Netherlands Knowledge Centre for Underground Space and Underground Construction

Proposal 5

Title: Adaptable construction and renovation of tunnels

Theme: Sustainable use of underground space
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Abstract:
At first glance, there seems to be a "contradiction in terminis" between adaptivity and civil structures, as the concept 'cast in situ' tends to exclude adaptivity. However, because of the influence of the structure itself on flexible use, sustainability and aesthetics as **value creation**, on the one hand, and **disturbances** caused by nuisance during construction, on the other hand, a different approach must be used in civil construction.

To achieve adaptability in this sector by 2050 we propose two roadmaps centred on:

1. **New technology and new materials**
   New technology and materials, will result in tunnels becoming 10-15% cheaper by 2050. In addition, faster construction reduces the cost of traffic measures and economic damage. In relative terms, these costs are significantly higher than the cost of new technologies and can become a major factor in renovation projects in particular. An example of new materials includes the use of steel and synthetic fibres to replace traditional reinforcement, and composites to replace concrete or create hybrid structures. We also look for (new) materials that, while maintaining the desired strength, fire resistance, stiffness, and water tightness improve the durability and reduce the carbon footprint of the structure. The added benefit is that these technologies will minimise or in some cases eliminate disturbance during construction or renovation and reduce the project's carbon footprint.
   Prefab and modular construction By moving towards standard elements for the entire sector allows market certainty and maximise returns on investment. This method provides significant advantages to clients because it ensures greater durability and reliability of the elements with a stable quality that can be controlled more effectively. The construction schedule is significantly reduced because the on-site construction period is much shorter.
   Robotization reduces on-site disturbances as the construction process is more efficient and has a smaller margin of error. Think about an automated production line or 3D printing.
   Other construction methods must be developed that would eliminate the need for deep construction shafts for tunnel construction in the urban environment. For example, the implementation of a mechanised tunnel process starting on surface level, or the complete underground expansion of smaller mechanised pilot tunnels to the desired diameter. In case of the renovation of tunnels, we will need to find ways to implement construction by scaling up technologies from the smaller infrastructure (such as relining) faster.

2. **Robust structures.**
   We can already build a tunnel with the required robustness parameters, but what is lacking is a cost-benefit analysis that considers the expectations and wishes for the future. In this line, we want to outline what these possible expectations and wishes are (scenario analyses – for example, do we need more or less space for installations?), who benefits from robust structures (for example, who has money left for the space on a tunnel roof). The second cost-benefit analysis is about reducing disturbances and the associated costs. How much more expensive is the construction of additional free space compared to the cost of renovation?

How far are we now and can we join forces internationally?