Stability problems in undermined areas

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Abstract
Virumaa (North-East part of Estonia) is a developing industrial area. There is also the Estonian Oil Shale industry. Oil Shale is mined in Estonia more than 90 years and much has been mined underground. Ida-Virumaa rapid economic development is prompted by a number of its businesses, governments and constructs buildings underground mined areas. Therefore underground mined area should be carefully considered in the search for a suitable site with several different factors. For example, to calculate how far could reach a different impact on mining operations, since the construction of suitable land underground may be submerged as well as stable. Mining Department has developed a computer program gives a basis for future reviews, which involves the extraction time, the direction of movement of mining, Mining Engineering, and have been used, where possible, extracting subjective factors on the precision.

Keywords
Oil Shale, undermined, calculation method, modelling, geotechnology, environmental impact of mining, visualisation.

Introduction
The principal mining regions of Estonia are: Lääne-Harju (Vasalemma, Padise, Harku etc. deposits), Ida-Harju (Lasnamäe, Väo, Maardu etc. deposits), Kunda-Rakvere (Toolse, Ubja, Aru etc. deposits) and Ida-Viru (Estonian oil shale deposit, peat deposit of Puhatu and many locations for mining building material). Smallest number of problems is faced in old mining regions, mainly because there exists the “State plan for utilization of oil shale, 2008-2015”. On the other hand, acceptable mining environment have been developed in old mining regions. Mining environment is understood as the entity including resources (deposits and groundwater), land (agricultural and housing land), engineering and technology.

Long-term research of TUT Department of Mining and the co-operators have shown that ground and landscapes changed by mining can be of better quality afterwards than before. If reclaiming is planned skilfully, the soil, landforms, forest, water bodies and agricultural land can be more valuable than before mining. All this is the basis for developing acceptable, environmentally friendly mining. Creating acceptable mining requires engineering research both in natural and technogenic environment, e.g. modelling and pilot projects. Such research is voluminous, what is the reason that in Estonia, as well as elsewhere, computer modelling has become the principal tool in solving problems related to all sorts of developments, technologies and effects. The key issue is defining criteria and restrictions that satisfy all the involved parties.

1. Hypothesis

- The principal direction of developing mining technology is filling the mined area. This provides a control on majority of environmental effects. For instance, filling the workings decreases the loss of resources, land subsidence and at the same time provides usage for stockpiling; filling the berms of an open mine decreases the dewatering; harmless waste can be used for filling open mines and in this manner create new building land.

- Local land subsidence is related to mining, extending also to technological networks. It is possible to find out the deformation parameters by geodetic monitoring. Taking these parameters into account make it possible to model further the extent and effect of the deformation.

2. Underground mined land stability problems
Underground mined areas are complex and have difficult problems of predictable of the stability, being valid both: for the whole world, as well as in Estonia. Underground mined areas of stability depends on many factors (the extraction time, technology, the thickness of sally and many others), part of which is known to be very difficult identifiable, or even unknown. The calculation and assessment methods are based on simplified models, which will be quite adequate to address the practical results.

Determination of conditions of land stability in Estonia underground mined areas for road construction or other service area for the later is quite complicated, because the mineral is a sally at different times and different mining methods. The land stability determination of the severity is connected with the mining methods various parameters (eg thickness of the layer, supporting type etc.).
3. Classification of underground mined areas

**Steady land** is located on the mining claims but is unmined because of protective or remnant pillars. The area of the steady land is always smaller than the area of the pillar. [Reinsalu E., Valgma I. 2003]

**Subsided land** is located above the hand-mined area: advancing-andretreating mining and longwall mining with double-unit-face areas. The relief of subsided land depends on the quantity of the filling material and filling quality, and on the roof structure. Mining technology and mining conditions used could characterize subsided land in an oil shale deposit. [Reinsalu E., Valgma I. 2003]

**Stable land** is located in pillar-protected areas. Land stability depends on the strength of pillars. The width of rooms and drifts is the second stability factor. These spaces may be so narrow that caving could not reach the land surface. Stable land covers the rooms whose pillars were not been mined before abandoning, and thickness of the hard roof remains in the range of 10...35 m. Secondary subsidences may occur in the areas with thinner limestone cover. [Reinsalu E., Valgma I. 2003]

**Quasistable land** and area forms in places where pillars keep mine workings during mining but may break afterwards. All the room-and-pillar mining area that is unstable is quasistable. Quasistable areas occur also by sides of caved longwall mining areas, and above drifts, adits, and galleries on low-depth mining area. [Reinsalu E., Valgma I. 2003]

