Education of drilling personnel carrying out pile and anchor drilling in Norway – effect on quality and plans for new education in Norway

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ABSTRACT
As a part of the research programme "LimitingDamage", it is carried out an interview study on how drilling operators carrying out pile and anchor drilling in Norway are trained.
The background for "LimitingDamage" is that unexpected and undesired damage occur to neighbouring properties and adjacent infrastructure, because of groundwork, and the goal is to find causes and means to limit the damage.

The goal of the interview survey was to identify needs for organized common training. In addition, the desire was to probe the interest of public venues for sharing experiences, and attitudes to certification within the industry.

It was of interest to assess geotechnical understanding among groundwork operators, as this could affect the quality of the work and the possibility to limit damages on neighbouring installations and buildings. It is important to map whether the operators have any chance to learn about geotechnical engineering by training or public venues and if they are interested in such knowledge.

The qualitative interview study consisted of 11 interviews with candidates from seven different foundation companies. The impetus to be interviewed was to have some form of responsibility for training of or be drilling rig operators themselves.

The educational options granted in Sweden and Denmark were also checked out.

It emerges from the interviews that the new drilling rig operators receive in-house training by experienced drillers. The training centres on operating the rig in an efficient manner and maintenance and not on the effects that drilling, e.g. water and air pressure, has on the structures of the soil, i.e understanding of geotechnical effects. The personnel are interested in understanding more of the effects of drilling on the structures of the soils, but have little chance of achieving this kind of knowledge.

Norwegian Association of Heavy Equipment Contractors (MEF) has recently applied to establish a three-year training programme in secondary school level for foundation work

Keywords: Geotechnical drilling works, drilled foundations, micro piles, training of rig operators

1 BACKGROUND

The background for the research project “BegrensSkade”, or translated into English "LimitingDamage", is that ground works such as deep excavations and foundation works performed in soft clay are known to frequently cause damage to neighbouring buildings and structures. The costs related to these types of damage can be substantial and there is probably a large potential for reducing these costs. This is the main topic of the research project funded by the Norwegian Research Council and a wide range of consultants, contractors, clients and institutes.

Improved performance provides savings by reducing the number of damages, facilitating faster implementation, fewer delays and fewer disputes.

"LimitingDamage" aims to develop new methods of execution and improve interaction processes to limit the damage that can be attributed to ground and foundation works in the building, construction and real estate industry. The project has broad support from the Norwegian BAE industry with 23 partners including representatives from all stakeholders (builders, contractors, subcontractors, consultants, real estate and insurance companies as well as research institutes and universities).

The project looks at the whole range of causes and possibilities for improvement from the engineering of ground and foundation work through to the execution and monitoring.

2 TASK DESCRIPTION FOR THE INTERVIEW STUDY

This paper is based on the report from the interview study made by Veimo, I. et al (2015) focusing on the topic "Mapping of Drilling operators’ training in groundwork in Norway".
The main activity for the study was interviews with key people in drilling firms in Norway. Additionally laws and framework governing performance of such work in Norway, as well as the approach to training of personnel in Sweden and Denmark, was reviewed. This paper however, focuses on the training of drilling operators.

A hypothesis is that the industry would benefit from a joint training, which might lead to more equal education and thorough training. This again might lead to better execution of work, and thus as a result less damages caused by foundation work. Said in another way, by better performance through more knowledge, more uniform practices and better reporting, it is likely that the quality of foundation work could be improved.

Possible side effects of common training may be to bring up a discussion on performance between the executing parties as well as to establish contact between personnel that perform the same job in different companies. It is reasonable to expect that arenas for the exchange of experience arise more easily when personnel meet.

As per today, there is little literature on carrying out drilling in Norwegian, anyway which is not related to those supplying equipment. Through systematic training designated training materials would have to be produced.

In the LimitingDamage project, it was also performed comparative experiments in the field of various drilling techniques for drilling rods, and made a report where causes of injuries, phrases and pore pressure variations due to drilling is discussed. Among other things, the use of air pressure and water during drilling are key issues. Knowledge about the mechanisms and causes of reactions in the soil by drilling is very important.

