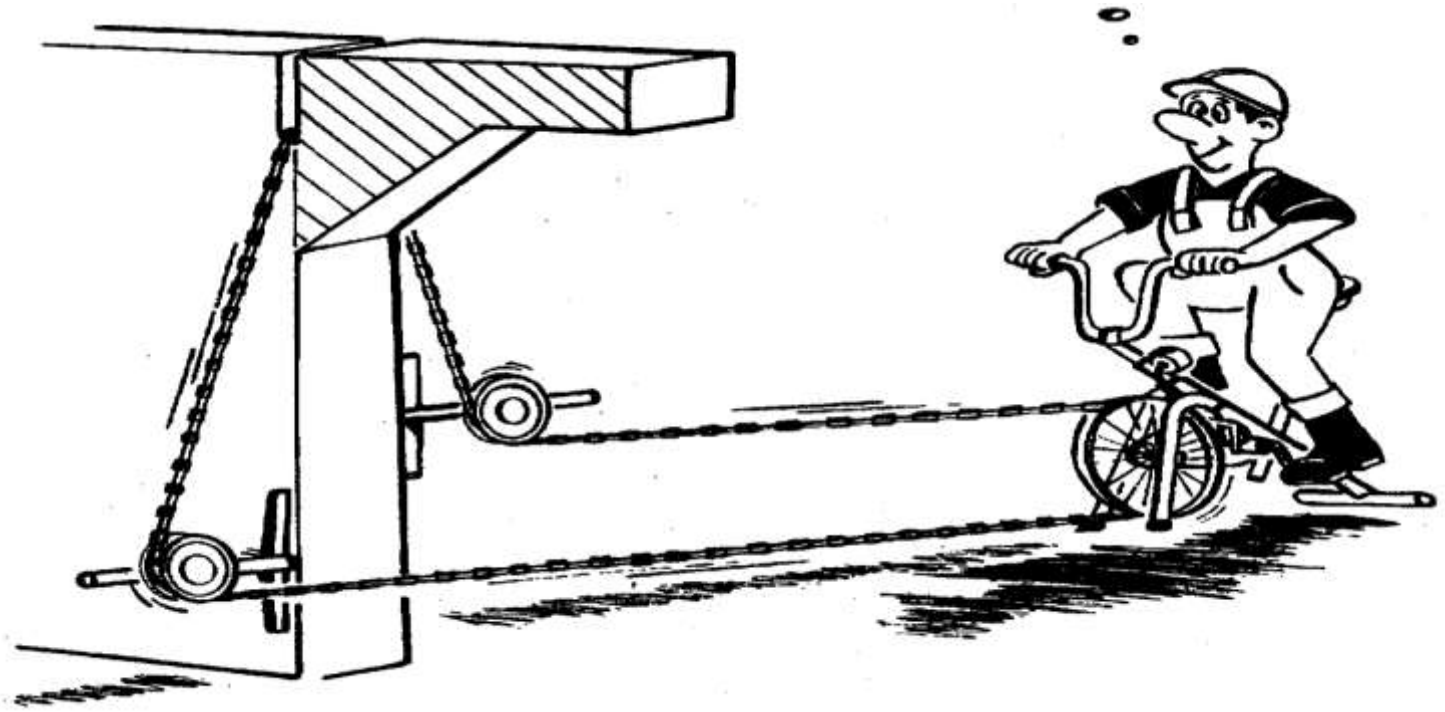


The drilling and sawing was done in two phases

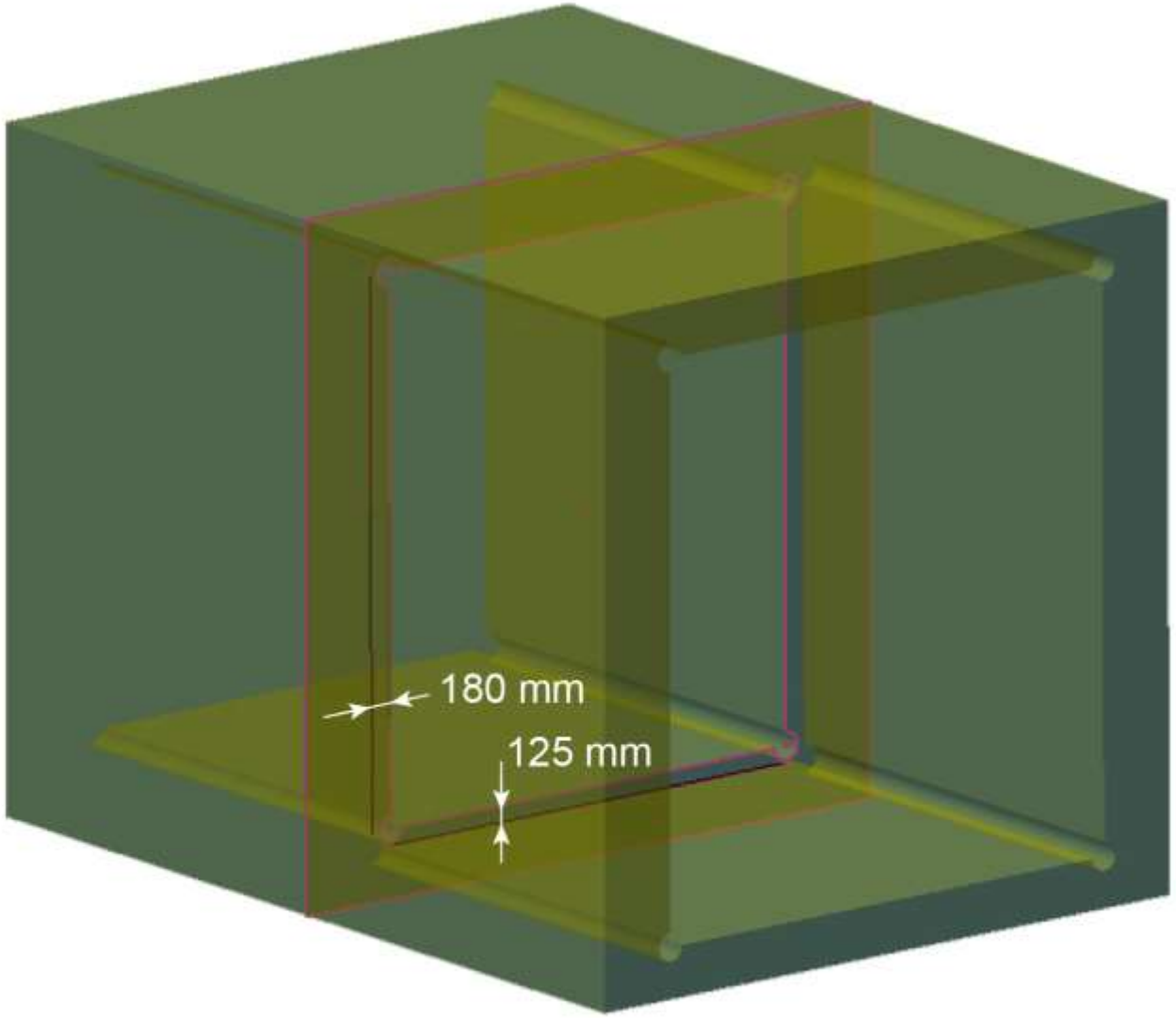


The deposition tunnel in the City Line was only about 16 m. However, the drilling and sawing was done in two phases in order to demonstrate the step with two phases for drilling and sawing.

Wire sawing – The basic principle



Drilling of corner holes and the step between phase 1 and 2



Equipment used for drilling of the holes for sawing

Drilling was done in three steps:

