BYGGEGROPVEILEDNINGEN – A TOOL FOR PLANNING BUILDING PITS

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KEYWORDS

Building pits, neighbors, settlement, pore pressure, sheet pile wall, excavation

ABSTRACT

Underground works like building pits have repeatedly led to unexpected and unwanted damage to properties and infrastructure nearby. For that reason, the BegrensSkade I research project was created as a consortium of most Norwegian members in the construction industry together with the Research Council of Norway. One of the main conclusions was that it is necessary to plan better to avoid damage from nearby building pits, and that sufficient mitigating measures must be established for neighbours.

The Norwegian Geotechnical Association took the initiative for a Building Pit Guide - Byggegropveiledningen. The purpose with this guideline is to increase the level of awareness of the planning adviser in geotechnics. It is agreed that improved execution results in savings through a reduced number of damages and fewer disputes.

The guideline deals with topics such as which regulations must be followed, which preliminary investigations should be carried out and how a building pit can affect the surroundings. It also deals with topics such as simple hydrogeology with a focus on pore pressure and influence zones, leakage and sealing requirements.

Furthermore, it goes into the most common methods for establishing construction pit walls, from open excavation, sheet piling to freezing. Each topic has a reference to the European technical standards for execution of special geotechnical work. There are also recommendations on how each type of wall should be followed up under construction on site, and how they can be dimensioned.

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1. INTRODUCTION

Old Norwegian Law on Neighbouring Areas:
Granneloven § 2: Ingen må ha, gjera eller setja i verk noko som urimeleg eller uturvande er til skade eller ulempe på granneeigedom. Inn under ulempe går òg at noko må reknast for farleg. I avgjerda om noko er urimeleg eller uturvande, skal det leggjast vekt på kva som er teknisk og økonomisk mogleg å gjera for å hindra eller avgrensa skaden eller ulempa.

Explanatory translation, not legal.
Neighbour law § 2: No one shall have, do, or implement anything that is unreasonable or unnecessary to the detriment or inconvenience of neighbour property. Also included in the disadvantage is that something must be considered too dangerous. When assessing whether something is unreasonable or unnecessary, emphasis shall be placed on what is technically and economically feasible to do to prevent or limit the damages or disadvantage.

Figure 1. Byggegropveiledningen – The Building Pit Guide

Since the establishment of construction pits and foundations of structures too often lead to building damage to neighbouring areas, a research project on the topic was carried out in the period 2012 – 2015 in Norway. The project was called Begrens Skade (Limit Damage). It is estimated that 3 – 8% of total investment costs for construction projects goes to repairing damage caused by geotechnical circumstances. The research results showed that it is partly the same type of damage that occurs and that it can take time before the damage appear and are discovered. This shows how important it is to carry out the groundworks correctly. Then the damage will be limited to a minimum and

thereby costs for repair. These damages are often a source of conflicts that require a lot of time and resources and can end up in the court system. It is not only the parties who pay a price, but it is the whole society that pays the final bill. By reducing the level of conflict, the focus can be on executing the projects in a good way and not on conflicts.

In the research project Begrens Skade, 23 partners from builders, consultants, suppliers, contractors, research institutes and universities, as well as financial support from the Research Council of Norway contributed. In practice, this meant that the entire building business sector participated, which contributed to a general increase in knowledge.

Ground and foundation work affects the surroundings, and it is necessary that the consequences of the works are assessed to plan and implement any measures. The Eurocodes set requirements for satisfactory design of structures. Furthermore, European standards of execution must ensure that the works are carried out in the best possible way.

In addition, the potential for damage due to installation methods for sheet piles, piles and anchors must be assessed during the design phase. The mapping carried out in the BegrensSkade-project shows that installation effects are usually not sufficiently assessed or probably underestimated. The risk of damage to neighboring property caused by groundwork depends on many factors. Choice of type of construction and foundation method, soil conditions and in particular the margin of the clay's pre-consolidation pressure, soil sensitivity, hydrogeology and pore pressure levels, depth of the construction pit (number of basement levels), choice of execution method, which procedures the contractor uses and construction time are examples of variables that affect adjacent areas to a construction project.

In addition, the understanding of the problem, depending on the expertise and experience of the participants (client, consultant, contractor, and supplier) will play a decisive role for the project. Furthermore, communication and cooperation can be affected by the contracts and the financial framework under which the players work.