The interview survey focuses on the training of personnel who carry out **drilling** of piles and casings. It may be considered to perform the same kind of research on driven piles,

sheet piling, and installation of rods if "Limit Damage" is expanded later.

3 FRAMEWORK

3.1 Drilling of water wells and drilling for foundations

Drilling of anchors and piles fall under the field of drilling wells and specialty drilling. In industry, it is typical that some firms only are doing well- and specialty drilling and some are working in a wider field within groundwork like sheet piles, driven piles etc. The first group often operates as subcontractors to the latter. This is partly because large projects require larger capacity drilling.
In Norway, there are two associations for well drilling and special drilling. One is Norwegian well driller Association (www.bronnborer.no) and the other is the Department of Low and Special Drilling under Norwegian Association of Heavy Equipment Contractors (www.mef.no). These unions seem to have a good working relationship.
There are no common professional forums for those who carry out practical foundation work where they can discuss their experiences at the operator level. In the interview survey, we ask if there is interest in joint academic arenas.

3.2 Required ssafety and security training

Although there is no requirement for certified training on drilling rigs, the employer is obliged to provide documented safety training (practical and theoretical), if work equipment is considered to require particular care.

3.3 Improved safety and working through drilling

MEF and NAF (regional safety representatives) are working actively to strengthen education within foundation work and safety training for machine operators. This seems to apply both within foundations and rock drilling where there has been many occupational injuries, partly because of dust and noise.

In 2013, the first specialist training for rig operators commenced at the technical college in Stjørdal. However, the number of applications for this study at college level has been low, and MEF has now applied for the establishment of a separate certificate in foundation.

If stricter requirements for training and equipment were to be introduced this would require an amendment of the regulations "Performance of work and use of work equipment". Groups that may have influence on the development of laws and regulations are:
- Regional safety representatives
- Within rock drilling: The reference group for the Labor Inspection’s regulatory forum, and the industry council on tunneling
- The Labor Inspection’s forum for work equipment
- MEF - Norwegian Association of Heavy Equipment Contractors

3.4 The Planning and Building Act, central authentication and search tags

Execution of works involving the drilling rig is regarded as specialist work that should be performed by trained and qualified personnel in order to ensure good quality of execution as well as maintain safety.

Foundation work like piling and sheet piling, including drilling of piles and casings for anchors, fall under the application code “earthworks” in the current Planning and Building Act. Excerpts of the guidance to building regulations (SAK10) which defines the areas for approval with examples show that approval area "earthworks" is a broad. In practice, there are also many machine entrepreneurs / dig firms that use the same authentication area as a special contractor in foundation uses.
This may lead to the requirements of documented knowledge within foundation being too low, or that those with good knowledge of the special work are treated on equal terms as undertakings with lower competence.

In practice foundations, firms sometimes perform work under the main contractor's right to accept responsibility, as the contractor has approval for site preparation, which also includes foundations. A potential separate search code for foundation work may be motivating for specialist companies within foundations. These would require specialist training in this field in order to get approval, which would in turn require the existence of relevant education and courses.

4 INTERVIEW STUDY – IMPLEMENTATION

4.1 Interview Survey

An interview study was chosen as the approach to map current practice of training drill rig operators. Interviews were conducted in the period from February to May, and September 2014. Eleven interviews were conducted.
Choice of interview candidates was random in the sense that the firms contacted picked candidates themselves by the CEO or training / human resources manager. It was requested that the person who was to be interviewed should have primary responsibility for the training of drilling personnel in the current business, but drilling rig operators were also interviewed.

It was decided to interview people in different positions and thus individuals taking part possessed different roles; chairman, mate, construction manager, project manager and experienced drilling operator.
Candidates' age ranged from young people to men with over twenty years of experience.

Information was sent out by e-mail in advance of the interviews. Several of the firms contacted are also partners in "LimitingDamage", and knew the research projects main goals already.

4.2 Main topics

The main goals of the interview survey were:
• To find out how the training of personnel who carry out drilling of piles and struts in Norway is undertaken
• Check the need for/attitude towards joint training, and check what such joint training should encompass
• Identify interest in and possible settings for common arenas for sharing experience
• Map the attitude towards a possible certification for this kind of work

These are further discussed in the next subchapters.