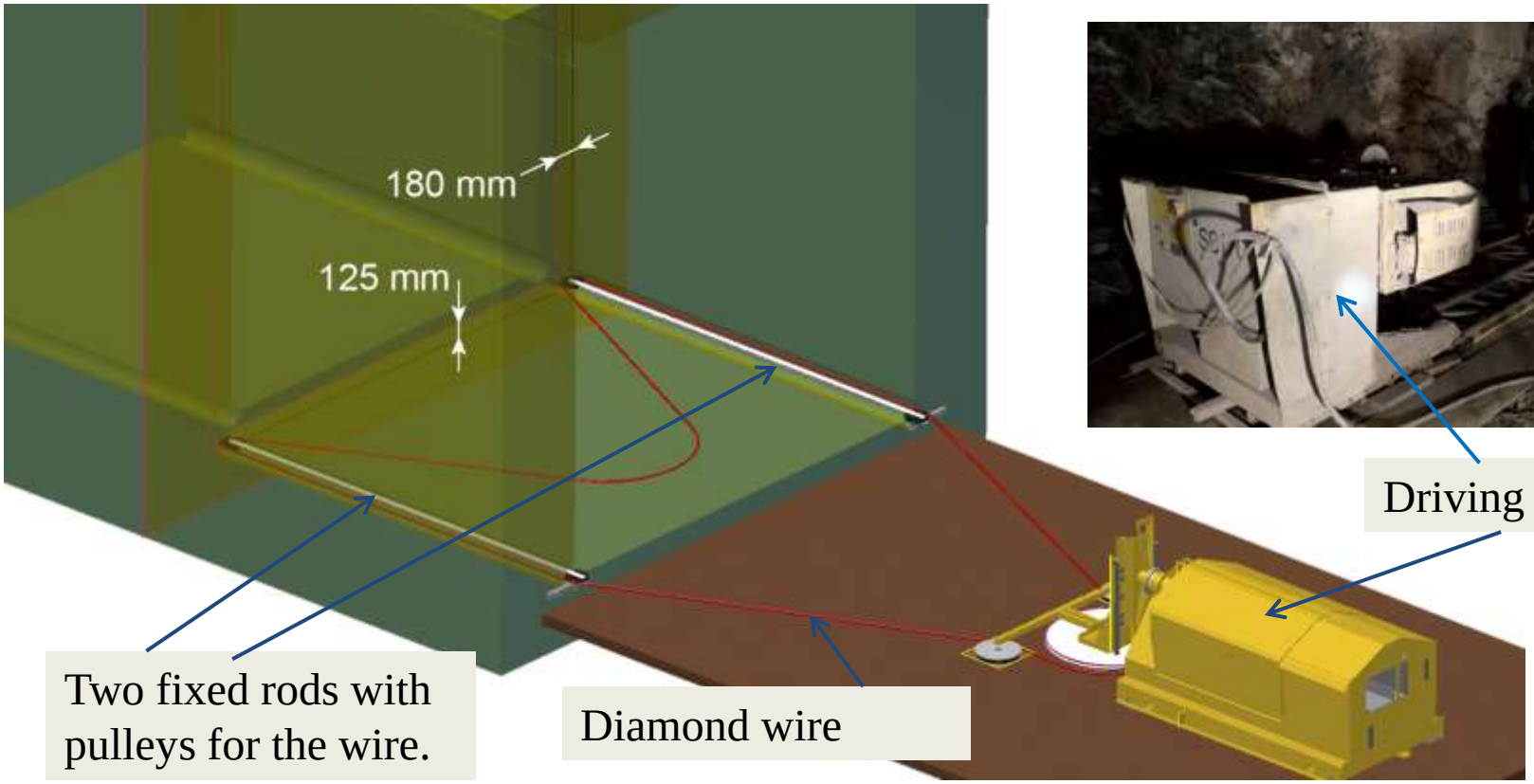
1. Core drilling machine, Ø 76 mm
2. Reaming, Ø 76 mm to Ø 165 mm
3. Reaming, Ø 165 mm to Ø 255 mm

The same boom and auxiliary equipment was used for both core drilling and reaming. This reduced the set up time for reaming.

Photo of the front of the track tunnel

The four corner holes for the deposition tunnel can bee seen on this photo.