2. COMPETENCE OF THE ACTORS

The Begrens-Skade project has shown that overall competence has a significant potential for improvement among all actors. Those who come out of universities as geotechnical engineers know some theory. They have learned to calculate piles, bracing etc., but it is limited what they have been educated on the totality of a construction project, what laws and regulations apply, can the work lead to damage to third parties, etc.

The Begrens-Skade project was an R&D project in which expertise was shared between the various actors. The geotechnical environment in Norway is such

that one is happy to share experiences if one does not sit on opposite sides in a conflict / court case. This collegial openness came to great news in the R&D project.

Based on Begrens Skade it was concluded that a Building Pit Guide where one collects and compiles the main part of what is important to have knowledge of that can have great significance for the geotechnics part of the industry. There is an understanding of regulations, an overall understanding of what a construction project entails also for the surroundings, the interface between the players (who is responsible for what), HSE/SJA for groundworks, what is important to map before starting work, what opportunities do you have to secure the construction pit and finally something about design.

By gathering the practical part of geotechnics in a book, one will more easily acquire knowledge that would otherwise have taken several years and learn from more experienced colleagues. In other words, the Building Pit Guide is a practical guide for structures in and against the ground.

3. WHAT THE GUIDELINE CONTAINS

The Building Pit Guide is a practical guide for constructions in and towards the ground. The following provides an overview of the content:

1. Background and regulations
    - The introductory chapter provides definitions of terms such as construction pits, encroachment zones and influence zones. Furthermore, information is provided about and to some extent an overview of the most relevant laws, regulations, standards, guidelines, and manuals.
    - The purpose is to provide an overview and some start-up help.
2. Overall assessments and relationships with neighbours and surroundings
    - The aim of this chapter is to provide an overview of what should be considered to gain a better overall understanding of the impacts a construction project can have on neighbouring areas.
    - At a general level, reference is made to different security options for a construction pit in relation to ground conditions and proximity to neighbouring structures.
    - Experience figures are provided regarding how much impact a construction pit can have on third parties.
    - Technical considerations about accessibility and opportunities are an important topic.
    - Risk assessments, which are currently a useful tool in construction projects, are discussed in a section. Both regulations and Norwegian standards set requirements for this.

3. Interface between actors
    - There are many actors in a construction project. In this chapter, an attempt is made to shed light on roles and responsibilities:
        - This is seen in relation to how far into the planning and construction process one has come, as well as in relation to different contract forms.
        - Interface between disciplines and actors.
    - An assessment is also given of the significance of the type of contract the parties have.
4. HSE and SHA during groundworks and planning for groundworks
    - It is important that one from the start of planning and engineering in a project, focuses on ensuring that the work is carried out as safely as possible.
    - Large machines and an understanding of how the works should be done as safely as possible have been attempted to be shown by examples and with reference to regulations.
5. Early investigations and monitoring programs
    - For large development projects and infrastructure projects, feasibility studies are required before the project is approved by the competent authorities and politicians. For projects that "only" plan to build a building in a construction pit, the same requirements for feasibility studies are not stipulated, most likely because this is normally carried out in areas that have already been zoned for construction. It is therefore easy to overlook the fact that early investigations and monitoring, outside the actual construction pit, must nevertheless be carried out.
    - Ground and neighbouring conditions are of great importance in geotechnical design and construction in the ground.
    - Guidance has therefore been provided on what is needed and how to find important information. This applies to both geotechnics and environmental geology.
    - References are made to the formal requirements that must be satisfied.
    - Control of execution and follow-up of monitoring programs throughout the construction process is shown with examples.
6. Support of Excavations
    - Support systems for excavations is a large chapter in which 8 types of supporting structures are discussed.
    - Furthermore, guidance is given on different types of bracing and anchors for the support structure. Both internal struts and anchors in rock and soil.

- This includes, among other things, securing the sheetpile foot at the rock surface, before excavating (drill&blast) the rock further down.
- Soil nailing, ground reinforcement with lime-cement piles and ground freezing are also covered by this chapter.
- The chapter also provides examples of how to reduce leakage into construction pits, including injection, water infiltration and sealing sheetpile walls.

7. Geotechnical engineering.

- This chapter provides general recommendations for geotechnical design and execution of ground works.
- Many of the solutions and possibilities shown in previous chapters are described in more detail regarding what is important in the design.

This guide will hopefully be of use to all players in the industry who need some more insight into practical issues and solutions.

4. EXAMPLES FROM THE BUILDING PIT GUIDE

We have selected a few examples to illustrate various topics covered in the guideline. As shown above, there is a wide range of topics that the Building Pit Guide covers. Here are some samples.