4.3 Mapping of training

Through the interviews, the aim was to answer the following questions:
• Is it true that training varies from company to company?
• Is the training systematically performed?
• Is it easy / hard to conduct training without training material?
• Is joint training desirable?
• Are certification requirements desirable?
• Is it a challenge that there is no official training?

Through the interviews, it was attempted to answer these questions through asking how training was done for the latest new hires at the firm.

4.4 Joint training

The focus of the questions to this topic was to uncover what joint training might encompass. During the interviews both training of personnel already in employment and training of new personnel and recruitment was discussed. The interview subjects were both asked open questions, as well as presented with a list of possible relevant topics in case the interviewee did not have have that many own ideas. Also, the answers from the interviewee was compared to this list. The list comes from the curriculum at the Technical College in Stjørdal.

4.5 Venues for exchange of experience

This point in the interviews was mainly covered through open conversation/ discussion. Initially, some of the candidates believed that they would in any case not have the time or the finances required to allow for such meetings, but after further reflection there were several candidates who expressed

that venues for the exchange of experiences was important. It appeared that the interviews acted to stimulate reflection on this topic for some of the candidates

4.6 Attitudes towards Certification

The topic of certification had in many interviews already entered the discussion previously when you got to this point, e.g. as part of the discussion on the equipment or if the machine operator license came up as part of the discussion on personnel training.
The question was nevertheless brought up at the end again to summarize the attitude towards certification.

4.7 Businesses in the industry

As part of the study, it was attempted to get an overview of the companies in the industry. Below is a list of the companies where interviews were performed, as well as a list of other firms that could have been relevant to talk to.

The capacity to do surveys were limited due to time and resources available, as well as by geography and ability to travel.

Interviews were performed with representatives of the following companies:
- Sør-Norsk Boring
- Brødrene Myhre
- Entreprenørservice
- Fundamentering AS (FAS)
- Nordisk Fundamentering AS, department Smefa and department NSP
- Hallingdal Bergboring
- Seierstad Pelemaskiner

Other potential candidates, not interviewed due to time constraints:
- Holt Risa (now Seabrokers Entrepreneur Service
- HERCULES Fundamentering AS
- Vestnorsk Brunnboring AS
- Båsum Boring
- Norsk Boreteknikk
- Brønn og Spesialboring AS
- KRAFT Energi og Brønnboring

5 SUMMARY OF INTERWIEVS

The outcome of the interviews uncover both similarities and differences between the various drilling contractors and operators. The main results from the interviews can be summarized in five different categories, see below. As can be seen, a new point in addition to those outlined in the interview guide is included, and it is HSE-related issues. This topic often came up in the discussions, and the interviewees asked about their experience with injuries.
The summary is thus divided into the following main categories:

A. In-house training
B. Attitudes towards joint training/courses
C. Common venues for knowledge exchange
D. HSE-related topics
E. Certification

5.1 A. In-house training

Most new employees in drilling firms begin on the floor as mate, in some cases as a welder. They will then usually be appointed an experienced drilling rig operator as mentor/ teacher that demonstrate and instructs them on how to perform the work. They will walk beside the experienced drilling rig operator and get a gradual introduction to the equipment and methods by trial and error with guidance. Many companies have a system for approval of the new drilling rig operator before he can become independent, and often it is an experienced drilling rig operator who gives such approval.

How long it takes a new operator to learn how to maneuver the rig depends on the person. Some learn quickly, while others take longer. It is obvious that people who are used to dealing with machines learn faster and often they can maneuver rig in a week's time. However, it takes longer to become a good drilling rig operator. Candidates reported a span of between 1 and 4 years to become good at drilling and drilling independently.

Once a new employee had begun to drill independently, they could always call for experienced drilling rig operators if there was

a problem. One candidate said that if it were not possible to solve the problem over the phone, the experienced personnel would visit the site to see if it was possible to solve the problem on site. However, one candidate also mentioned that rig operators become independent prematurely because of work pressure and that it would be better if the training period could have lasted longer.

It is considered easier to start with rock drilling compared to soil drilling. This is because it is easier to interpret sound and cuttings from rock drilling. One company reported that they recruit many drilling rig operators from Sweden. This is because they have education in the well drilling and are good at drilling rock. However, they are not as adept at drilling in soils, as this is not included in their education.