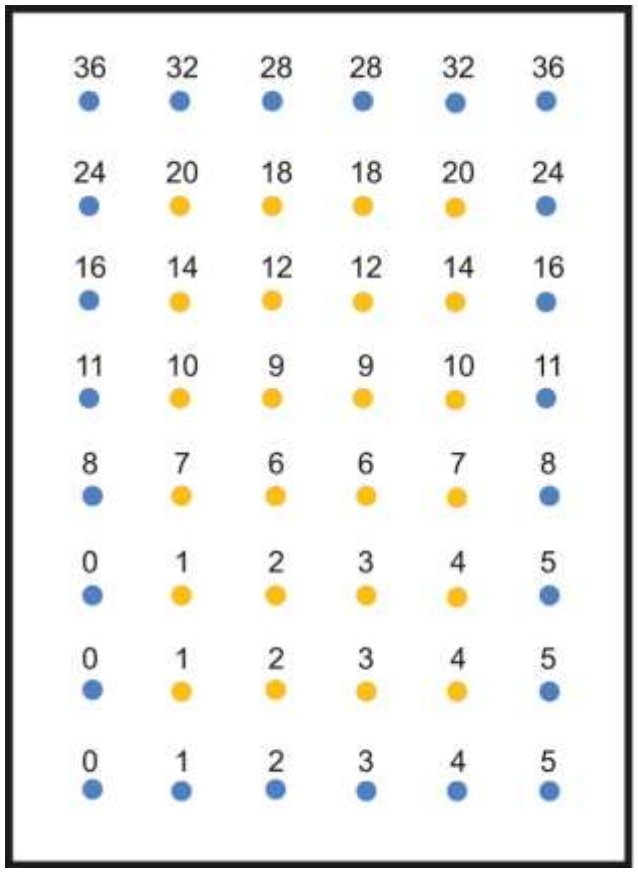
3D model of tunnel and sawing equipment, phase 1



3D model of a sawn tunnel with two drilling and sawing phases. Fixed push rods with pulleys for the diamond wire was used for sawing of the floor, walls and roof. The driving unit for the wire was mounted on rails and was keeping correct speed and tension of the wire during the sawing.

Phase 2 – Scaffolding and platforms was needed for drilling and sawing at the upper level

Drilling and charge plan for the sawed tunnel



The aim of the blasting is to fracture and remove the rock. The number of holes for the blasting can be reduced, no contour holes are needed as all surfaces are sawn. In the City Link we used 48 holes for charging compared with about 95 for conventional drill-and-blast. The number of blasting holes could probably be reduced further but was not tested.

Overview photo of the finished blasted tunnel, phase 1 closest to the camera

Detail of the finished blasted tunnel. The light field is the step between phase 1 and 2.

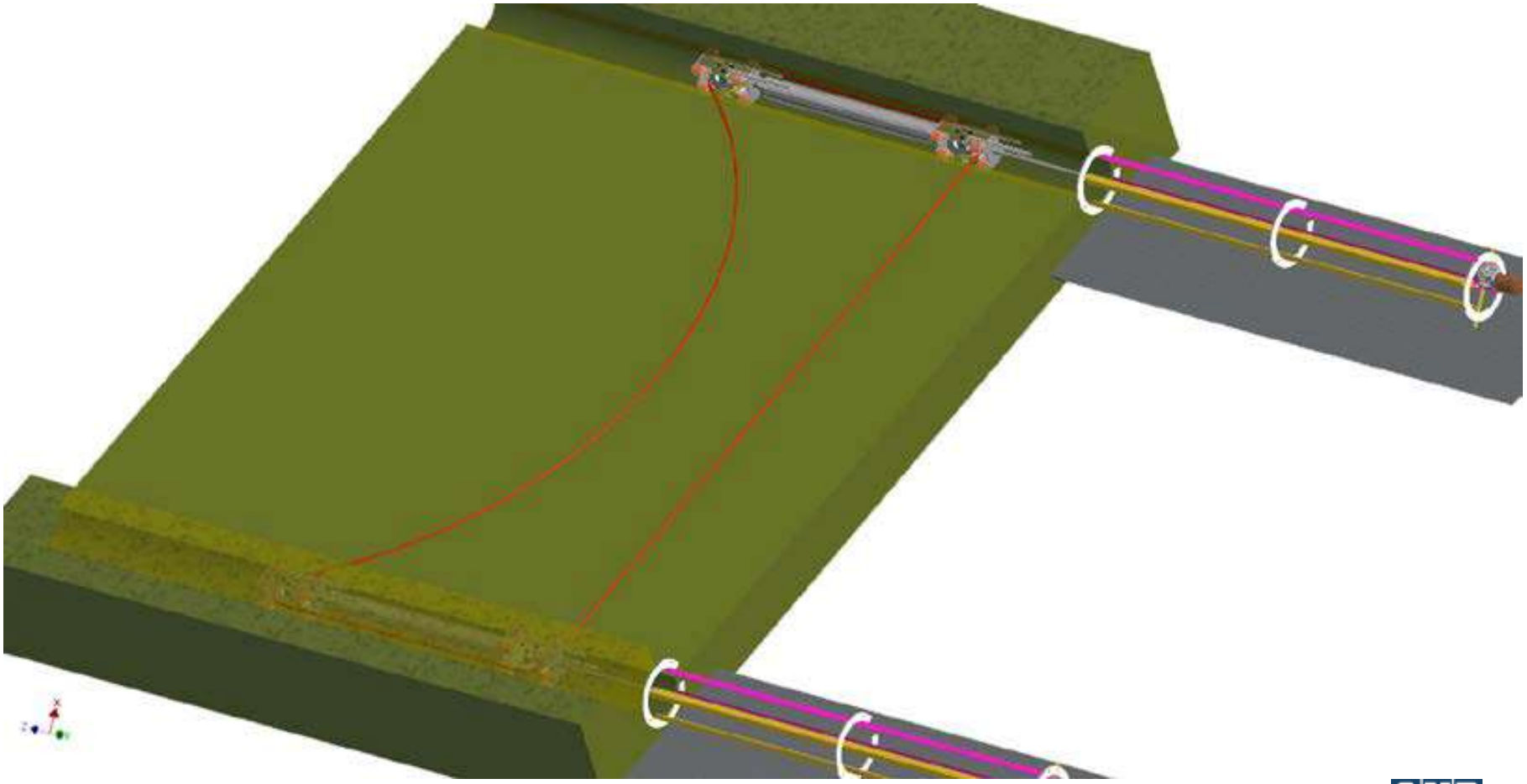
Major cost differences between the main alternatives for 1 500 m deposition tunnels