Investigations in early planning

Eurocode 7 sets requirements for geotechnical investigations in early planning phases such as: “Collection and interpretation of geotechnical information must always be carried out. This information must include geology, geomorphology, seismicity, hydrology, and the history of the construction site”. Norwegian environmental legislation sets requirements for investigations of contaminated soil and the Cultural Heritage Act sets requirements to survey for archaeological objects. Nevertheless, issues such as changes in hydrogeological conditions, vibrations and settlements on neighbouring buildings and infrastructure is not covered directly by the regulation and easy to forget.

The Building Pit Guide lists checkpoints that should be reviewed in the design phase for various topics to be surveyed.

Mapping depths to rock surface

Mapping the depths to rock surface is a useful tool for surveying the potential for subsidence and settlements, and for determining whether neighbours may experience settlements due to changes in pore pressure or groundwater level. In the Building Pit Guide, it is described how these maps can be used together with pore pressure observations to determine where settlements should be followed up on neighbouring buildings. It is also useful as a tool for predicting vibrations from blasting. An example of a map with soil depths to rock surface is shown in figure 2.

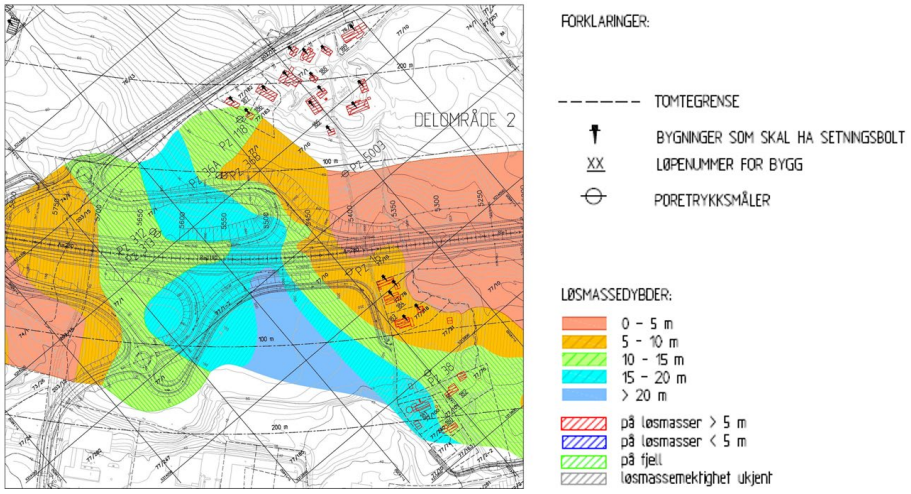


Figure 1 An example of a map with soil depths to rock surface as guide for following up on buildings where settlements may occur due to reduced pore pressure or lowered water table caused by the road construction. [1].

Survey of neighbouring buildings and infrastructure

Survey of neighbouring buildings and infrastructure that lies within a building pit's influence zone is necessary when blasting is planned in the building pit. It may also be necessary to carry out before sheet piling, or before other earthworks that causes deformations or settlements. The guideline describes how the inspection can be authorised, what must be checked externally and internally in a building and how it must be reported.

Wells for water infiltration

An example of the practical approach in the guideline is shown in the chapters on Hydrogeology (chapter 5.4) and Infiltration wells (chapter 6.21). In the chapter on hydrogeology, it is illustrated with figures and text that explain hydrogeology in and beneath marine sediments. It is described how a building pit can affect pore pressure and groundwater level, both within the footprint of the pit and also outside the building pit, see figure 3. This is to a small extent captured by Norwegian geotechnical textbooks used in education.

Great emphasis has been placed on explaining the difference between groundwater level and pore pressure. Hydrostatic pore pressure from groundwater level can deviate significantly from measured pore pressure in the case of large thicknesses of marine clay combined with large height differences. With the formation of groundwater in areas lying above the terrain level where a building pit is planned, artesian pore pressure often occurs in the small and almost closed aquifers of moraine under dense and mighty clay layers, see figure 4.