One company reported that they have a certificate of drill competence. Other companies viewed this favorably and expressed an interest in similar set-ups. They expressed that there was a competitive advantage when the certificate concerns safety issued and that it is important to establish something similar.

5.2 B. Attitudes towards joint training

The results from questions about training and joint training drilling operators is different. In principle, everyone believes that a common training for drilling operators would be beneficial, but the answers are different when it comes to the time, content and distribution between theory and practice in such training. There are also varying opinions about whether this should be an education at technical college or not.

Many companies wish for a common education in the hope that it will be easier to recruit new people to the firm. All interviewees who participated in the study consider that the training/ course should include both theory and practice. There is a need for courses for both new drill rig operators and those with experience. Such courses could be of varying duration and content depending on the expertise of the participant.

Different proposals came in regarding how long the training should last, ranging from 2 days for experienced drilling rig operator and one month for new employees. Some wanted a longer course up to 2 years, but at the same time, there is a concern that if the training is too long the drill rig operators will not remain within the profession because of high aspirations that drive them to move on with other work. Others believe in an education following high school.

The responses from the interviews are consistent when it comes to that education should include both theory and practice, although in different amounts. Some want a little theory and more practice, while others believe that the practice is taught through at the job training and therefore theory is more important in c course. In general, it may be a challenge that rig operators do not want too much theoretical education, as they have a preference for practical work. As an example, one candidate believed that the Swedish education is too theoretical. There is still a desire by that companies that the drilling rig operators know more about geotechnics.

Several of the candidates believed that the subjects taught in Stjørdal form a good base for training/ courses. What is wanted beyond what exists there is more geotechnics, HSE, and maintenance. The course should also be geared towards geotechnical challenges to capture the interest of drilling rig operators. The theoretical parts of the course should cover geotechnics, geology, drilling techniques and method in order to generate a greater understanding of the craft that a drilling rig operator performs. One candidate expressed that the course should cover new developments, new machines and methods. The practical part should include more on maintenance of machines and hydraulics.

5.3 C. Venues for knowledge exchange

The response to the possibility of creating more common venues for knowledge sharing within the industry was positive. Such venues

might form a good complement to the conferences that exist today, which are often too academic for drill rig operators and foremen. Many said that it might be a good idea to do something in conjunction with fairs where vendors show new equipment. However, if such venues for personnel to meet across corporate boundaries are created they should not be so lengthy that it would negatively influence production. Some thought that it would be difficult to achieve a common day of training and knowledge sharing and suggested instead online training.

The interviews uncovered that there is not much contact between the drilling companies today, and one of the candidates said: "Many entrepreneurs will be reluctant to share information, and therefore it is challenging to exchange experiences."

5.4 D. HSE-related items

Generally, most people were conscious about safety and working environment, and claim that their companies are focused on this too. There are many risky situations occurring during drilling work, and many had also witnessed or heard about accidents. Squeezing injuries and injuries due to falling objects are frequent.

Generally, the candidates were not focused on accidents caused by lack of understanding of soil mechanics, i.e. land and groundwater behavior due to the influence of air and water pressure through drilling.

5.5 E. Certification

There are differing opinions on whether there should be certification required for drilling rigs or not, however, those who do not want such a certificate express that a machine operator license should be required. The interviewees put much emphasis on safety and want a machine operator license/ certification which increases both safety and quality in drilling. Many of the interviewees were generally positive towards a certification.

Several candidates brought up the example that it is not allowed to run a dig at 5 tons without machine operator license, but that there is no requirement to operate a drilling rig at 70 tons. It is a desire that the rules are made stricter in relation to this. As a candidate said: "It is not good that a 16 year old can legally drive such a machine without special training." Otherwise, some thought that it would be difficult to certify the already experienced rig operators. The firms also wanted to know if certification would be a one-time cost or result in a continuous introduction of new requirements.

