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# Training for specialised civil engineers

## Formation destinée aux spécialistes de la fondation

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**ABSTRACT:** Foundation and ground engineering is one of the most accident-prone sectors of the whole construction industry. It is therefore of the utmost urgency to give employees even more intensive training and also to convey knowledge and skills in the field of work safety and health protection. The paper illustrates how systematic training of workers can reduce accident figures, improve quality and cut costs.

**RESUME:** La fondation spéciale est un des secteurs de toute l'industrie de construction connaissant un des taux d'accident les plus élevés. Il est pour cette raison indispensable de donner aux employés une formation solide qui leur permettra de disposer de connaissances et de méthodes de travail dans le domaine de la sécurité et de l'hygiène du travail. L'exposé explique pourquoi une formation ciblée peut réduire les taux d'accidents tout en améliorant les conditions de travail et contribuer à la baisse des coûts de production.

### 1 INTRODUCTION

Underground construction projects are constantly presenting everyone, involved in these works, with new tasks requiring special knowledge and experience. When enclosing a building pit with steel sheet pile walls or in situ concrete pile or diaphragm walls, in foundation underpinning using injections or soil freezing methods and driving microtunnels, it is vital that the assumptions made in the preliminary design stages are constantly reviewed. Depending on the local conditions, earlier findings must often be revised at short notice and substituted by completely different technical solutions.

The sector is one of the most innovative specialist areas in civil engineering. Mechanical and construction developments can only be successfully implemented when employees prepare for these innovations with versatility and a willingness to learn, rendering them suitable for practical applications and making efficient use of them.

Foundation and ground engineering works involve an exceptionally high level of mechanisation. Reliable and well-trained experts are required to operate and maintain this highly developed equipment.

The training of the workers must be a continuous process. In their basic training, they must receive specialist instruction both on the job and in training establishments. This knowledge can be updated in in-house courses and supplemented by external training sessions. The technical training of executive staff must be made particularly demanding.

These high demands on the qualifications of employees and the considerable expense that is necessary for further education and training are a difficult matter especially when market conditions are not favourable. The pressure of competition, which the construction industry is currently having to cope with all over Europe and which, due to the lack of public investment options, is not likely to improve in the foreseeable future, sometimes leads to "false economies". Dispensing with targeted personnel development can only produce short-term savings; in the long and medium term, however, it becomes clear that additional costs are incurred through inferior quality and interruptions in the construction process resulting in material damage and personal injury.

Accidents constitute a major cost factor in foundation and ground engineering. The well above-average frequency of accidents in this segment of the industry means that the costs of sick pay following accidents and of rectifying material damage as well as the costs of liability insurance, all-risks construction insurance

and accident insurance are also exceptionally high. Accident prevention measures are therefore also measures for cutting costs and accident prevention begins with proper training of staff.

### 2 ACCIDENTS IN FOUNDATION WORKS

Tiefbau-Berufsgenossenschaft (TBG) is the statutory accident insurance institution for construction companies in Germany that are mainly involved in civil engineering. Unlike the schemes prevailing in other countries, the German accident insurance system is not organised as an official body, but as an independently administered mutual institution. Contributions are paid by the member companies and all the major decisions devolve on committees in which employers and employees are equally represented.

The sector of "prevention" and its technical and medical experts advise and supervise the more than 13,000 member companies. Extensive training opportunities are offered with courses on a wide range of subjects for the over 540,000 people insured. The many years spent observing and analysing the causes of accidents highlight the areas in which deficits exist and where technical or organisational and personnel measures for preventing accidents need to be suggested - or even prescribed.

TBG is working intensively on this subject in cooperation with representatives of the trade unions and employers. An extensive survey of accidents going beyond the normal scope of accident reporting was carried out among companies engaged in foundation and ground engineering together with the Bundesfachabteilung Spezialtiefbau (BFA STB) im Hauptverband der deutschen Bauindustrie (Foundation and Ground Engineering Department in the Central Association of the German Construction Industry). The results of the ensuing analysis were published in 1995 in the TBG journal "TIEFBAU".

Investigations have shown that hazards arise in particular in interaction in the relationship between "Man + Machine", resulting in an increase in the number of accidents.

Interesting results were also obtained in the evaluation of the age and length of time that the people involved in accidents belonged to the company. It revealed that younger workers who had only recently joined the company were far more frequently involved in accidents than their more experienced colleagues.