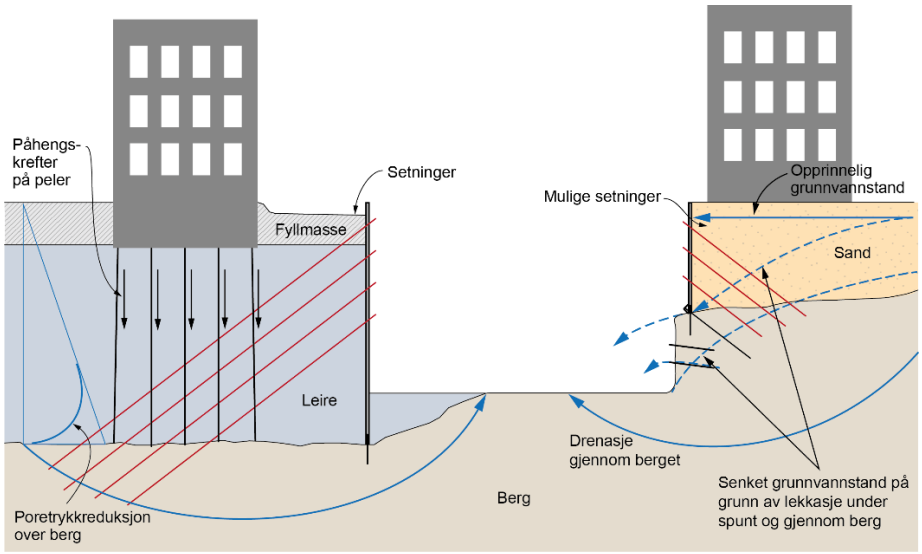


Figure 2 Two different ways a building pit can affect the groundwater level and pore pressure. On the left, pore pressure reduction at the rock surface is shown. It can be due to direct leakage through rock, or leakage in drilled anchors or drilled piles. On the right is shown the lowering of the groundwater table towards a construction pit. [1]

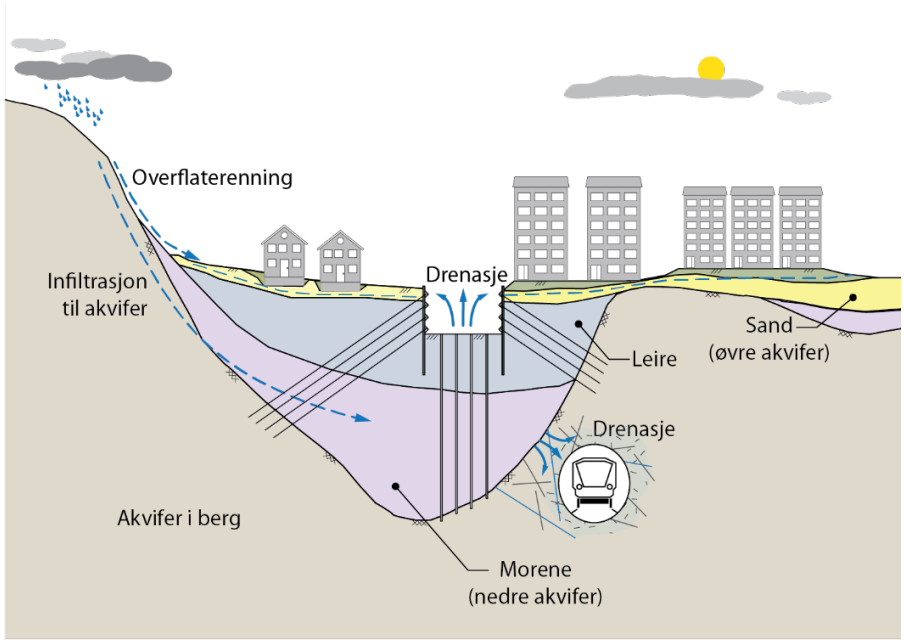


Figure 3 An artesian pore pressure is often developed in the moraine and rock beneath the clay layer due to the height difference between the area where the groundwater is formed and the aquifers in the rock and the moraine. When the terrain is lowered during the excavation, the gradient increases towards the bottom of the building pit. [1]

When these pockets with artesian pore pressure are punctured, for example by drilled piles or drilling for anchors without any sealing, the pore pressure drops, and effective stresses increase above the rock surface. It often takes a long time before enough water refills the pockets and restore the pore pressure. In the meantime, settlements arise in the layers above the rock, and buildings and constructions are damaged.

Leakage into the building pit can lower the pore pressure above the rock surface. An important countermeasure in addition to injection is the infiltration of water into the rock using a well, see figure 5. The method has been used for many years with great success. It is included in requests for tenders, but where the well is to be established, how it should interact with the rock surface, geology and fracture directions are not stated in the tender documents. This information is often only handed over orally internally within the different companies. It is important to share this knowledge since the use of infiltration wells can save neighbours from major damages at a low cost.