To summarize, key take-away from the interview study include:
- Beginners learn from experienced drilling rig operators
- It is easier to do rock drilling for starters rather than soil drilling, as drilling in rock provides clearer feedback through to sound etc.
- Machine operator license for drilling rigs should be mandatory.
- There are differing attitudes towards certification by various firm
- Any course should have a large part practical learning. Maintenance of machinery and hydraulics is essential.
- It is interesting to obtain knowledge about the various drilling methods
- Drilling personnel is interested in geotechnics
- Drilling operators are interested in joint training and venues for exchange of experiences
- There is much focus on HSE, and especially safety and working environment. There is less focus and knowledge on risk of damage to the surrounding environment due to land and groundwater behavior through the influence of air and water pressure by drilling

6 TRAINING PROGRAMS NORWAY

This chapter contains an overview of education in Norway on drilling and on general geotechnics for people with practical qualifications. Offerings in high school as part of the programs on building and construction or engineering and manufacturing are not included here.

6.1 Stjørdal Technical College

A training scheme has been developed at Stjørdal Technical College as a one-year program with a scope of 60 credits. The program is organized in modules with both theoretical and practical training.

Candidates would be specialized in one of the following three areas:
1. Foundations
2. Drilling for rock blasting
3. Well drilling

Common topics for all three specializations:
• Machinery and equipment
• Applied geotechnics and geology
• Quality assurance and HSE (laws and regulations, standards and contracts).
• Communication (drilling report, work procedures, checklists)
• Surveying (coordinates and altitudes, launching and surveying points)

6.2 Purposed education program

Heavy Equipment Contractors Federation (MEF) has submitted an application to the Directorate of Education on the establishment of a separate certificate for "Foundation work" in secondary school.

Four different modules are planned:
- Well Drilling
- Rock work (rock blasting, injecting, rock support)
- Foundations (piling, sheet piling and shoring, anchoring)
- Directional drilling

In the draft curriculum received from the MEF in June 2014, it appears that there are also plans for a common part covering the following topics:
• Laws and regulations
• Relevant standards
• Production
• Drilling technique
• Machinery and equipment
• Quaternary Geology
• Hydrogeology
• Safety
• Quality assurance

6.3 Geotechnical subjects in Well Water Project in Buskerud

In connection with the project "Good Water" being implemented in the Drammen region to ensure good water supply in the future (http://www.godtvann.no/), some study programs were created at Buskerud and Vestfold University College.
A course called Geotechnical construction and organization has been taught as part of a bachelor called "Water and Environment". This subject has been taught for personnel with practical competence, and has been possible to take as individual subjects through workshops.

This example is included here to show that there are few opportunities to gain insight into geotechnics without taking engineering education or studying at the university level, but these opportunities are not many in Norway at present.

6.4 Flexible learning, basic geotechnics

A course is under development in flexible learning in basic geotechnics at “Norgesuniversitetet”.

An overarching aim is to increase cooperation between academia and the workplace to raise the geotechnical expertise in the industry. A prerequisite for achieving this is to take advantage of flexible distance learning.

A project consortium has been created with several participants, among them universities, private and public institutions.

The course consist of the following modules:
• Module A: Soil Properties
• Module B: Field and lab
• Module C: Geotechnical structures
• Module D: Calculation
• Module E: Construction geotechnics

6.5 Other courses

Several associations can be/are initiators of courses in geotechnical and drilling technique:
• Tekna

• Norwegian Geotechnical Society (NGF)
• Machine Contractor (MEF) union branch Well and special drilling
• Pile and steel sheet pile contractors association
• Norwegian well drillers association

Tekna and NGF collaborate on courses within geotechnics. In 2014 they had courses in "Stability" and "Peleveiledningen" and "Ground drilling". Courses are generally theoretically based, with the exception of the basic drilling course, and are aimed at engineers who already have basic geotechnical expertise.

MEF has more practically oriented courses for contractors. They provide, for example, courses in piling machines with duration two days. The course gives, together with 40 hours of documented experience, expertise license in piling rigs.

There is as far as we know, little cooperation between the various associations on giving courses. Here the industry has something to gain by better cooperation.

7 7 EDUCATION IN NEIGHBORING COUNTRIES

7.1 Training in Sweden

In Sweden drilling personnel are educated through GEOTEC, which is the well drilling industry's association. They have approximately 80 member companies. GEOTEC offer courses and as a voluntary certification scheme.