In this age of growing international cooperation, comparative figures reflecting accident experience in the different countries ought to be compiled. But the national statistics that have been published are prepared on the basis of different recording and

analysis criteria, making them virtually incomparable. As a result, the "Safety and Education" Working Group of the European Federation of Foundation Contractors (EFFC) - an association of foundation and ground engineering companies from 15 European countries - decided to draw up a data analysis of its own. This international project also had the objective of identifying the main accident areas and working out a basis for introducing technical changes and developing training programmes.

- assembling/dismantling equipment
- shifting loads
- walking
- operating an equipment/a plant-unit
- handling materials
- working with hand-tools
- climbing up machines or plant-units
- repairing works

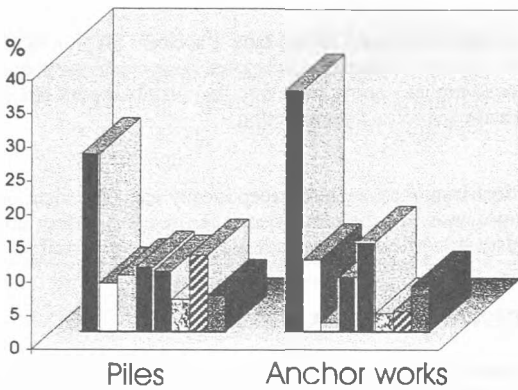


Figure: Main accident areas: Activity of the injured party (Ensinger, 1995)

### 3 FOUNDATION AND GROUND ENGINEERING WORKERS

Surveys conducted by the BFA and data collected by TBG reveal that about 10,000 people are currently employed by German contractors operating in the field of foundation and ground engineering. The proportion of salary earning staff has risen sharply over the past few years and now represents more than 20 % of the total labour force.

Executive staff working in this sector have usually completed a course of study in civil engineering at Technical Universities or Technical Colleges or in isolated cases in mining. In addition to basic instruction in foundation engineering and soil mechanics as well as construction management, prospective foundation and ground engineers can at many universities also attend courses in other specialist subjects.

The scope and manner in which students are prepared for the subject of "work safety and health protection" varies greatly according to where they study. While some universities at least offer the basic principles in the form of compulsory lectures, other universities restrict themselves to voluntary immersion courses, or the subject is not offered at all.

The situation is similar when it comes to training technical staff, superintendents and foremen. While the number of hours devoted to teaching the principles of preventive work is reasonable at some training establishments, other colleges restrict this subject to a few modest references. Graduates from such colleges run the risk of having to assume responsibility for the safe organisation of operating procedures at their first job, without ever having received the necessary training.

In Germany, there is at the moment no specific apprenticeship for foundation and ground engineering workers. Workers spe-

cialising in this sector have therefore received no specialist training, but have often completed an apprenticeship in another construction trade. Many foundation and ground engineering workers were given instruction and trained in the companies - without any state controlled training scheme. It is easy to imagine that under these conditions the level of training for these "specialists" is bound to vary greatly.

## 4 LEGAL PRINCIPLES OF PREVENTION WORK

### 4.1 General

The employer is responsible for ensuring the best possible safety and health of employees at work by using appropriate equipment and organising operating procedures properly. This basic responsibility of the employer is laid down in laws, decrees and accident prevention regulations.

It goes without saying that each employee also has certain obligations as regards work safety and health protection. What is especially important is that every employee has to respect certain safety instructions - such as operating instructions for using a machine or handling a hazardous substance.

### 4.2 EC "Work Safety" Directive

The principal features of the obligations on the contractor and his staff, which were previously governed by national regulations, were reformulated in the course of the European efforts towards harmonisation. Standard minimum requirements were laid down by law in all the member countries of the EC by the "Council Directive on the introduction of measures to encourage improvements in safety and health of workers at work" (89/391/EEC) - the "Framework Directive".

In 1996 this Directive was implemented in Germany as well and is part of the "Arbeitsschutzgesetz" (Work Safety Act). In addition to the above-mentioned obligations on the employer and employees, the act also contains binding regulations stipulating

- the determination and evaluation of hazards,
- the implementation of measures for preventing hazards according to the state of the art,
- the documentation of the results of hazard assessment and the ensuing work safety measures and
- appropriate instruction of employees on safety and health protection at work.

In the course of this instruction, the employer must give directions and explanations to his employees that take account of the special conditions prevailing at the place of work and in the scope of work of the employee. As a result, such instructions must be provided straight away when a new employee is engaged and then at regular intervals and especially when major changes are made to equipment or working methods.

These instructions are based on the hazard determination and assessment measures already described above. Both the hazard analysis and the instructions can only be efficiently implemented when this responsibility is assumed by reliable expert personnel.