An entire chapter is devoted to infiltration wells, where the challenges of placement, on terrain and under the rock surface are shown. The location must be adapted to the main geological lines, the local fractural patterns and directions in the rock masses, and the distance from the rock surface, see figure 6 and figure 7. You can also find in the guideline recommended dimensions and slopes of the wells, information on water consumption and pressure, on the use of packers and sealing, how wells is tested and how they should be followed up, maintained and terminated.

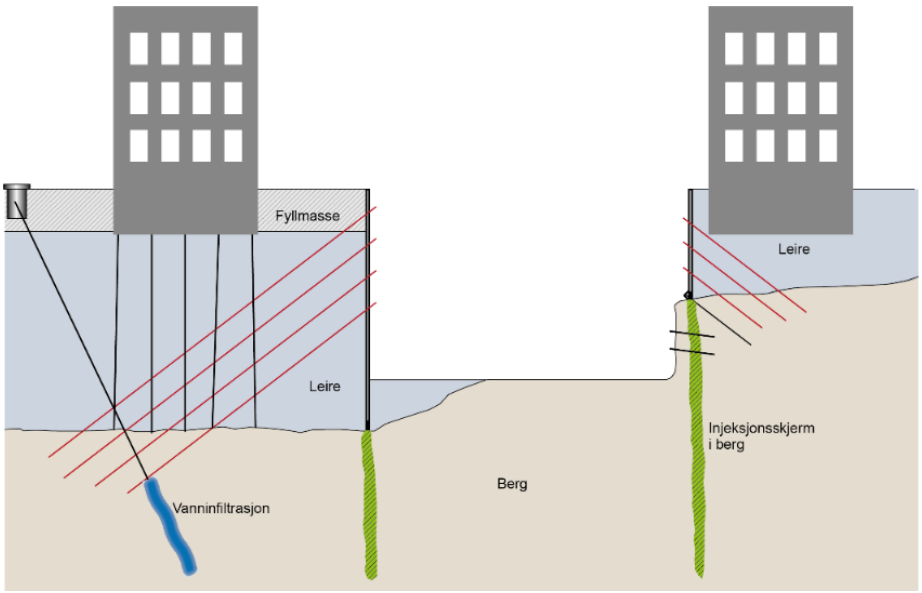


Figure 4 Illustration of an infiltration well close to a building pit [1]

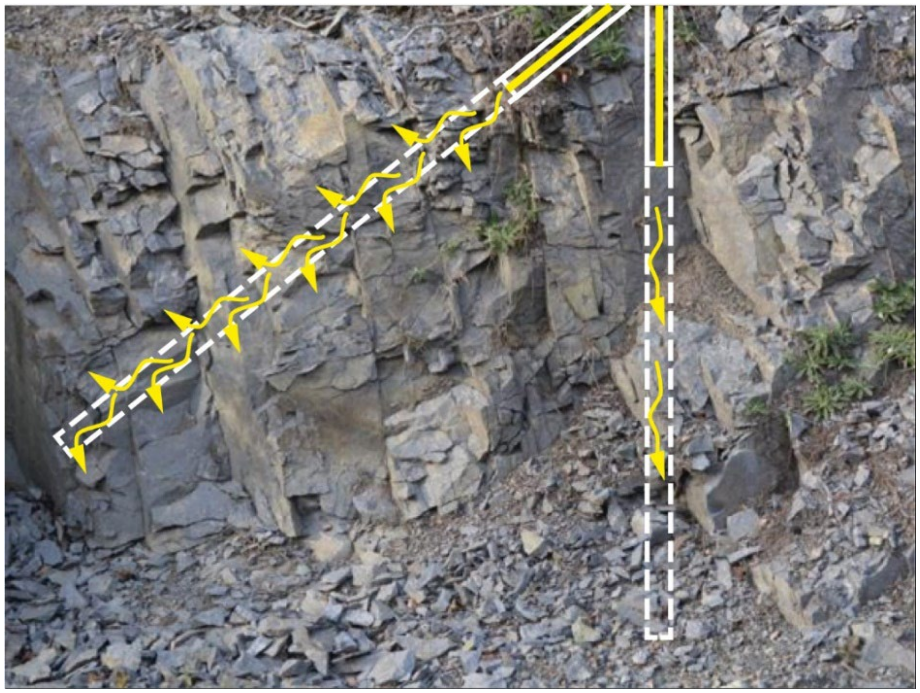


Figure 5 The effect of drilling the water infiltration well through layers and fractures in the rock. The vertical well is mostly in lightly fractured rock, while the inclined well covers many cracks into which it may be possible to infiltrate water [1]