SAFE Swedish Grundläggning is a Swedish association for foundations firms. SAFE offers educational programs for operators and functionaries where part of the training is common.

7.2 Training in Denmark

In Denmark, there is training organized by the Association of Danish Well drillers. (www.broendborer.dk)

The following describes the contents of a part of the courses:
• "Removing and description of drill samples" contains a thorough review of Denmark's geological history from the Cretaceous to the present. Moreover, efforts are sampling and description and the legal requirements for reporting to GEUS.
• "Maintenance of equipment and materials" deals including hydraulic systems, pump technology and a statutory welding environment courses.
• "Applied drilling technique» undergo all common drilling methods to onshore drilling compared geology and purpose.
• "Management of drilling tasks" undergoing the relevant legislation and provides an introduction to hydrogeology and water chemistry. Groundwater Lowering be reviewed with calculation examples.

In Denmark, in addition to learning the actual drilling, the courses much focus on the environment and pollution risk. Drilling causing spreading of contamination in groundwater is an important issue in the practice of drilling in Denmark.

8 MAIN CONCLUSIONS, SUGGESTIONS FOR FURTHER WORK

Interviews with eleven candidates from seven different firms have been conducted during winter and spring of 2014 to study the training of personnel who carry out drilling of piles and casings.

In short, the typical findings from the interview study are the following:
- There is a requirement for documented safety work
- Beginners learn from experienced drilling rig operators
- It is easier to do rock drilling than soil drilling for starters, as drilling in rock provides clearer feedback through to sound etc.
- "Heavy Machine driving License" required to drive almost all other equipment like digging machines and groundwork machines should be mandatory also for drilling rigs

- There are differing attitudes towards certification by various firms
- Any course should have a large share of practical learning. Maintenance of machinery and hydraulics is essential
- Insight into the drilling methods and choice of these is interesting to obtain
- Drilling personnel are interested in geotechnics
- Drilling operators are interested in joint training and venues for exchange of experiences
- There is a lot of focus on HSE, and especially safety and working environment. There is less knowledge about risk of damage to the surrounding environment due to land and groundwater behavior through the influence of air and water pressure by drilling

8.1 The way forward

Approval plans in the Planning and Building Act reflects to a small degree foundations and foundation drilling as a specialty. This is another common trait that affects several types of specialty contractors, but should be communicated in the appropriate fora that could cause a small advantage for those who decide to invest in expertise and training. There are several programs in geotechnics and drilling technique under development in Norway now. Among other things, an online course in basic geotechnical, and a certificate in foundation. Within the well and rock drilling there education in both Sweden and Denmark, and one can gain experience there. It is for the group's assessment a minimum to get a claim for machine operator license to carry a drill carriage. Limit Damage to communicate this to the legislators. It should also develop training associated secondary schools that provide some deeper insight and which also ensures recruitment to foundation industry. Limit Damage and MEF should have experience and cooperation on a training plan for drilling operators. Geotechnical Training offered to a small degree for people in the workplace who are not trained in geotechnical engineering from the University / College. Conferences and seminars organized by Tekna and NGF are mostly adapted to this group. It may hinder their expertise spread among more convenient personnel and officials in the construction industry. Missing basic geotechnical competence affecting insights into subjects and workmanship and in turn the quality. In a collaboration between the various associations can develop courses more geared toward entrepreneurs with a practical aspect, and undergo basic geotechnical expertise.
The group proposes that consideration should be given to making the same kind of investigations for example, driven piles, sheet piles, and installation of rods. There has been expressed a desire within the research project "LimitingDamage" to make such investigations in relation to the other disciplines within foundation work as well.

8.2 8.2 Main conclusions regarding courses and exchange of experience

The interviews and the communication environment in general are the following:
• NGF and Tekna organizes today courses in soil mechanics and foundation.
• MEF or similar organizations where contractors and suppliers are more strongly represented should be encouraged to arrange courses in geotechnical and drilling technique.
• Training and exchange of experiences within foundation and geotechnical engineering should be arranged both for the practical construction industry and for the more theoretical advisor industry.
• It is possible to build on the mandatory safety training and the machine-specific training.

9 REFERENCES

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