### 4.3 Foundation and ground engineering regulations

#### 4.3.1 Regulations governing machinery

The essential health and safety requirements for machinery are laid down in the Machinery Directive (89/392/EEC). The protective objectives set forth in this Directive are defined in greater detail by European standards.

The following harmonised standards are of particular importance to foundation and ground engineering machinery:

- EN 791 Drill Rigs - Safety and
- EN 996 Piling Equipment - Safety requirements.

These recently resulted in some major changes compared with the previous national regulations governing design and construction. Machine operators, and in particular maintenance personnel,

must now be informed of these new regulations and trained accordingly as a matter of urgency.

#### 4.3.2 Regulations in the field of design and execution

Over the past few years a large number of standardisation projects on foundation and ground engineering subjects have been initiated and handled in CEN TC 288 "Execution of special geotechnical works". In the meantime, draft standards have been prepared for nearly all sectors of foundation and ground engineering and initial standards have already successfully gone through the international voting procedure.

Many of the stipulations laid down in these European standards have a major influence on safe design, construction and quality control in the execution of civil engineering structures. This transition from national standards, which construction workers were familiar with, to new regulations often involving substantial changes makes it particularly necessary to provide appropriate training.

In this connection, it should be noted that the initial applications of EC 7 and its calculation and design requirements have led to, and are still giving rise to, much discussion among experts. Upon its publication in Germany "for trial application", it was expressly pointed out that the results should be reviewed to ascertain whether they resulted in any "uneconomical over- or dangerous underdimensioning". This makes it clear that considerable further information is needed when introducing these new standards.

#### 4.4 EC Directive "Temporary or mobile construction site"

As early as 1992, a European Directive was drawn up pertaining to safety aspects in the planning and execution of construction projects. Even in the design phase, stipulations must be made that have a major effect on work safety and health protection during the subsequent execution and operation of the structure. The Directive thus stipulates that a safety coordinator shall be appointed by the employer even at this early stage.

In the course of construction safety, problems frequently arise because different companies are working on the same construction site without having a contractual relationship with each other, but being engaged directly by the owner. The Directive also obliges the employer to appoint a coordinator for this construction phase whose task it is to coordinate cooperation between the companies working on the site at the same time in such a way that mutual hazards are avoided as much as possible.

Germany, unlike other partner countries, has unfortunately still not managed to implement this Directive into national law. But despite this, efforts towards drafting and implementing courses in this new field of "Construction Coordinator" are already underway.

#### 4.5 Regulations governing construction operations

In the fields of "Social work safety" and "Regulations governing construction operations" the EU limits itself to stipulating uniform minimum requirements. It is left up to the member states to prescribe more far-reaching national regulations.

In Germany, such regulations are in most cases laid down by the statutory accident prevention and insurance institutions. The accident prevention regulations covering "Construction work", "Earthmoving machinery" and "Piling equipment" are of particular relevance to the field of foundation and ground engineering.

The new "Rules for safety and health protection in foundation and ground engineering work" due to be published for the first time in April 1997 provide us with a set of regulations containing safety requirements for construction work in all sectors of foundation and ground engineering. For introducing such new regulations it is essential that appropriate training and information sessions be offered.

## 5 TRAINING COURSES OFFERED BY TIEFBAU-BERUFGENOSSENSCHAFT

### 5.1 General

The institutions responsible for accident prevention and insurance run a large number of training establishments of their own throughout the Federal Republic of Germany, in which the trainees are accommodated and catered for in facilities of hotel standard. Classrooms are available for lectures and seminars.

The travelling expenses and costs of food, accommodation and courses for employees from member companies are borne by the respective institution. The training courses are usually held at locations obviating long journeys.

In the courses organised by Tiefbau-Berufsgenossenschaft, technical supervisory officers act as lecturers. Through their supervisory work on construction sites, they are kept up-to-date with the latest developments in construction activities, so that the training programmes and examples offered can be regularly updated.

Like actual construction practice, the training of employees of construction companies is very much of a seasonal nature. TBG takes account of these constraints by offering courses for construction workers mainly in the months of December, January and February.

### 5.2 Courses for supervisors

These 3-day seminars are aimed at management staff on the construction sites, meaning resident engineers, superintendents and foremen. Owners of small construction firms often take part in these courses themselves. In addition to such safety-related subjects as "sheeting and working widths", "protection against falling", "use of earthmoving machinery" or topical examples relating to accidents, legal aspects ("responsibility and liability") are also dealt with.

Apart from courses on "general civil engineering", training programmes are also offered for specific target groups. Examples of such courses are "building construction and civil engineering", "sewer construction", "structural engineering and highway construction", "pipe-line construction" or "work in contaminated areas".