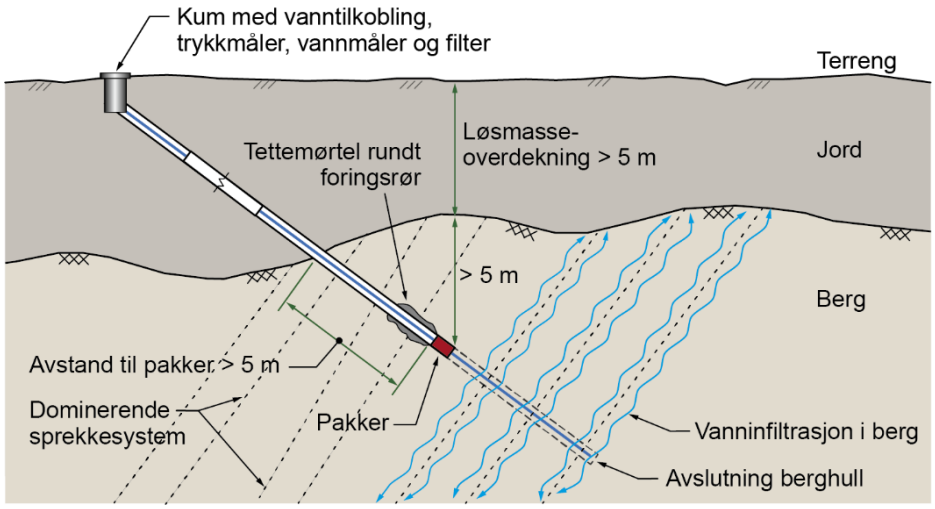
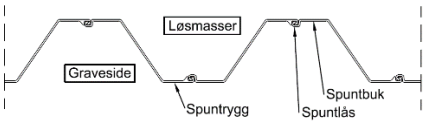
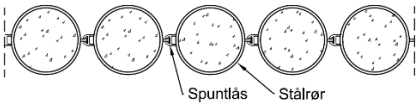
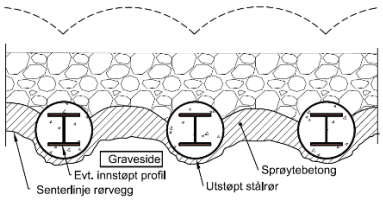
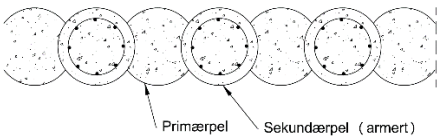
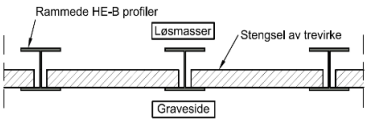


Figure 6 Principles for an infiltration well in bedrock [1]

Types of excavation support

Another example is the overview of the various types of support constructions shown in chapter 6. The advantages and disadvantages of each method are listed here. In addition, it has been set up what and how the solution is to be controlled during establishment.

	Sheet piling, see chapter 6.3
	Drilled continuous pipe pile wall, see chapter 6.4
	Tubular wall, see chapter 6.5
	Secant pile wall, see chapter 6.6
	Wall of stop logs (Berliner-wand), see chapter 6.9

Figur 7 Excerpt from table showing the most common types of excavation support in Norwegian building pits.

This chapter discusses recommended solutions such as open excavation, sheet piled walls, drilled pipe piling, secant and tangent pile walls, diaphragm walls, jet piles, wall of stop logs and soil freezing.

5. SUMMARY

The Building Pit Guide is a tool for spreading knowledge throughout the building and groundworks industry. Either those working with planning and design, contractors who carry out groundwork and foundation on construction sites or owners. The effect on the neighbouring area of the work we do in building pits that was mapped through BegrensSkade is no longer something we can ignore.

The committee for the Building Pit Guide also conducts small webinars, both to elaborate on topics in the book, and to supplement with new knowledge.

The guideline is available on the website for the Norwegian Geotechnical Society.

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[3] J Langford et al.: Begrensning av skader som følge av grunnarbeider (BegrensSkade I). Sluttrapport. 2026.

[4] Eurocode 7: Geotechnical design – Part 1: General rules. (NS-EN 1997-1:2004+A1:2013+ NA:2020).

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