Annual costs in MSEK	**Drilling blasting**	**Sawing all surfaces**	**Sawing only floor**
Capital costs	2.5	2.4	3.5
Consumables	4.8	10.3	6.8
Labour	2.5	9.6	6.6
Additional cost for additional rock	1.4	0	1.1
Cost for tunnel floor levelling/cleaning	3.8	0	0
Additional cost of backfilling	9.6	0	7.2
Total:	24.6	22.3	25.2

Development of new drilling and sawing equipment

1. The testing of wire sawing in the City Line was done with conventional drilling and sawing equipment and therefore nor optimised for this applications.
2. The production rate could be improved by reducing the start up time for the drilling and sawing using a dedicated carrier for the drilling and sawing equipment.
3. The drilling equipment should be accommodated for drilling hole in the right and left hand side with minimum size of the lock-out between two drilling steps. By using a carrier for the drilling equipment fixed scaffoldings are not needed.
4. The wire saw should be remotely operated and self propelled using two crawler units in each of the corner holes.
5. The start of the sawing is done with help of start tubes handled by dedicated carrier and fixes scaffoldings will not be needed.
6. The diamond wire can be optimised for the area to be cut and the surface will be within small tolerances.
7. The sawing start with the floor, the two sides are sawn at the same time with two saws and the top is done last.

Future wire sawing equipment



Testing of wire sawing at a quarrel, May 2015

This slide indicates that wire sawing is already extensively used at the quarrel in Lysekil. They are also using a stationary saw for division of rock blocks into slices. The last photo is the prototype saw under development.

Plans for future studies and field testings

1. The results of the field tests at Lysekil will be used for updating of the production time and cost used in SKB report R-14-08.
2. In order get better basis for decision regarding the final production method for the deposition tunnels more studies and field test would be required.
3. Based on the results from Lysekil the future actions are likely to be the base for a more extensive filed test of e.g. a 50 m deposition tunnel using the new drilling and sawing equipment with a load carrier.
4. The new drilling and sawing of a tunnel should also include the step between two phases in order to make it possible to evaluate if the step between the phases would be a problem for the backfilling process.
5. The future plans should also include testing if the blasting method could be more optimised then used in City Line project.

Thank you for your attention

Questions?