When the new regulations for foundation and ground engineering are published, it is planned to include more foundation and ground engineering subjects in the range of courses offered for supervisory staff.

### 5.3 Courses for safety delegates

By law, a certain number of workers must be designated as safety delegates, depending on the total number of employees. Their training also lasts 3 days and here too special courses are offered for the various construction trades.

### 5.4 Courses for specific trades

In view of the great demand from member companies of TBG, more emphasis is being placed on safety seminars for specific trades. The target groups include machine operators, maintenance personnel for construction equipment („competent person"), electricians, apprentices or commercial staff.

### 5.5 Courses for engineers

The frequently very mixed nature of people attending courses for supervisory staff has induced TBG to provide courses specifically aimed at the target group of "engineers".

These courses occasionally offer parallel lectures, giving the participants the chance to select subjects that are of interest to them and important for their work from among the range of subjects on offer.

Following initial successes, more engineering courses will in future be organised specifically for foundation and ground engineers.

### 5.6 Training of safety engineers

The German „Arbeitssicherheitsgesetz“ (Industrial Safety Act) provides that each company must employ experts in work safety. 5-week training courses for these safety experts (engineers, technical staff and foremen) are offered by the accident prevention and insurance institutions for this purpose.

In the course of this extensive safety training, a prerequisite of which is appropriate specialist training and several years of professional experience, topics covering all aspects of construction are dealt with. The courses also focus on conveying and training skills in communication techniques - the job of the safety experts is after all primarily a matter of persuasion and involves motivating their colleagues to greater safety consciousness.

The particular requirements of foundation and ground engineering are outlined and discussed in detail in the 5th week of the course.

Safety experts graduating from the course are kept regularly informed of all major innovations in the field of prevention by a circular sent out by the institutions and they are invited to attend advanced training sessions.

In small businesses, the employer can in some cases himself assume these safety duties after receiving appropriate training. The accident prevention and insurance institutions also provide suitable seminar programmes for them.

### 5.7 Courses organised in cooperation with universities and other training establishments

Through lectureships, the staff of TBG offer lectures for civil engineering students at a large number of Technical Universities and Technical Colleges. The range of subjects on offer is so extensive that they usually cover key areas in the training of work safety experts.

The training centres of the construction industry and the construction trades also offer lectures on the subject of prevention as part of their regular courses. The same is true of schools for technical staff and foremen and close cooperation is maintained with the specialist instructors at vocational schools.

### 5.8 Other special courses

Only a few of the special training courses run by TBG are mentioned here. The following courses are of particular importance to foundation and ground engineering workers:

- Work in contaminated areas
- Tunnelling
- Working under compressed air conditions
- Coordinators for works at contaminated sites
- „Project execution“ coordinators according to 89/392/EEC
- Quality management systems - Prevention

### 5.9 Seminars on foundation and ground engineering

Within the scope of a research project sponsored by the German Federal Ministry of Research and Technology, TBG has developed a Tunnelling Training and Experimental Institute („TLV“) in cooperation with several partners. The aim of this institute is to provide experts working in the field of civil engineering with advanced and further training by offering lectures as well practical real-life exercises.

The training programmes are meant to focus on work safety and health protection. But the subjects are to be presented with a near-to-actual approach maintaining constant contact with civil and mechanical aspects of tunnelling and foundation and ground engineering works.

Many of the training programmes proposed and in preparation will be of interest both to tunnelling workers and to other workers in the field of foundation and ground engineering. Courses are for instance planned in:

- shotcreting
- blasting
- working under compressed air conditions.

In addition, the TLV is also preparing special courses in foundation and ground engineering for engineers - whether they are involved in the design and mobilisation or in the construction phases - and for machine operators of foundation and ground engineering equipment.

## 6 CONCLUSION

Foundation and ground engineering is a sector of the construction industry in which the highest demands are placed on the qualifications of personnel. Underground construction work requires well-trained employees who display a sense of responsibility and a readiness to take decisions. The rapid developments in civil and mechanical engineering, the rising quality requirements and in particular the extremely problematic present market situation are making it essential to exploit every possibility of personnel development.

At the same time, it must be noted that a well above average number of serious industrial accidents occur in foundation and ground engineering work. Systematic implementation of accident prevention measures is therefore of the utmost urgency - for economic reasons among others.

Investments in advanced and further training of workers are wise and necessary. Tiefbau-Berufsgenossenschaft offers a large number of such courses and seminars at which safety problems are discussed and appropriate steps are presented for improving work safety and health protection.

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