<table>
<thead>
<tr>
<th>Type of land</th>
<th>Buildings, roads, etc</th>
<th>Agricultural and forest land</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steady</td>
<td>No limitations</td>
<td></td>
</tr>
<tr>
<td>Stable</td>
<td>Only light buildings</td>
<td>No limitation</td>
</tr>
<tr>
<td>Subsided</td>
<td>Considering the possibility of size and nature of land deformations in the future</td>
<td>Considering possible changes of humidity regime, especially unfavourable composition of Quaternary sediments</td>
</tr>
<tr>
<td>Quasistable</td>
<td>Generally building is forbidden, permission only for the project which has passed geotechnical ex-</td>
<td>Considering the risk of cultivated plant destroying, especially unfavourable composition of Quaternary sediments</td>
</tr>
</tbody>
</table>

4. Case studies

**4.1. Case 1. Geotechnical problems in sewage project**

One problem to be solved in the Jõhvi-Ahtme sewage project was pipeline installation in the mined-out area. Mining Department of TUT evaluated and analysed various possibilities of different pipeline locations taking into account the used mining methods and exact locations of underground workings. The final decision was made by considering Tammiku underground map, surface situation and area boundaries. The new sewage pipe is located near the underground mine which geotechnically influences the surface. [Karu et al., 2008]

Another problem is changing water level in closed mines. The development plan of Estonian Oil Shale Company Ltd. is planning opening of a new strip mine in the Tammiku-Kose field. Drainage of the new surface mine affects the existing water regime and that, in turn, may influence stability of underground pillars. That was the most important reason to avoid location of a pipeline in the area where the room-and-pillar method was used. Because of the karst zone, there are some unmined areas there which were suitable for pipeline location. Relatively important was the fact that overburden in the mined-out area decreases from 20 meters to 7–10 meters. Six different model versions were under consideration. It is strongly recommended to investigate and plan before starting to build. The boundaries of mined-out area, land stability and subsidence must be carefully studied. A computer program was worked out to describe the impact. The program presents the basis for future expert estimations. [Karu et al., 2008]

**4.2. Case 2: Secondary road 13134 Kukruse–Tammiku**

According to Ida-Teedekeskus initiated secondary road 13134 Kukruse–Tammiku paragraph Kukruse-Pajuualuse environmental impact assessment. Secondary road length is 8.07 km and connects two major roads: main road No 1 (E 20), starts 160.04 km of Tallinn-Narva (Kukruse Manor intersection) and ends in the main road nr. 3 (E 264) Jõhvi-Tartu-Valga 4.55 km (Tammiku intersection). The first 1.5 km of road are located in Kohtla field, thence major road accession of No. 3, is located in Jõhvi field.

Secondary road the test area using the following mining process:

a) Hand-mined area (Fig 1). Ceiling is based on pack wall. There is a massive land subsidence (there is no water run-off).

b) Using longwall face. Top of bed will be crash down. Subsidence will occur.

c) Room and pillar mining. Ceiling is based on pillars, the land is stable. Collapses may be occur.
Using the calculation method [Karu 2005], it can be argued that underground mined area in secondary road region is quasi stable (Fig 2) - it means limestone grib and elements of the support is not broken during the extraction, but it may be later.

Underground mined area main issue is ground deformations and their qualitative and quantitative indicators. The most common are two possible scenarios:

a) Ground collapses evenly. Vertical sink does not cause significant damage to the road.

b) Ground sink unevenly. This raises the subsidence slope gradient, which occurs after the vertical and horizontal deformation. Deformation of the horizontal component causes tensile stresses, which causes the road surface and base failure.

[Reinsalu et al. 2002]. Incorrect pillars have been estimated broken time. Since the mines are filled with water, it is unknown underground situation and strength. Research results on the last named situation of the Estonian Oil Shale mines indicated.
5. Summary

In conclusion, we can say that scientists have a set of methods that allow parameters to predict the subsidence, but the exact time is difficult set. There are also measures to prevent and mitigate flooding. Adequate, cost and safety with a reasoned decision to be adopted together with the road construction professionals with regard to their specificity, and opportunities. Tallinn University of Technology scientists have made recommendations what must be taken into account when designing secondary road. When eventually road construction be reached, it is too early to answer, it all depends on the volume already in the design and the various possibilities of structural funds.

To get better results should be evaluated for the collapsing areas in undermined areas. Specifying the locations at the collapse of mining methods, geological conditions and other parameters can better assess the width of the collapse of influence.

The results of the calculation method makes it possible to choose a suitable route to avoid dangerous places. Given the different steps to help you build in undermined areas as well as in limited circumstances.

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References: