

Augmented Reality training manual for formwork and scaffolding assembly



ARFAT

Augmented Reality training manual for formwork and scaffolding assembly



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ARFAT: The Augmented Reality Formwork Assembly Training

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1. Introduction and learning outcomes

About the project

Falls from height are the most common causes of serious accidents, often fatal, not only in Poland but throughout European Union. As human life is the most important value, there is a great need of elevating H&S level. This problem has been raised in European Directive 2001/45/EC, which obliges to take appropriate measures to improve safety and health at work.

The project address H&S issues as it stems from the need of prevention of accidents on construction sites. These accidents are mainly caused by falling from height, especially from scaffoldings. Works at heights (i.e. formworks, scaffolding works) are one of the most dangerous among construction works. One of the main reasons is: because current training methods are insufficient. As the research shows, workers are not interested in classic trainings. Use of mobile devices (smartphones, tablets), modern AR technology and supporting media files will make ARFAT training much more interesting and unforgettable. The need for the projects was also confirmed by the questionnaires and previous project (ARCW – Health and safety procedures for curtain walls with the use of Augmented Reality Technology). Both construction employees and employers stated that there is a great need for construction trainings with the use of AR.

As a result of the project, training system will be created together with paper manual, application for mobile devices and supporting media files. Training will be open for all interested parties, it will use innovative methods that suit in the best way modern, digital era.

OUTPUTS OF THE PROJECT:

- O1: Evidence based learning outcomes. This output comprises learning outcomes on formworks and scaffolding works namely statements of what learners should know, understand and be able to do upon completion of the ARFAT training, in the form of definitions of specific knowledge, skills and competences.
- O2: ARFAT training system.
- O3: ARFAT manual.
- O4: ARFAT application (software). It is foreseen to prepare two versions of application for two most common systems for mobile devices in EU: android OS and iOS.
- O5: ARFAT AR markers.
- O6: ARFAT instructional movies.

The objective of these outputs is to develop up-to-date, tailor-suited to sectoral needs, modern formworks and scaffolding works training, appropriate to be integrated into existing VET offerings or to serve European community as a stand-alone training. These outputs will address modern skills needs of construction engineers, construction workers, stakeholders and associations in the construction sector, SMEs and companies (construction sector), VET providers, and technical universities, delivering a European solid, reliable and comprehensive pedagogical tool.

The partnership of the project consists of:

- The Faculty of Civil Engineering, Warsaw University of Technology (WUT)
- Technische Universität Darmstadt (TUDA)

- Polish Association of Building Managers (PABM)
- Fundación Laboral de la Construcción (FLC)
- Universitat de Valencia (UVEG)
- PERI (PERI)

For more information about the project, please visit its official website:

www.arfat.il.pw.edu.pl



About the manual and training system

This manual can be used as a stand-alone source of information on formworks and scaffoldings. However the user can maximize the learning outcomes thanks to other components of the ARFAT training system: mobile application, AR markers and instructional movies.

The mobile applications are available both for iOS and android systems. You can download them through the project's official website or using QR codes below.

bit.ly/ARFAT_IOS



iOS version

bit.ly/ARFAT_ANDROID



Android version

The AR marker is composed into the manual cover, you can also download AR markers separately from the project website and print them by yourself. These markers are necessary to fully experience the augmented reality.

On the project website you will find additional guide, tutorials, movies and all other information about formworks and scaffoldings.

ARFAT learning outcomes

The final ARFAT learning outcomes were carefully selected on the base of the questionnaires results, meetings with important stakeholders and partners expertise in the field of scaffoldings and formworks. Due to the limited size of ARFAT training program the most important aspects were chosen. These aspects address H&S issues as the project aims for prevention of accidents on construction sites.

Learning outcomes listed below are summary of what learners should know and understand upon completion of the ARFAT training, in the form of definitions of specific knowledge, skills and competences.

The objective of ARFAT was to develop up-to-date, tailor-suited to sectorial needs, modern formworks and scaffolding works learning outcomes, appropriate to be integrated into existing VET offerings or to serve European community as a stand-alone training. These evidence based learning outcomes address modern skills needs of construction engineers, construction workers, stakeholders and associations in the construction sector, SMEs and companies (construction sector), VET providers, and technical universities, delivering a European solid, reliable and comprehensive pedagogical tool. The following chapters / procedures include:

Overview:

Selected formworks and scaffoldings systems and types, related regulations, examples of different elements in various systems.

Scaffolding transport:

Lifting equipment, guidance of suspended load –

“Handling of elements, preparation for lifting and guidance of suspended load”.

Handling order: marking the work zone, checking the palette, suspending elements, giving signal for crane.

Scaffolding assembly:

State of the soil: stabilization, anchoring, examples of bad and good application.

Fall protection elements: safety of workers, compliance with instructions, not mixing systems, checking of state of elements (faults), priority of group safety measure over individual protection (EU law).

Scaffolding use:

Communication on scaffolding, ladders, flaps, platforms. Access.

Structural integrity, periodical checks of scaffoldings, human factor (own modifications, etc.).

Scaffolding disassembly:

Work zone protection, proper storage, proper order of disassembly.

Formwork transport:

Stacking (transport in and out of the site), lifting of elements.

Guidance of suspended load, selection of hooks (type, up-to-date certification), guidance ropes.

Formwork assembly:

Presentation of how to assemble different elements, assembly on the ground, assembly of additional elements (platforms, safety rails).

Formwork use:

Concreting, concrete pressure, safety during concreting (safety rails), tools to calculate pressure

Formwork maintenance, release agent application, cleaning.

Formwork disassembly:

Time of dismantling: regular way and early striking – difference and factors, responsibility and decision-making (site manager, system), “back-propping”.

2. Overview – Formworks, scaffolds and falsework

Introduction

The area of formwork, scaffolds and falsework is for the management of construction projects a relevant element, since they are temporary works equipment for the support and assembly of structural building parts until these structures have reached a sufficient load bearing capacity as well as for the creation of workplaces. This construction equipment is relevant to the work progress, to the construction project's economy as well as to the safety of work processes and adherence to the time schedule. They are important for design and safety of workplaces from which, for example, assembly works can be carried out and accompanies a building in the whole life cycle, in the phase of construction, during the operation in the case of possible repair or modernization works as well as in case of demolition. Temporary works equipment include for example working and façade scaffolds, protection fans for scaffolds as well as specific construction techniques in bridge and civil engineering construction, such as climbing systems and slipform method for the erection of vertical components, incremental launching and launching truss systems for the construction of horizontal bridge superstructures as well as tunnel formworks for the construction of underground buildings. A possible systematic approach of the temporary works equipment as discussed above is shown in Figure 1.

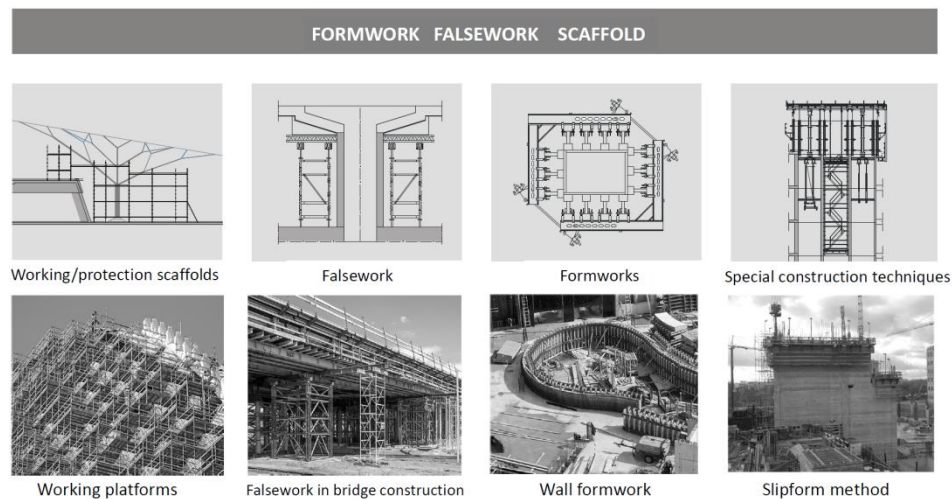


Fig. 1: Formwork, falsework, scaffolds – application cases (ref. to [1])

It is to underline that formworks, falsework and scaffolds are complex engineering systems, which require special care and the use of experts and specialists in their design and use on construction site.

Normative bases and definitions

Standards for formworks, falsework and scaffolds

The rules for the design and dimensioning of falsework are normatively defined, like for example in Germany according to DIN EN 12812: 2008-12 [R1] (the equivalent is, for example, BS EN 12812: 2008). Of relevance to the management of construction sites is Annex A (informative), which specifies the coordination of the works in the area of falsework, thus regulating the aspect of safety. The following standards are also to be specified in connection with falsework:

- BS EN 12813:2004-09 Temporary works equipment - Load bearing towers of prefabricated components - Particular methods of structural design [R2],
- BS EN 1065:1998-12 Adjustable telescopic steel props - Product specifications, design and assessment by calculation and tests [R3],
- BS EN 16031:2012-09 Adjustable telescopic aluminum props - Product specifications, design and assessment by calculation and tests [R4],
- BS EN 13377:2002-11 Prefabricated timber formwork beams - Requirements, classification and assessment [R5],
- DIN 20000-2:2013-12 Application of construction products in structures – Part 2: Prefabricated timber formwork beams [R6],
- DIN 18216:1986-12 Formwork ties; requirements, testing, use [R7],
- DIN 18218:2010-01 Pressure of fresh concrete on vertical formwork [R8]. This standard is dealt with in chapter 3.4.4, since it is of particular relevance for the daily use of vertical formwork in terms of quality and work safety.

The following standards are to be specified for the working and protective scaffoldings:

- BS EN 12811-1:2004-03 Temporary works equipment – Part 1: Scaffolds - Performance requirements and general design [R9],
- BS EN 12811-2:2004-04 Temporary works equipment – Part 2: Information on materials [R10],
- BS EN 12811-3:2003-02 Temporary works equipment – Part 3: Load testing [R11],
- BS EN 12811-4:2014-03 Temporary works equipment – Part 4: Protection fans for scaffolds - Performance requirements and product design [R12],
- BS EN 12810-1:2004-03 Facade scaffolds made of prefabricated components – Part 1: Products specifications [R13],
- BS EN 12810-2:2004-03 Facade scaffolds made of prefabricated components – Part 2: Particular methods of structural design [R14],
- BS EN 13374:2013-07 Temporary edge protection systems - Product specification - Test methods [R15].

It should be pointed out, that the requirements of BS EN 12812: 2008-12 must be taken into account in case of special design and foundation engineering requirements for working and protective scaffolds. The requirements of BS EN 12811-1: 2004-03 are to be used with regard to occupational health and safety requirements for falsework [2]. In this context, the application of adequately supervised and certified systems is required.

Differentiation between Formwork, Falsework and Scaffold

BS EN 12812:2008-12 [R1] can be used to define the differentiation criterion of the terms of formwork and falsework:

Quote:

3.3

falsework

temporary support for a part of a structure while it is not self-supporting and for associated service loads

3.4

formwork

part of temporary works used to give the required shape and support to in-situ concrete

Quote End

The definition of the different types of scaffold can be found in BS EN 12811-1:2004-03 [R9] for working scaffolds, in BS EN 12810-1:2004-03 [R13] for facade scaffolds made of prefabricated components and especially in Germany in DIN 4420-1 for protective scaffolds.

BS EN 12811-1:2004-03 is a European standard for access and work scaffoldings. They should provide a secure workplace with secure access that is suitable for work. This document specifies the performance requirements for scaffolding. These are essentially independent of the materials.

Quote:

3.26

working scaffold

a temporary structure necessary to provide safe work place while erecting buildings, performing maintenance works, repair or demolition of buildings and other structures as well as providing necessary

Quote End

BS EN 12810-1:2003 deals with prefabricated façade scaffold systems. The façade scaffolds are intended for use while connected to the façade with ties.

Quote:

3.1 Scaffold system

- a) set of interconnecting components, mostly purpose designed for the scaffold system, and
- b) the assessed standard set of system configurations and
- c) the product manual

Quote End

For example in Germany there is a separate regulation for protective scaffolding according to DIN 4420.

Quote:

3.1 Schutzgerüst

temporäre Baukonstruktion veränderlicher Länge und Breite, die an der Verwendungsstelle aus Gerüstteilen zusammengesetzt, ihrer Bestimmung entsprechend verwendet und wieder auseinander genommen werden kann

Quote End

3.1 protective scaffold

temporary building construction of variable length and width, which can be assembled at the place of use of scaffolding parts, used according to their purpose and then taken apart again

Protective scaffolding should be understood as a temporary building structure used to protect people and objects against fall from height

Figure 2 shows the differentiation between formwork, scaffold and falsework. The formwork forms the concrete body, the falsework supports this form until the time of proper and appropriate stripping of formwork and the scaffold provides the access to the working places.



Fig. 2: Differentiation Formwork – Falsework – Scaffold [Source: C.Motzko]

Classifications

Falsework

According to BS EN 12812:2008-12[R1], for the falsework the design classes A and B are defined, which should be selected by the falsework design engineer. The design class A defines falsework, which comply with established good practice and covers in situ erected simple slabs and beams with limited geometric dimensions concerning their cross-sections, span widths and heights (see BS EN 21812:2008-12, No. 4.2). The design class B contains falsework, which has to be completely calculated on the basis of the corresponding Eurocodes and according to the additional boundary conditions and specifications of the subclasses B1 and B2 (see BS EN 21812: 2008-12, No. 4.3). The management of a construction site should be aware of the four relevant load cases for the design of the falsework to be applied according to individual circumstances as per BS EN 21812: 2008-12, No. 8.5:

- Load case 1: Unloaded falsework e.g. before concreting phase,
- Load case 2: Falsework during loading, e.g. concreting phase,
- Load case 3: Loaded falsework, e.g. the phase after concreting,
- Load case 4: Loaded falsework subjected to seismic effects, for the case of the area of significant earthquake risk.

Formwork

Figure 3 shows a possible classification of formworks:

- Universal formworks: Manually applicable formwork, object- and crane-independent. Object-independent means, that an individual design for the formwork and a formwork solution for the construction project is not necessary.
- Standard formwork systems: Object-independent, industrial made frame formwork systems and prefabricated girder formworks. Geometric dimensions adjusted to road transport.
- Special formworks: Individual formworks, specially designed for specific components of the building construction. For example self-climbing formworks or slipform technology.

Universal formworks		Standard formwork systems				Special formworks	
Object-independent		Object-independent				Object-dependent	
Crane-independent		Crane-independent		Crane-dependent		Crane-dependent	Crane-independent
Square timber formwork	Girder formwork	Light frame formwork	Frame formwork	Heavy frame formwork	Girder formwork	Large scale formwork	Large scale formwork - movable

Fig. 3: Possible classification of formworks

For **square timber formwork**, loose squared timbers with boards or shuttering panels are manually assembled for each formwork and disassembled into individual parts after disassembly.

The **girder formwork** differs from the square timber formwork in that instead of squared timber as a substructure at least in one direction girder made of wood or metal are used. As a result, larger column and anchor distances are possible.

The **frame formwork** is system, where the formwork shell and the substructure are firmly connected and form a unit – the frame. Depending on the fresh concrete pressure there are light, moderate and heavy frame formworks. They are available for horizontal and vertical components.

Large scale formwork is assembled on the construction site or in the workshop from individual components (e.g. several frame panels) to a formwork unit. The formwork is specially designed for the building construction. The formwork can be moved with cranes or self-climbing systems.

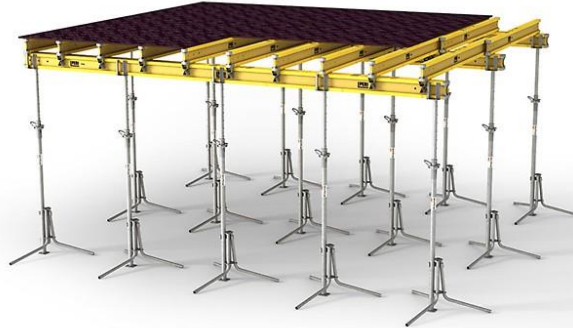


Fig. 4: Girder formwork, crane-independent – PERI MULTIFLEX [Source: PERI]



Fig. 5: Light frame formwork, crane-independent – PERI SKYDECK [Source: PERI]



Fig. 6: Heavy frame formwork, crane-dependent – PERI MAXIMO [Source: PERI]



Fig. 7: Girder formwork, crane-dependent – PERI VARIO GT24 [Source: PERI]

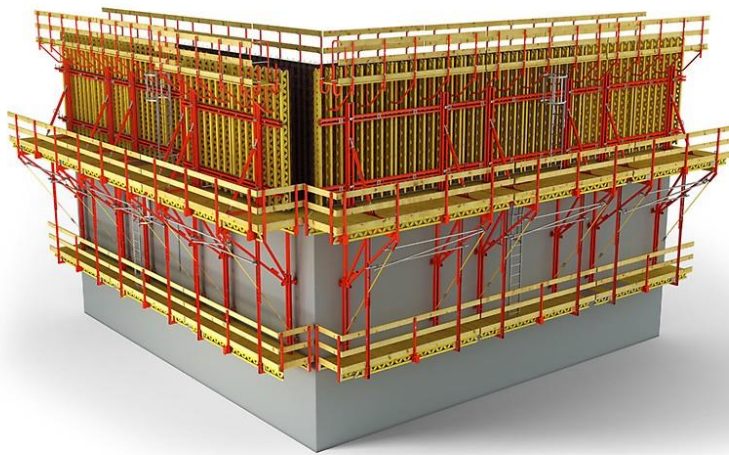


Fig. 8: Large scale formwork, crane-dependent – PERI CB [Source: PERI]

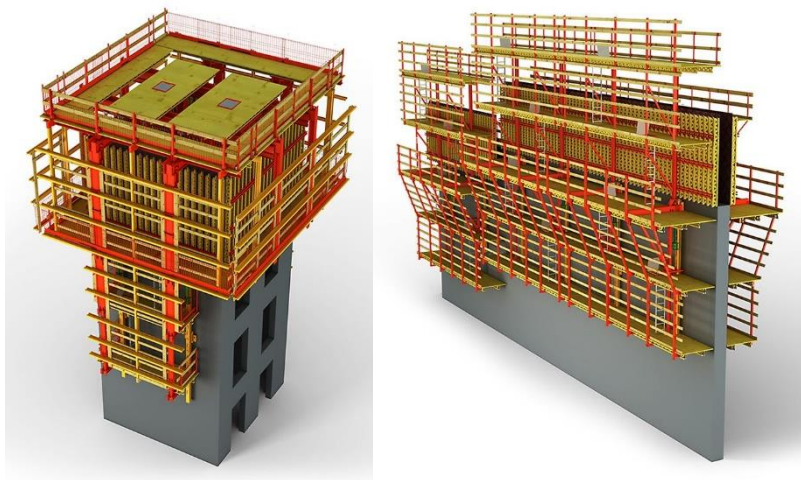


Fig. 9: Large scale formwork - movable, crane-independent – PERI ACS [Source: PERI]

Scaffold

Different types of scaffolding:



Fig. 10: Working scaffold – PERI UP Flex Reinforcement Scaffold [Source: PERI]



Fig. 11: Façade scaffold – PERI UP Flex Facade Scaffolding [Source: PERI]

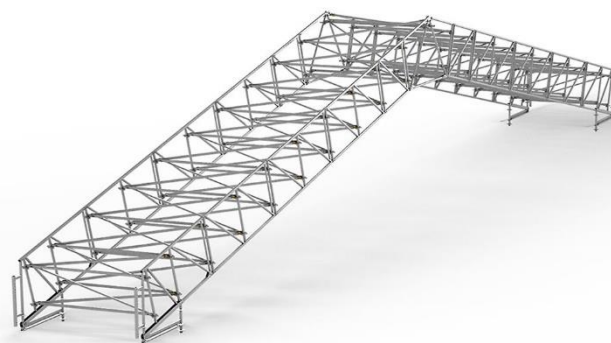


Fig. 12: Protective scaffold – PERI UP Flex Weather Protection Roof [Source: PERI]

To standardize the nomenclature, the following terms are defined according to standard BS EN 12811-1:2004-03:

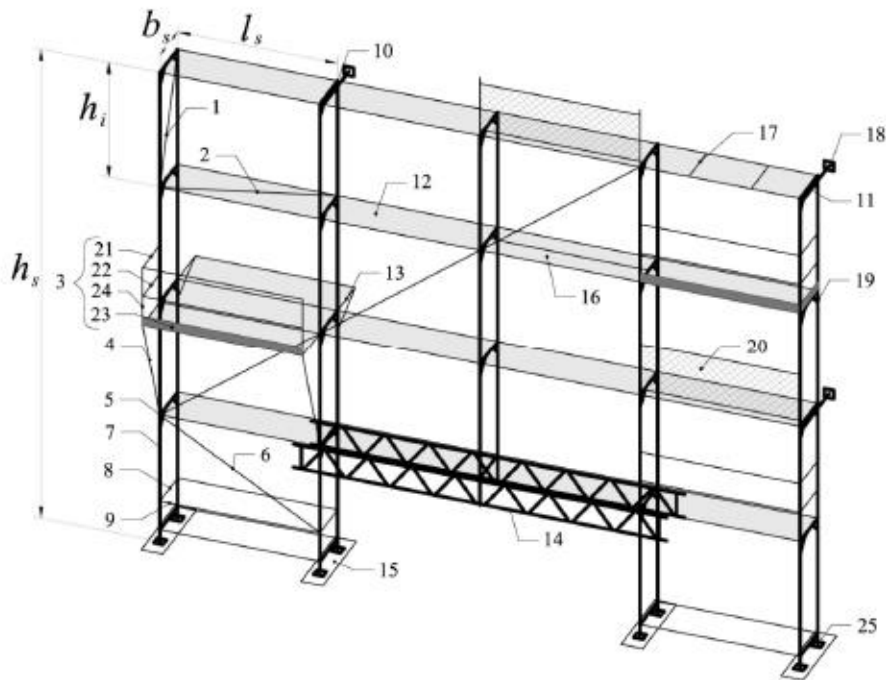


Fig. 13: The scheme of scaffold with marked elements (ref. to [R9])

- bracing in vertical plane (transverse diagonal) – 1,
- bracing in horizontal plane – 2,
- side protection – 3,
- bracket brace – 4,
- node – 5,
- bracing in vertical plane (longitudinal diagonal) – 6,
- standard – 7,
- transom – 8,
- ledger – 9,
- coupler – 10,
- tie member – 11,
- platform – 12,
- bracket – 13,
- bridging ledger – 14,
- base plate – 15,
- platform unit – 16,
- horizontal frame – 17,
- anchorage – 18,
- vertical frame – 19,
- fencing structure – 20,
- principal guardrail – 21,
- intermediate guardrail – 22,
- toeboard – 23,
- post – 24,
- base jack – 25.

In addition to the stability and the load-bearing capacity, scaffolding should also be dimensioned in terms of ergonomics. The most significant requirements and classifications are mentioned below.

Tab. 1: Service loads on working areas (ref. to [R9])

Load class	Uniformly distributed load q_1 [kN/m ²]	Concentrated load on area 500 mm × 500 mm F_1 [kN]	Concentrated load on area 200mm × 200mm F_2 [kN]	Partial area load	
				q_2 [kN/m ²]	Partial area factor a_p
1	0.75	1.50	1.00	-	-
2	1.50	1.50	1.00	-	-
3	2.00	1.50	1.00	-	-
4	3.00	3.00	1.00	5.00	0.4
5	4.50	3.00	1.00	7.50	0.4
6	6.00	3.00	1.00	10.00	0.5

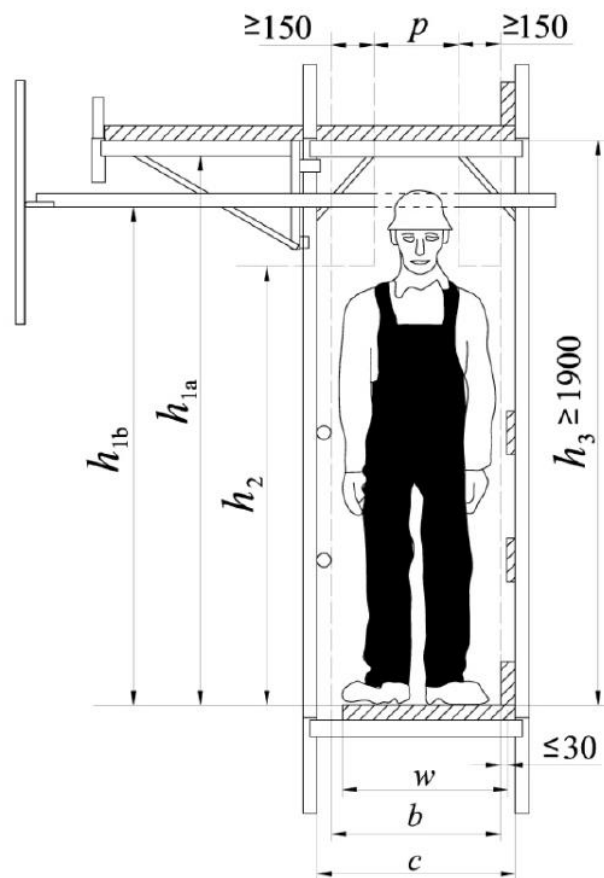


Fig. 14: Designations of working area dimensions (ref. to [R9])

Tab. 2: Width classes for working areas (ref. to [R9])

Width class	W [m]
W06	$0.6 \leq W < 0.9$
W09	$0.9 \leq W < 1.2$
W12	$1.2 \leq W < 1.5$
W15	$1.5 \leq W < 1.8$
W18	$1.8 \leq W < 2.1$
W21	$2.1 \leq W < 2.4$
W24	$2.4 \leq W$

Tab. 3: Headroom classes (ref. to [R9])

Class	Clear headroom		
	Between working areas h_3	Between working areas and transoms or tie members h_{1a}, h_{1b}	Minimum clear height at shoulder level h_2
H_1	$h_3 \geq 1.90 \text{ m}$	$1.75 \text{ m} \leq h_{1a} < 1.90 \text{ m}$ $1.75 \text{ m} \leq h_{1b} < 1.90 \text{ m}$	$h_2 \geq 1.60 \text{ m}$
H_2	$h_3 \geq 1.90 \text{ m}$	$h_{1a} \geq 1.90 \text{ m}$ $h_{1b} \geq 1.90 \text{ m}$	$h_2 \geq 1.75 \text{ m}$

A scaffold system shall be classified in accordance with Table 4.

Tab. 4: Classification of scaffold systems (ref. to [R13])

Classification criterion	Classes
service load	2,3,4,5,6 in accordance with Table 3 of EN 12811-1:2003
platforms and their supports	(D) designed with (N) not designed with drop test
system width	SW06, SW09, SW12, SW15, SW18, SW21, SW24
headroom	H1 and H2 in accordance with Table 2 of EN 12811-1:2003
cladding	(B) with or (A) without cladding facilities
vertical access method	(LA) by ladder or (ST) by stair way or (LS) by both

Constructive and use-specific conditions

The temporary works equipment such as falsework and scaffolds is with regard to the structural and use-specific conditions differently conceptualized in comparison to the permanent structures. A number of differentiation elements based on [1] and [2] is listed below. Referring to the fact, that the falsework and formwork areas have a high degree of engineering-technical complexity, the participation of experts and falsework design engineers in the planning and construction phase is highly recommended.

- Temporary works equipment is not subject to the scope of the Regulation (EU) No. 305/2011, which lays down the harmonized conditions for the marketing of construction products, because it does not remain permanently in the structure of the building.
- Temporary works equipment has a more unfavorable frequency distribution of the resistance and effects of actions than in case of permanent structures.
- Formworks, falsework and scaffolds are designed under the premises of a multiple and efficient assembly and disassembly processes at different construction sites and under varying operating conditions as well as to fulfil changing tasks.
- Especially for the load bearing capacity of falsework and scaffolds, the dimensional and form deviations of the components as well as the product of tolerance related cross-sectional values and scattering resistance of the material must be taken into account. Due to the requirement of easy assembly and disassembly processes on construction sites in case of formworks, falsework and scaffolds, clearance fits are often required at the connection points of the components.
- The foundation of falsework and scaffolds is another important element, which has to be subjected to intensive monitoring during the works on construction site. BS EN 12812: 2008-12 [R1] defines

various possible types of foundations within the validity of Eurocodes, such as a specific sub-structure provided for the purpose, direct foundation on the surface of the existing ground, e.g. rock, a partly excavated and prepared surface, e.g. in soil, foundation on a structure which already exists and foundation according to No. 7.5.2. - support without any embedment in the ground. It should be borne in mind that the foundation of temporary works equipment is not as complexly designed as the case of permanent constructions (example see Figure 15). In order to ensure sufficient stability, extensive static calculations must be done, which not only consider the force transmission into the ground, but also takes into account the interaction with the falsework, for example the differential settlement.

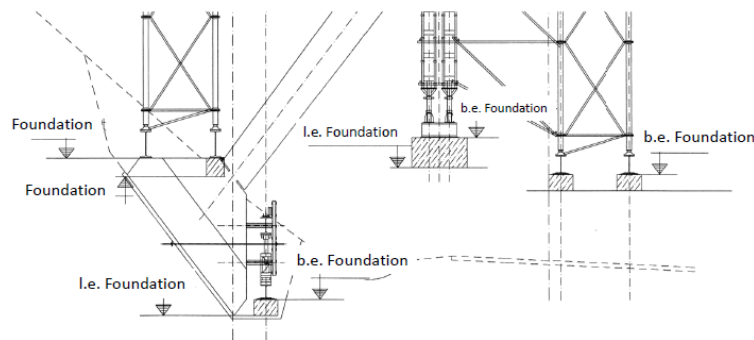


Fig. 15: Examples of foundations of falsework (ref. to [1])

- The temporary works equipment (formworks, scaffolds, falsework) is constantly and repeatedly used under design values of actions (loads). In opposite to this, permanent structures in the majority of the cases do not achieve the design values of actions (loads). That leads to significant differences in the design approaches, for example the structure of node points.
- Formwork and falsework have a high degree of panelization as well as standardization and are developed partly as modular systems, thus also in compatibility of different product groups (s. Figure 16), while permanent structures are designed as prototypes.
- Temporary works equipment can be complemented by mechanical or hydraulic moving aids in the case of specific tasks (e.g. self climbing formworks), in contrast to the definitive design of permanent constructions.

- In addition to complying with the constructive rules, the requirements for occupational health and safety are of relevance for the management of a construction project.

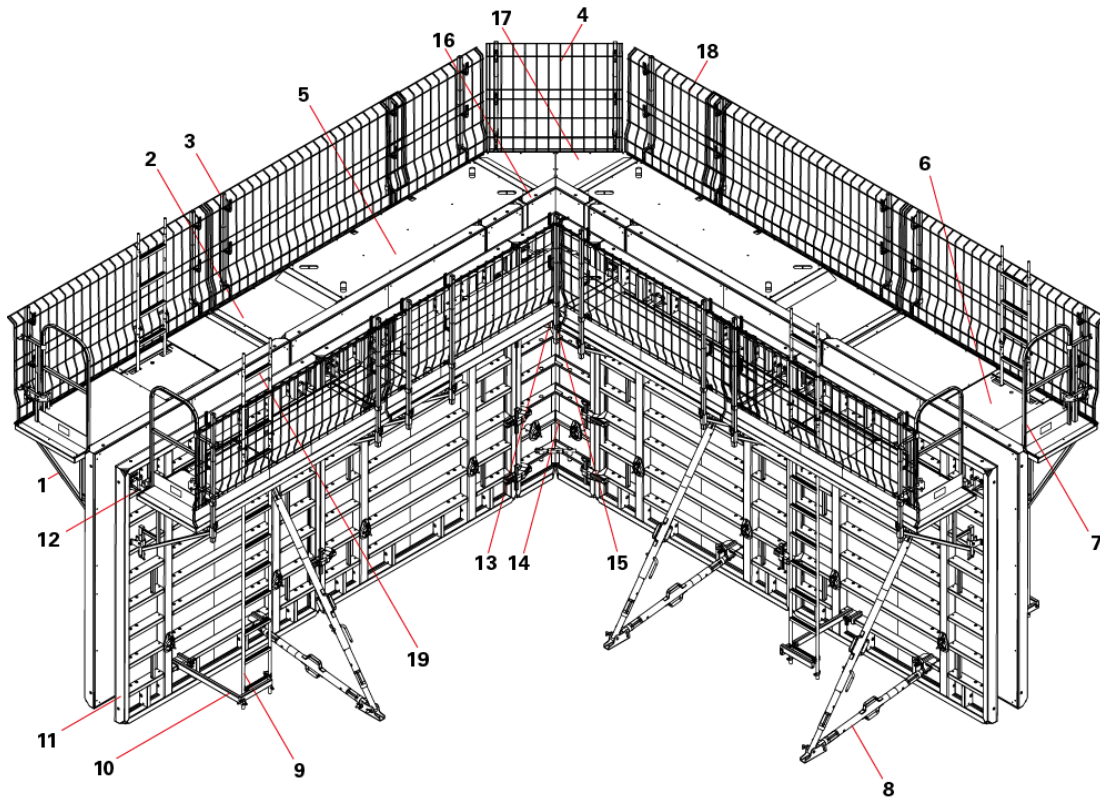


Fig. 16: Modular panel wall formwork
(PERI MAXIMO MXK Instructions for assembly and use)

1	Scaffold Bracket MXK	11	MAXIMO Panel 270x240
2	Scaffold Deck MXK	12	Intermediate Board
3	Guardrail Post MXK	13	Inside Corner Adapter MAR-MXK
4	Side Mesh Barrier PMB 120	14	Inside Corner MXI 270x60
5	Compensation Deck MXK	15	Inside Corner Post Holder MXK
6	Scaffold Deck MXK with Access Hatch	16	MAXIMO External Corner MXA 270x45
7	Stopend Guardrail MXK	17	External Corner Deck MXK
8	Push-Pull Prop RS	18	Side Mesh Barrier PMB 90
9	Ladder MXP 270	19	Ladder MXP 90
10	Ladder Connector MXK		

- The instructions for erection and use and additional documents are required for the use of falsework on construction sites, which indicates the validation parameters or design classes for the present case. Furthermore, the provisions of No. 5 BS EN 13670:2011-03 [R16] have to be considered. The same applies to formworks, where appropriate, the type of support, assembly, anchorage, disassembly, including possible emergency support, must be indicated precisely.

3. Procedures

Scaffolding transport – Lifting

SCAFFOLDING TRANSPORT – LIFTING



[Source: PERI]



Aims

Once this unit has been studied, the trainee should have learned:

- Identifying the more important hazards derived from the reception and transport of the scaffold material in the site.
- Knowing the safety standards and preventive measures that should generally be applied to control those hazards.
- Establishing the basic steps on safety to be followed on stock and transport of the scaffold material.



Key ideas

The supply of scaffold material involves the loading and unloading from the transport vehicles at the place of storage or stocking area, and its transfer to the place of installation.

The operations of moving, lifting and distributing of scaffold material involve the use of lifting equipment for palletized loads during loading and unloading from the transport vehicles, and the manual handling of scaffolding during assembly and disassembly as well.

Among other preventive measures, it is necessary to plan the access points and the stocking areas, organize the transport ways for the transport vehicles, carry out an orderly stock and use the appropriate lifting equipment, with the aim of achieving safe working conditions during the transport of the scaffold material in site.

Besides, measures to prevent injuries from overexertion and from the adoption of awkward postures during the manual handling of scaffold elements. During the de-palletizing of the material received in the site, as well as during the assembly and disassembly and stacking for its further remove, the workers transport, lift and place manually several elements (cross braces, frames, several types of platforms, etc.). The weights of these pieces are mostly below 25 kg, in opposite to the weight of platforms which may exceed the 25 kg. In addition, the pieces are handling in unfavorable ergonomic

conditions, mainly due to the height in which are handle, which varies from floor level to 2 meters over it.



Common hazards



- Falls stemming from the lack of order and cleanliness in the stocking and the work areas.



- Crashes or blows caused by vehicles traffic or the movement of suspended loads, or by moving parts of lifting devices.



- Falls from height during the ascent and descent from the vehicle that transports the material during the operations of coupling or disengagement of the load, and during the accomplishment of works in height for the hoisting or lowering of pieces from the different scaffolds levels.



- Smashing or knockings due to accidental fall of suspended loads caused by improper attachment or mooring, breakage of the lifting device caused by improper strapping or incorrect palletize.



- Trapping during loading, unloading and storage of scaffold material (e.g., dropping of elements when removing the straps from the packed material).



- Overexertion during the manual handling of loads and the adoption of forced postures (tasks with arms extended in the placement of platforms above the head, squatting or with the trunk flexed to perform tasks at the height of the feet, etc.)



Safety basic rules and preventive measures

- The stocking areas must be delimited properly (by ring-fenced or beaconing mesh), signaling (danger sign of suspended loads, no admission of unauthorized persons), neat and clean.



The stock of the scaffold material must be organized properly, arranging the pieces by types, sizes and according to the order of assembly, maintaining a corridor to facilitate the workers' movement, in order to avoid stumbling or treading the material.



[Source: GESPRE]

- When in the stocks the hooking points are not accessible from the transport truck box or at the ground level, workers should carry out the load slinging using protected auxiliary elements or stable ladders.



Stacking material of a height greater than 2 m should be avoided.



[Source: FLC]

- Transport and stock of scaffold elements should be carried out using pallets and suitable transport containers, which also allow to get safe stacking. 4 branches slings should be used for its elevation.
- The lifting accessories should be selected taking into account the load features: weight, sizes, shapes, etc.



The supplier's instructions must be taken into account when dealing with the election of the most suitable lifting accessories, tying and hooking points of the load and storage conditions.



The slinging operations should only be performed by qualified and well-informed staff.



[Source: FLC]



[Source: LAYHER]

- For hoisting or lowering the material during assembly or dismantling operations, respectively, it is convenient to use proper lifting mechanisms.



The correct working of the lifting equipment must be verified before using it, and check that it is suitably attached to the scaffold structure in accordance with the manufacturer's instructions.



Only load lifting equipment that has been considered or evaluated in the scaffold design shall be attached to its structure.

- A safe area must be delimited and signaled to prevent unintentional access, whatever the means are used for hoisting scaffold elements during assembly and dismantling.



Operators must never be placed under the load suspended vertically.

- In low height or small size tubular structures, the loads lifting and lowering are carried out manually and the operators constituting a vertical human chain. In these situations, the operators should take extreme precautions against the risk of fall from height and falling objects and materials.



When carrying out the assembly and dismantling operations of scaffolds, the following individual protection equipment must be used: safety helmet (preferably with chinstrap), reinforced leather gloves, safety shoes and fall arrest harness with double anchoring spring hook.

[Source: ULMA]

- The risk of injury from **manual handling of loads** can be reduced by:
 - Establishing an optimum prior organization of materials to avoid unnecessary movement.
 - Putting the heavy material stock near the installation area.
 - Using an adequate technique of lifting loads during the collection of material from the containers or pallets, or in their stacking.
 - Handling heavy or large pieces by several people.



[Source: GESPRE]



Manual handling of loads should be avoided, where possible, with the use of necessary mechanical means of transport and lifting. Heavy or bulky loads are to be handled by two or more people.



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Scaffolding assembly – Stabilization

SCAFFOLDING ASSEMBLY– STABILIZATION



[Source: irleh.com.pl]



Aims

Once this unit has been studied, the trainee should have learned:

- Identifying the more important hazards derived from the soil stabilization and scaffold anchoring at the construction site.
- Knowing the safety standards and preventive measures that should generally be applied to control those hazards.
- Establishing the basic steps on safety to be followed on stock and transport of the scaffold material.



Key ideas

Correct placement of the scaffold is essential for its safe assembly and disassembly. The problem consists of two components:

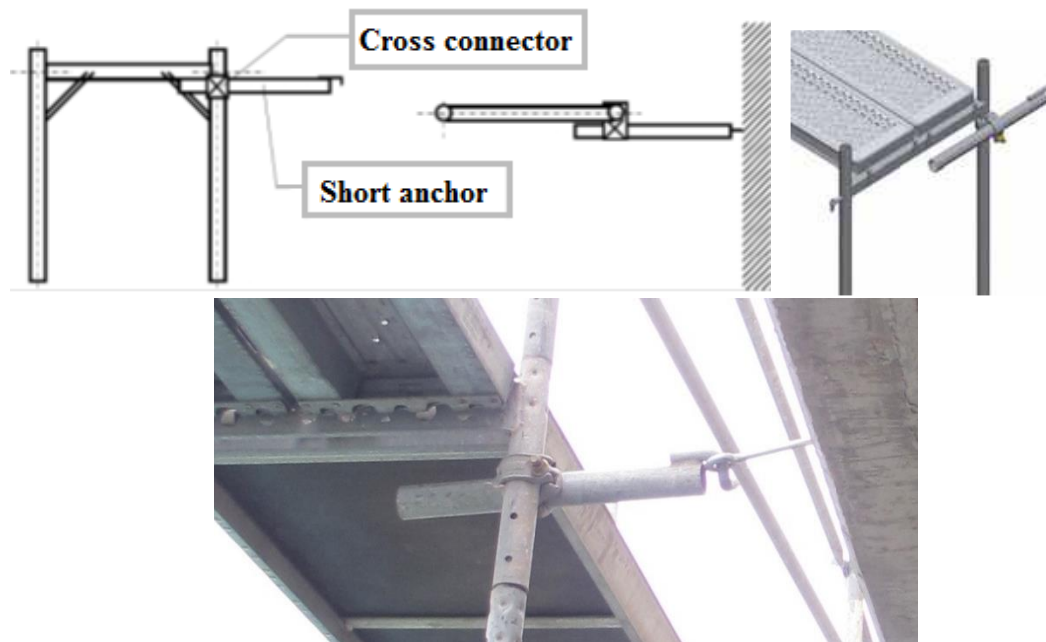
- Bearing capacity (which may require stabilization).
- The stability of the sills, which replace the point load of the scaffold supports on the load evenly distributed on the ground.

Soil stabilization is a method of improving soil properties by blending and mixing other materials. Following are the various soil stabilization methods and materials [7]:

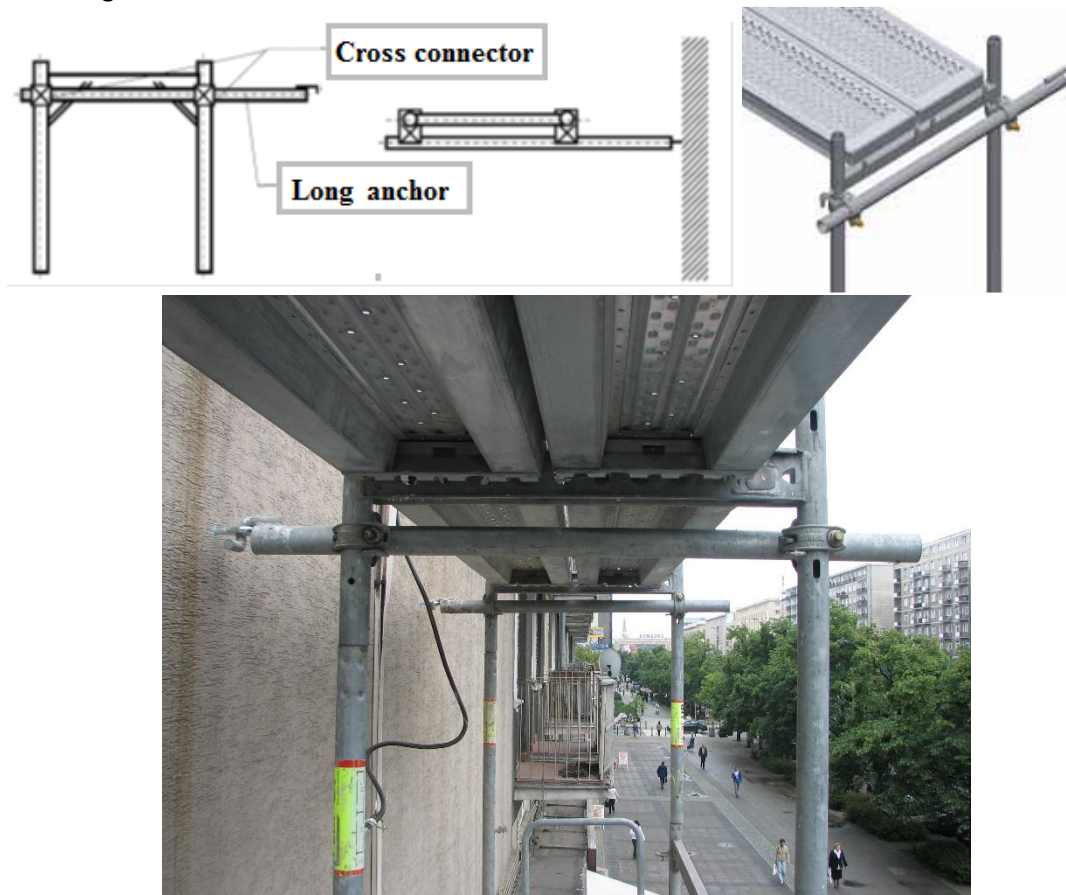
1. Soil Stabilization with Cement.
2. Soil Stabilization using Lime.
3. Soil Stabilization with Bitumen.
4. Chemical Stabilization of Soil.
5. Electrical Stabilization of Clayey Soils.
6. Soil Stabilization by Grouting.
7. Soil Stabilization by Geotextiles and Fabrics.

TYPES of anchors:

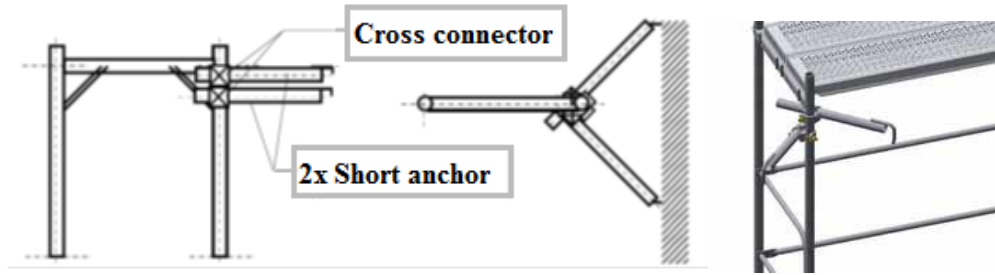
1. Short anchor:



2. Long anchor:



3. Traingular anchor (V method):



[Image sources: PERI]

[Drawing sources: 8]



Hazards:



- The risk of using too heavy a scaffold system on a substrate with insufficient bearing capacity.



- Risk of slipping scaffolding on employee.



Safety basic rules and preventive measures



The bearing capacity of the subsoil on which the scaffold is mounted cannot be less than 10 kPa. It should be defined according to national standards or in another technically justified way.



In the case of structural substrates, their carrying capacity should be determined on the basis of strength calculations. The unit load from the scaffolding structure must not exceed the load capacity allowed for the substructure. In case the substrate does not meet the described requirements, it is necessary to reinforce the substrate before assembling the scaffold. This should be confirmed and documented by appropriate strength calculations.



[Source: 9]



Scaffolding should be used on foundation substrates. The dimensions of the sleepers should be selected so that the requirements of the preceding paragraphs are fulfilled. The sleepers should be laid on a properly prepared substrate perpendicular to the building wall in such a way that all the bottom of the backing is pressed against the backing, with the backing face being spaced 5 centimeters away from the base of the building. Two adjacent feet of a given frame should stand on one backing.



If the sleepers are in a sloping area and the slope of the ground is 6 degrees above the scaffold, terraces should be constructed. The width of the single terrace should be at least 0.8 m. The ground support should extend beyond the row of external stands at a minimum of 0.8 m.



Before laying the scaffold on a frozen ground, the surface of the ground should be leveled with a layer of damp sand.



It is unacceptable to set the frames on cracked and cracked sleepers as well as on wedge or bricks.



Structures of scaffolding on roads, streets and pedestrian sidewalks are permitted provided the safety requirements for the communication lines (handrails, board boards, guardrails, fences, warning signs and boards) are complied with. It is also necessary to obtain the consent of the competent local authorities.



The rain water from the surface of the substrate should be drained away from the width of the strip.



Screws should be at least 200 mm adjustable.

[Source:10]



The strength and stiffness of the sleepers and helical supports should provide the maximum (projected) load from the working scaffold to the ground.

[Source: 11, 12]



Anchoring should begin at the second level.



Anchors should be placed symmetrically throughout the scaffolding.



The anchors should be arranged every second frame horizontally and every second level. The adjacent rows of anchors are shifted in relation to each other by one field.



The frames should be located every 4 meters from each side.



The scaffolding on the highest level should be anchored at every frame.



All frames that are attached to a wide, external expansion console must be anchored. In situations where anchoring platforms of 3.0 m are used, anchors should also be anchored one at a level down to 4 m.



Anchors should be installed on the external verticals of the assembled scaffolding.



The positioning of the anchor should allow for free movement on the scaffolding. In addition, the closest possible to the scaffold node and perpendicular to the wall should be made.

[Source: 14]



[Source: 13]



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Scaffolding assembly – Fall protections

SCAFFOLDING ASSEMBLY – FALL PROTECTION



[Source: PERI]



Aims

This learning material will allow for review of the following issues related to assembly and disassembly of scaffolding. The purpose of this procedure is to acquaint the reader with important topics such as:

- Identification of key issues related to the installation of the scaffolding, in particular related to health and safety at work.
- The use of appropriate procedures to minimize the risk of an accident during scaffolding assembly and disassembly.



Key ideas

Safety at work during the use or assembly of scaffolding should be provided in accordance with the instructions prepared by the manufacturer and individual project characteristics. It is critical that the scaffolding assembly and operation is performed correctly, reducing the risk of an accident and ensuring the safety of works on the construction site and areas adjacent to it. Use and assembly of scaffolding can be done by workers who have been granted permission to perform such works, confirmed by relevant certificates and training for scaffolding fitters and workers, according to regulations concerning this type of work.

Collective protection measures

Protection against falling from heights can be divided into two types:

- measures reducing risk of falling from heights,
- measures preventing risk of falling from a heights.

Considering the type of protection equipment, it can be further divided into:

- collective protection equipment,
- personal protective equipment.

Protective equipment against falls from a height, in order to properly perform its functions, must be properly matched to a type of work and work place that it is going to be used.

There are following collective protection measure that should be used on construction sites:

Railings

According to health and safety regulations in the EU countries, all construction works performer on heights must be secured by fundamental collective safety measure such as railings.



Scaffolding railing. [Source: PERI]

Railing should consist of a toe board of 0,15 m. and handrail installed on 1,1 m.
A special type of protection in the form of railings may be required in order to secure the work.

Guardrail mounted in advance

The guardrail for the next scaffolding level is mounted from the lower level. As a result, the scaffolder is in a safe position when entering the next level. The end guardrail can also be mounted from below. For safe assembly of the basic structure, no additional individual components are required nor must personal protective equipment to prevent falling be worn.



[Source: PERI]

Safety nets

The safety nets are another, increasingly popular collective protection measure. In many cases, their use is the best way to secure work at heights. The safety nets are usually made of polypropylene or polyester, 100 mm mesh grids mainly made of threads with a thickness 4-5 mm. Additionally they have a rope lining, through which a grid is attached to the structure.

There are three types of safety nets according to safety standards:

- Type S: Horizontal safety nets
- Type T: Safety nets anchored to brackets
- Type V: Safety nets anchored to brackets – gibbet style support

Type U: Vertical safety nets protecting edges of the structure

These safety nets are used for edge protection. They are mounted to a specially designed bars and they limit and secure the entire free space of facade or scaffolding.



Safety nets - Type U. [Source: PERI]

Classification of personal protective equipment

As a general rule, personal protective equipment should be used in situations when one cannot avoid or reduce risks by means of collective protection or work organization.

Personal protective equipment is designed to protect the health and lives of workers. It is a device (tool) or equipment intended for wearing or holding by the user, in order to protect against one or more sources of risk that may affect workers safety and health.

Personal protection consists of protective clothing, such as the abdominal protectors, chest, shoulder, limb protection, protective footwear, protectors of the feet, knees, elbows, hands; head – mostly helmets; face and eyes - safety goggles, ear muffs, ear-plugs, measures for protection against falls from a height for example harness with dorsal clamping buckle, textile shock absorber with lanyard or automatic fall prevention device.

According to regulations, employer may not allow the employee to work without providing a worker with personal protective equipment, necessary for the workplace and work type. The employee is required to use provided personal protective equipment, in accordance with their intended purpose, while the employer is entitled to control the compliance with this obligation and to take action to enforce its use.

Personal protective equipment

Selecting a protective measure should take into account:

- certificate and Declaration of Conformity,
- conformity with the essential requirements for personal protective equipment listed in Directive 89/686/EEC as amended by Directive 93/68/EEC, 95/93/EEC, 96/58/EEC,
- type of malicious physical and potentially harmful factor,
- the duration of the harmful factor,
- frequency of operation under harmful factor during the day,
- weather condition,
- types of activity: conditions and nature of the work,
- correct marking on protective equipment,
- type of product, trade name or code number, conformity with European standards (EN),
- graphic signs.

Summary of the most important health and safety issues during assembly and disassembly of scaffolding.

Safe scaffolding should:

1. Have the length and width allowing for safe work and storage of the necessary amount of material.
2. Provide secure communication and access to working posts.
3. Create the ability to perform work in the position preventing overexertion.
4. A typical scaffolding should be used and assembled in accordance with the characteristics of the construction site and operation designed by manufacturer based on appropriate standards and regulations.
5. Unusual scaffolding should be made in accordance with the project design.
6. Scaffolding should have a certified label, and their installation should be carried out in accordance with the manufacturer's instructions.
7. Staff engaged in the installation and removal of the scaffolding should be in possession of the required permissions and properly trained.
8. Performing works at heights, workers should be protected with protective belts and harnesses with rope anchored to solid elements of the structure or scaffolding.
9. Assembly and disassembly of scaffolding should be performed in secured hazardous area.
10. The use of scaffolding is permitted after the acceptance of supervising person, confirmed in the construction logbook.
11. Climbing and descending from scaffolding should be carried out in the places intended for this purpose – climbing on racks, bars, railings etc. is prohibited.
12. The anchorage should be distributed evenly across the surface of the wall or other elements of structure, according to technical design.
13. The distance between the outermost positions of work from the vertical communication shaft should not be greater than the 20 m.
14. Carrying capacity of mechanical winches and cranes mounted to the structure of the scaffolding cannot exceed 150 kg.
15. Scaffolding located directly on the roads and streets should have protective cowls installed.
16. Steel scaffolding must be earthed and have a lightning protector installation.
17. Assembled scaffolding should be tested according to documentation and operation manual.

18. Repair of scaffolding may be carried out after lowering the bridge deck to the lowest position.
19. Leaving tools at the edges of scaffolds is prohibited.
20. Scaffolds should be checked periodically, and after every occurrence of strong wind, precipitation and working breaks longer than 10 days.
21. Throwing elements of scaffolding is prohibited.

Personal protection against falls from heights during assembly and disassembly of scaffolding.

Functionality of the equipment is determined by the following factors:

- technical parameters (such as tensile strength),
- correct selection relevant for the type of work,
- methods of use.

Personal protection against falls from a heights:

- harness, lap belts and shoulder straps,
- shock absorbers,
- ropes (anchorage directly at the place of work),
- automatic fall prevention device.

Equipment must be used in a way that free fall of a worker is not greater than 2 m.

Safety equipment should consist of three elements:

- anchorage to the bearing structure,
- shock and energy absorption,
- harness etc..

Correct selection of the protection equipment against falls from a height is a prerequisite for safety of works during assembly, use and disassembly of scaffoldings.



Dangers during assembly and disassembly of formwork



- Falls caused by a lack of order on the construction site and in the place of assembly/disassembly of scaffolding.



- Falls from unsecured scaffolding.



- The risks associated with lifting and transporting of items to the place of assembly/disassembly.



- Fall of tools from heights during assembly and disassembly works.



- Loss of stability or falling of the scaffolding as a result of the improper removal of structural elements, loss of stability caused by incorrect assembly, influence of the wind.



- Risks associated with assembly/disassembly conducted during inappropriate weather conditions (strong wind, heavy rain, ice, dense fog, etc.).



- Injuries caused by improper lifting and moving elements that are too heavy.



Key safety rules during assembly and disassembly of scaffolding:

- Construction site should be secured, fenced and organized to prevent accidents.
- Climbing directly onto scaffolding is prohibited – designated communication shafts need to be used.
- Use of ladders should be reduced to a minimum and only with specialized safety equipment, if there is no other ways of carrying out works in a safer way.
- Assembly and disassembly should be carried out according to Technical and Safety Instructions, by qualified personnel.
- Assembly and disassembly of scaffolding should be carried out with a special regards to weather and atmospheric conditions.
- If this collective protection cannot be used at the workplace, then personal protection is required.



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Scaffolding use – Access

SCAFFOLDING USE – ACCESS



[Source: PERI]



Aims

Once this unit has been studied, the trainee should have learned:

- Identifying the more important hazards derived from the scaffolding use in the site.
- Knowing the safety standards and preventive measures that should generally be applied to control those hazards.



Key ideas

Tubular scaffolds are temporary auxiliary structures that are used for the workers' positioning in the works at height and for their access to them.

Works at height exposes workers to the special risk of fall from height which, if happen, have serious consequences. So, it is very important to choose the most adequate scaffolding to the nature of the work and the foreseeable difficulties, so that the workers' access and stay don't mean a hazard for their safety and health.

The scaffolding elements should be installed and used in such way that they cannot fall, overturn and move, endangering workers. Previously, the conditions of stability, strength and safety of the scaffold should be checked as well as its need to be check that its use doesn't represent a danger for users and for other people.

The scaffolds inspections should be done by qualified people, with an adequate training and experience. Scaffolds must be inspected prior to their commissioning, periodically and after any modification, period of non-use or any other circumstance that could affect their strength or stability, to ensure its safety at all times. The scaffolds users have to follow the given instructions on the use and maintenance of scaffold in order to carry out the works in conditions of safety.



Common hazards



- **Falls from height** caused by the absence of an easy and safe means of access to work levels, the inadequate arrangement of working platforms or the lack of perimeter protections.
- **Falls at the same level** due to the lack of order and cleanliness in the work platforms.
- **Falling of objects and materials** due to the absence of toe boards, mesh nets and protection fans.
- **Collapsing or overturning** of the scaffold due to failure of the supports or to loss of stability of the scaffolding structure, or **collapse** of work platforms as a result of a overloading.
- **Impacts against fixed objects.**



Safety basic rules and preventive measures

- The **access** to scaffold work platforms should be done through the service stair modules, or through the integrated ladders. In no case climbing through other elements, such as horizontal standards and ledgers, of the tubular structure is allowed.



[Source: pixabay.com]

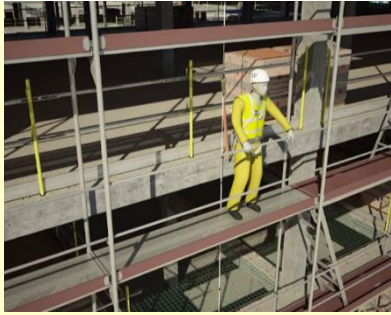


[Source: pixabay.com]



The access hatches should be kept closed.

- The **work platforms** should be made of a resistant and non-slip material; they should have locking devices that prevent their accidental tilting, and should be protected by means of guardrails.



[Source: COAATM-IRSST*]

- When access to the scaffold or the execution of a specific task requires the temporary removal of a protection against falls from height, the compensatory and effective safety measures provided for such situations should be adopted. Once this work is completed, either permanently or temporarily, the protection devices should be replaced.



*Scaffolds **must not be used** in operations or under contraindicated conditions or not foreseen by the manufacturer. They cannot be used either without the necessary protection elements.*

- The width of the work platforms should be precise for the easy workers' movement and the adequate storage of supplies, tools and materials essential for the task.



The work platforms shouldn't be overloaded. The users have to know the scaffold's maximum permissible load, which can be indicated in each platform.



[Source: COAATM-IRSST*]

- The work platforms should be clean and free of objects and they should have toe boards.
- It is necessary to delimit the lower level of the tubular structure to avoid the traffic of people under the scaffold. If needed, awnings or protection fans should be installed and the scaffold should be covered with a dense net to protect the site accesses, the passing areas or an adjoining street against the falling of objects.



Cleanliness and tidiness in the work platforms of the scaffolds should be kept. The material should not be stocked in excess, neither in an untidy and instable way.



[Source: COAATM-IRSST*]

- Pulleys or load lifting equipment shall be only installed in the locations authorized for this purpose and following the scaffold manufacturer's instructions.

- In those cases where there is a **risk of impacts or damages** with elements of the scaffolding, which could affect the areas of passage or traffic of people, it will be necessary to cover them with padded linings that avoid direct contact and attenuate possible damage.

- **Mobile work towers** should not be moved with personnel working on them. Likewise, all the susceptible of falling materials on the platforms must be removed before moving the tower.



Before accessing the tower it should be checked that all the wheels are blocked.



[Source: COAATM-IRSST*]

- The work on the scaffolds should be interrupted when the **adverse weather conditions** (heavy rain, storm, strong wind, snow, ice, etc.) suppose a risk for workers' safety.

* Images by COAATM-IRSST: Official Association of Surveyors, Technical Architects and Building Engineers of Madrid and Regional Institute of Health&Safety at Work of the Region of Madrid. Virtual building for training in safety and health in construction sector.



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Scaffolding use – Structural integrity

SCAFFOLDING USE – STRUCTURAL INTEGRITY



Aims

After the study of this learning unit, training participants will be able to:

- Identify the most significant risks arising from the use of scaffolding.
- Know the safety and preventive measures generally applied to control those risks.



Key ideas

Scaffolds are temporary auxiliary structures that are used for the workers positioning in the works at height and for their access to them.

Incomplete scaffolding and unauthorized modifications can lead to falls from the height and accidents. Scaffolding is distinguished between system scaffolding made of prefabricated components and steel pipe coupling scaffolds.

Before you could use a scaffold, check whether it is released. For example look at the test report. Here you can see for example a type of a German checklist version from the BG BAU.

Prüfprotokoll für Arbeits- und Schutzgerüste		CHECKLISTE			
Gerüstersteller (ggf. Stempel)	Baustelle: _____	Überprüfung	In Ordnung ja	nein	nicht zutreffend
Auftraggeber:		Gerüstbauteile			
Befähigte Person:		Standardsicherheit			
Arbeitsgerüst (DIN EN 12811)		Tragfähigkeit der Aufstandsfläche			
☐ Fassengerüst ☐ Raumgerüst ☐ Fahrgerüst		Fußspindel – Auszugslänge			
Schutzgerüst (DIN 4420) als		Verstreben/Diagonalen			
☐ Fanggerüst ☐ Dachfanggerüst ☐ Schutzdach ☐ Treppenturm		Längsriegel – in Fußpunkthöhe			
Sondergerüste		Gitterträger – Aussteifungen			
Laastklasse		Verankerungen – nach Montageanweisung/ Aufbau- und Verwendungsanleitung			
☐ 2 (1,5 kN/m ²) ☐ 3 (2,0 kN/m ²) ☐ 4 (3,0 kN/m ²) ☐ _____ (kN/m ²)		Beläge			
Die Summe der Verkehrslasten aller übereinander liegenden Gerüstlagen in einem Gerüstfeld darf den vorgenannten Wert nicht überschreiten.		Gerüstlagen – voll ausgelegt/Belagsicherungen			
Breitenklasse ☐ W06 ☐ W09 ☐ W _____		Systembeläge – einschließlich Konsolenbeläge			
Nutzungsbeschränkung: _____		Eckausbildung – in voller Breite herumgeführt			
Durch befähigte Person des Gerüsterstellers geprüft		Gerüstbohlen – Querschnitt, Auflagerung			
Datum _____ Name / Unterschrift _____		Öffnungen – zwischen den Belägen			
Vor der Benutzung ist das Gerüst durch den Gerüstbenutzer auf Betriebssicherheit zu prüfen.		Arbeits- und Betriebs- sicherheit			
Warnhinweise:		Seitenschutz – einschließlich Stirnseitenchutz			
   		Wandabstand ≤ 0,30 m			
   		innenliegender Seitenschutz			
   		Aufstiege, Zugänge – Abstand ≤ 50 m			
   		Gerüsttreppe, Leitgang			
   		Anlegeleiter ≤ 5 m			
   		Schutzdach			
   		Verkehrssicherung – Beleuchtung			
   		Fahrgerüste			
   		Fahrrollen			
		Ballast/Verbroterungen			
		Kennzeichnung			
		Gerüstkennzeichnung – an den Zugängen			
		Sperrung:			
		Nicht fertig gestellte Bereiche abgegrenzt und Verbotsschilder „Zutritt verboten“ angebracht			
		Bemerkungen/ Hinweise:			



[Source: BG BAU]

Unusable scaffolding are to lock from the erector.

Scaffolding should only be used for the intended purpose (load class and width class).

Tab. Load class (ref. to [R9]):

Load class	Uniformly distributed load q_1 [kN/m ²]	Concentrated load on area 500 mm × 500 mm F_1 [kN]	Concentrated load on area 200mm × 200mm F_2 [kN]	Partial area load	
				q_2 [kN/m ²]	Partial area factor a_p
1	0.75	1.50	1.00	-	-
2	1.50	1.50	1.00	-	-
3	2.00	1.50	1.00	-	-
4	3.00	3.00	1.00	5.00	0.4
5	4.50	3.00	1.00	7.50	0.4
6	6.00	3.00	1.00	10.00	0.5

Tab. Width class (ref. to [R9])

Width class	W [m]
W06	$0.6 \leq W < 0.9$
W09	$0.9 \leq W < 1.2$
W12	$1.2 \leq W < 1.5$
W15	$1.5 \leq W < 1.8$
W18	$1.8 \leq W < 2.1$
W21	$2.1 \leq W < 2.4$
W24	$2.4 \leq W$

Installation of additional equipment (e.g. elevators, rubble chutes) are only approved after the consultation with the scaffolding supervisor.

Before the beginning of the work, each user has to check the scaffolding. The scaffolds inspections should be done by qualified people with an adequate training and experience. Here you can see for example a type of a German checklist from the BG BAU.

Prüfung vor der ersten Inbetriebnahme von Gerüsten durch den Gerüstbenutzer		
Gerüstbenutzer:	Datum:	
Gerüststeller:		
Bauvorhaben:		
Überprüfung	ja, ohne Mangel	nein, Mangel
Verwendungszweck (geeignet z. B. für Mauerarbeiten, Stück- und Putzarbeiten, Malerarbeiten)	☐	☐
Ist das Gerüst an sichtbarer Stelle (z. B. Aufstiege) gekennzeichnet?	☐	☐
– Arbeitsgerüst und/oder Schutzgerüst nach DIN EN 12811/DIN 4420	☐	☐
– Lastklasse und Nutzlast, Breitenklasse	☐	☐
– Gerüststeller	☐	☐
Ist das Gerüst augenscheinlich verankert?	☐	☐
Arbeits- und Betriebssicherheit	☐	☐
Sind sichere Zugänge oder Aufstiege, wie z. B. Innenliegende Leitungsänge oder Treppentürme, vorhanden?	☐	☐
Ist jede genutzte Gerüststange vollständig mit Belägen (z. B. Rahmentafeln oder Bohlen) ausgelegt?	☐	☐
Sind die Gerüstbeläge und -bohlen so verlegt, dass sie weder Wippen noch ausweichen können und sind sie gegen Abheben gesichert?	☐	☐
Ist bei der Einrüstung einer Bauwerksecke der Belag in voller Breite herumgeführt?	☐	☐
Sind Belagelemente augenscheinlich unbeschädigt, z. B. nicht eingerissen, eingeschnitten?	☐	☐
Sind Gerüststangen bei mehr als 2,00 m Absturzhöhe mit einem 3-teiligen Seitenschutz (Geländerholm, Zwischenholm und Bordbrett) versehen?	☐	☐
Ist der 3-teilige Seitenschutz auch an Stilmasten und Öffnungen angebracht?	☐	☐
Ist ein maximaler Wandaustand von 0,30 m eingehalten? (wenn nicht, ist auch hier Seitenschutz erforderlich)	☐	☐
Anforderungen an Fang- und Dachlängengerüste	☐	☐
Ist bei Dachlängengerüsten die Belagfläche mindestens 0,60 m breit?	☐	☐
Liegt der Belag des Dachlängengerüsts nicht tiefer als 1,50 m unter der Traufkante?	☐	☐
Beträgt der Abstand zwischen Schutzwand und Traufkante mindestens 0,70 m?	☐	☐
Ist die Schutzwand aus Schutznetzen oder Geflechtem ordnungsgemäß am Gerüst befestigt?	☐	☐
Ist bei Fanggerüsten die Belagfläche mindestens 0,90 m breit?	☐	☐
Liegt der Belag des Fanggerüsts nicht tiefer als 2,00 m unter der Absturzkante?	☐	☐
Sonstige Anforderungen	☐	☐
Sind spannungsführende Leitungen und/oder Geräte im Gerüstbereich abgeschaltet, abgedeckt oder abgeschränkt?	☐	☐
Ist die Beleuchtung zur Sicherung des öffentlichen Verkehrs gewährleistet?	☐	☐
Ist am Gerüst beim Einsatz im öffentlichen Bereich ein Schutzdach vorhanden?	☐	☐
Datum: _____ Name/Unterschrift der befähigten Person des Gerüstbenutzers: _____		

[Source: BG BAU]



Common hazards



- Falls on the same level resulting from the lack of order and cleanliness at workplace.



- Falls from the working platforms of scaffoldings and other workplaces if these are used in an inappropriate manner.



- Falling objects and materials from activities located in upper levels.



- Collapsing or overturning of the the scaffold due to failure of the supports or to loss of stability of the scaffolding structure, or collapse of work platforms as a result of a overloading.



- Other risks from exposure to adverse weather conditions (strong winds, heavy rain and snow, storms ...).



Safety basic rules and preventive measures

- Workers should use a personal fall arrest protective equipment, when it's necessary to remove guardrails or other safety elements (e.g. for material transport).
- Workers have to consult the scaffolding supervisor and restore the original condition when they remove safety elements.
- The workplace has to be kept clean and tidy in order to prevent falls and consequences of stepping on objects (cuts, punctures, sprains or strains).
- When adverse weather conditions involve danger for workers' safety, work must be stopped (e.g., lack of visibility in presence of a thick fog, lightning strikes, slippery surfaces caused by frost or intense rain, overturning a scaffolding by wind).
- Avoid working on multiple scaffolding levels on top of each other. In case it cannot be avoided, it is necessary to install solutions to prevent possible falling of materials and objects to lower levels of the working site (such as netting solutions or protective visors). Furthermore, it is convenient to use tool belts as well as secure the tools with ribbons or strings, in anticipation of involuntary or accidental loss.



Do not make any constructive modifications to the scaffolding without permission.



Do not use any damaged scaffolding parts.



Do not remove or damage any anchors, guardrails, diagonal braces or other scaffolding components.



Close the access hatch after use.



Do not overload the scaffolding.



Keep the scaffolds clean and free of objects.



Interrupt the work on the scaffolds when the weather conditions suppose a risk for workers safety.



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Scaffolding disassembly – Work zone protection

SCAFFOLDING DISASSEMBLY – WORK ZONE PROTECTION



[Source: pixabay.com]



Aims

Once this unit has been studied, the trainee should be able to:

- Identifying the most important hazards in the operations of the scaffolding disassembly.
- Knowing the safety standards and preventive measures that should generally be applied to control those hazards.



Key ideas

Tubular scaffolding structures disassembly is generally done from the top to the bottom, in reverse order to assembly. Disassembly sequence will depend on the scaffold type and model: modular or multidirectional of facade, work tower, etc.

In any case, the scaffolding disassembly should be done following the manufacturer instructions; in the case of especial configurations, it should be done following the assembly, use and disassembly plan, elaborated specifically by a qualified technician.

The disassembly operations, as well as the assembly ones, should be carried out by well-trained workers that are able to deal with the specific hazards, and always under the direction of a qualified and experienced person.

Likewise, during the scaffolding disassembly the workers should use the same personal protective equipment and the lifting devices used in the assembly (manual pulley or light electric hoist) to lower the disassembled materials.



Common hazards



- **Falling of objects, tools and materials** during the scaffolding disassembly.



- **Collapsing or overturning** of the scaffold due to the stability loss of the scaffold structure caused by the uncontrolled removal of the mooring and stabilization elements or by the wind action.



- **Falls at the same level** due to the lack of order and cleanliness in the work platforms and in the stocking area.



- **Falls from height** caused by the absence of collective protections or by not using fall arrest system.



- **Overexertion** during the manual of loads handling or by the adoption of forced postures.



Safety basic rules and preventive measures

- The area affected by the disassembly operations should be enclosed and signaled to prevent involuntary access of pedestrian and unauthorized vehicles.



*A **safe area should be delimited** whatever the means used in the disassembly for the scaffold elements lowering are.*



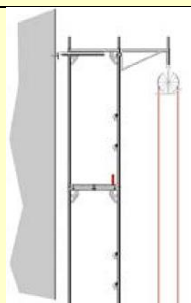
[Source: pixabay.com]



***The workers should never be placed under the vertical line of suspended loads.** And in no case, the launching of the scaffolds elements is allowed, whatever the height.*



Electric device



Manual device

- The working of the mechanisms used for lowering the materials should be checked before used them. These mechanisms should be suitably affixed to the scaffold structure in accordance with the manufacturer's instructions.



The lifting and lowering mechanism (electric or manual device) should be placed on a resistant element of the structure of the scaffold that is suitably tied.

[Image source - Lifting mechanism: Spanish National Institute of Health and Safety at Work - INSHT]



[Source: pixabay.com]

- The stabilizers or mooring elements of the scaffold will be removed as the disassembly progresses, from level to level, so as to ensure stability according to its height.



If the scaffold is covered with a net or safety tarp, it will be removed before the disassembly starts.



The works should be stopped when the weather conditions prevent to carry out the tasks of the scaffold disassembly safely. When the wind is strong (more than 70kms/h) is desirable to stop the disassembly, moving the materials or tools which may fall away from the scaffold platforms.



[Source: GESPRE]

- The different scaffold elements which are being dismantled should be stocked correctly and in a tidy way in a delimited area, and they should be removed as quickly as possible to keep the work area clear of obstacles.



The work area should be kept clean and tidy.

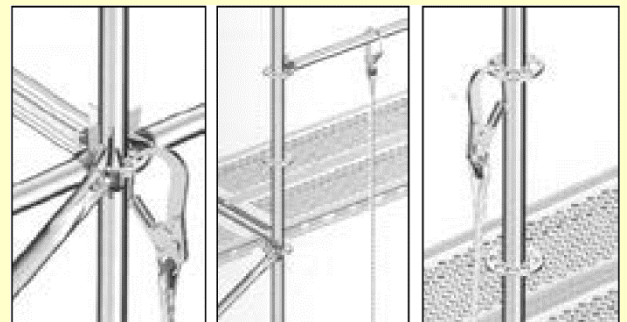
- During the scaffolding dismantling, **the workers should always wear the personal protective equipment against the falls from height**, even though the scaffold has collective protections.



The moorings of the fall arrest system to the scaffold should be only done on those points or elements indicated for this task in the manufacturer's instructions.



SCAFFOLDING FRAME



SCAFFOLDINGS WITH CONNECTION NODES FOR DIFFERENT CONFIGURATIONS

Points to tie the personal protective equipment against the falls from height.

[Image source: Spanish National Institute of Health and Safety at Work - INSHT]

- The workers should maximize the cautions in all steps of the disassembly, performing the disassembly sequence so that they are protected by collective protections, e.g., removing the material from the lower level or using provisional guardrails, according to the scaffold model.



*Assembly and Disassembly from the lower level
– “guardrail in advance”*

[Source: PERI]



Provisional guardrails

[Source: GESPRE]



*During the performance of the disassembly operations the following personal protective equipment should be used: **safety helmet** (preferably with chinstrap), reinforced leather **gloves**, **safety shoes** and **fall arrest harness with double anchoring carabiner**.*

- The hazard of injury by the **manual handling of loads** during the scaffold disassembly can be reduced by the use of lifting equipment for the material descent and acting on work organization.



The disassembly of a tubular scaffolding structure should be done with an enough number of workers. As minimum two workers located on the scaffolding platforms to dismantle all elements, and one or two workers placed on the lower level to carry out auxiliar tasks of reception and stocking of material.



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Formwork transport – Stacking and lifting

FORMWORK TRANSPORT – STACKING AND LIFTING



[Source: PERI]



Aims

Once this unit has been studied, the trainee should be able to:

- Identify the most important hazards derived from the reception and transport of the formwork material on the site.
- Knowing the safety standards and the preventive measures that should generally be applied to control those hazards.
- Establishing the basic steps on safety to be followed on stock and transport of the formwork material.



Key ideas

The formwork works involve the use of a large number of heavy and bulky elements that imply special risks for the workers safety and health, both during assembly and dismantling, and in the transport and stocking operations on site.

The supply of the formwork material entails carrying out loading and unloading operations of the transport vehicles at the place of storage or stock and their subsequent transfer to their placements in the site.

The operations of movement, lifting and distribution of the formwork material demand the adequate use of transport vehicles and lifting equipment, depending on the loads characteristics and the scope needed.

With the aim of achieving safe work conditions during the transport of the formwork material on the site, among other preventive measures, it is necessary: to plan the access points and the stocking areas, organize the traffic routes of the transport vehicles, organize an orderly storage and use the appropriate lifting equipment and accessories.



Common hazards



- Falls stemming from the lack of order and cleanliness in the stocking area.



- Crashes or impacts caused by the vehicles traffic or the movement of suspended loads, or by the moving parts of the lifting devices.



- Falls from height from transport vehicles in the operations of the coupling or uncoupling of the load.



- Smashing or impacts because of the accidental fall of suspended loads due to: improper coupling or mooring, the breakage of the lifting attachment or failure to be strapped or palletized correctly. It can also occur because of the overturning of inadequately stocked formwork material.



- Trapping during loading, unloading and stock of formwork material.



- Overexertion during the manual handling of loads or by the adoption of forced postures.



Safety basic rules and preventive measures

- The stocking areas should be delimited properly (by ring-fenced or beaconing mesh), signaled (danger sign of suspended loads, no admission of unauthorized persons...), as well as neat and clean.



[Source: PERI]

- The stocks should be located in places where access and maneuvering of transport vehicles and the location of lifting devices are facilitated. When it is possible, the stocks should be placed near to the formwork installation, and away from the passing areas and without interfering with other activities.

- It is advisable that the different formwork elements are supplied perfectly labelled, so that they are distributed in the stocking area according to the installation steps.



- When in the stocking areas, the tying points are not accessible from the transport truck box or from the ground level, the workers should carry out the slinging from protected auxiliary elements or from stable ladders. The stacking of formwork material with a height greater than 2 m should be avoided.

[Source: PERI]

- The stability of the stocks should be guaranteed carrying out them on a resistant or compacted surface and away from slopes.
- The stock of formwork panels will be carried out in a horizontal plane, using wooden sleeper ties for their leveling. In a vertical stocking, the panels should be chocked and placed with an inclination to avoid their slip and tilt.
- It is advisable that the transport and stocking of the elongated elements (props, ledgers, straining pieces, etc.), and of the small formwork material are carried out through the use of pallets and adequate transport containers, which, besides, allow the safe stacking. Four-lane slings should be used for their hoisting.



[Source: PERI]

- The slinging activities should be carried out by qualified and well-trained people.
 - The supplier's instructions about the most adequate elevation accessories (slings), the tying points or of load hooking, and the stocking conditions should be taken into account.
 - The elevation accessories should be chosen taking into account the load characteristics: weight, measurements, shape, etc.



[Source: PERI]

- During the lifting of formwork material, the workers should be away from the vertical line of the suspended loads and should be positioned in the crane operator visual area. The panels, and the big formwork elements, should be guided with ropes and cables.

- Manual load handling should be avoided through the use of mechanic means of transfer and lifting, or handling the load between two or more people.



[Source of figures: PERI]



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Formwork transport – Guidance of suspended load

FORMWORK TRANSPORT – GUIDANCE OF SUSPENDED LOAD



[Source: 15]



Aims

Once this unit has been studied, the trainee should be able to:

- Identify the most important hazards derived from the crane slings use at the construction site.
- Know the safety standards and preventive measures that should generally be applied to control those hazards.
- Establish the basic safety steps to be followed during crane slings use.



Key ideas

The definitions of the basic concepts associated with this chapter [15]:

Crane slings – auxiliary hook lifting accessories. Used for lifting, tipping or holding loads.

WLL – Working Load Limit – maximum permissible mass of load in tons or kilograms lifted or supported by the suspension in a way that does not cause a danger.

Wire – a single piece of cable, chain or belt connecting the aggregate cell, with a hook or a handle. This is the basic element of the crane slings. There are single-wire, double-wire and multi-wire crane slings, as well as a closed loops.

Chain – made of steel. The chain class is an abbreviation of the string strength of the chain material expressed in N/mm^2 (MPa) e.g. class 8 is 800 N/mm^2 ; Class 10 is 1000 N/mm^2 . The class of chain is defined in the crane sling specification.

Cable – made of steel wires. The smallest element is the wire strands wrapped around the core of the rope. Ropes can be made of natural fibers (sisal, hemp, cotton, jute) and artificial (polypropylene and polyamide).

Hook – normalized curved rod element for hooking and holding. Steel hook is usually equipped with a safety latch to prevent the disengagement of the lifting wire rope sling. It is the most commonly used suspension ending in the construction industry.



Hazards:



- Risk of crushing a person or object due to an improperly hanged load.



- Risk of being struck by a falling crane slings component.



- The risk of the suspended load hitting a hardly visible worker who might be in the working range of the crane slings.



Safety basic rules and preventive measures



Crane slings should be complete and technically functional.



Each crane sling should have a rating plate and documentation confirming the performance parameters and approval of technical inspection.



Before each use, an employee performing the hook function should assess the technical condition. Check: if components are complete and original, mobility, for any visible damage or signs of excessive use.



Each operated crane sling should be registered, that is, it should have its slings tab and also be included in the crane slings register. The register and the cards are kept by the owner of the crane slings.



Often a service is ordered with accessories. In this situation, the person authorized by the construction manager should check the documentation of the operated crane slings before starting works.



A copy of the complete documentation of the crane slings should be at construction site.



The crane slings and accessories should be used according to the intended use and the manufacturer's instructions.



Crane slings and accessories should be stored in places where they are protected from damage or contamination. It is best to keep them hanged.



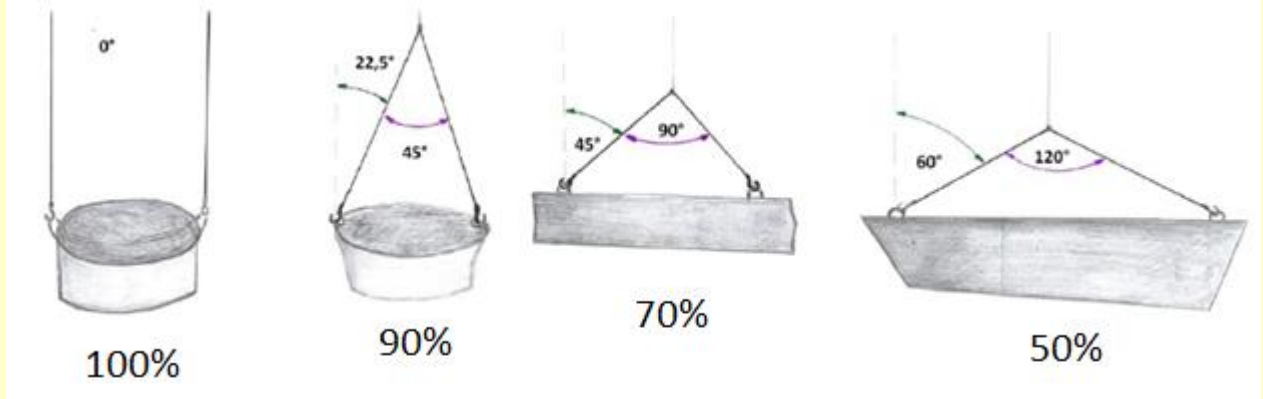
In case of multiple slings (more than 2 wires), only 2 wires are used for WLL calculations.



When two separate crane slings are used, only one crane sling is accounted for the WLL. For example, when attaching two lifting hooks with WLL 5 T each (at a specified angle of wires), we calculate only 5 T for the whole set of WLL



While handling crane slings, take the modified (decreased) WLL due to the slit angle of wires.



The effect of the angle of pulling the wires on the WLL [16]



The maximum allowable angle between wires is 120 degrees.



While attaching two (or more) crane slings directly to the hook (without collectors), the maximum angle of stranding cannot exceed 90 degrees.



The method of attaching the load has a decisive influence on the WLL and should be taken into account during selecting the crane slings.



During work planning, the moment of squeezing the crane slings should always be taken into account. The bigger the angle of the crane sling, the larger the moment of squeezing. For example, at a 90 degree angle, it is 0.71 of the mass of the load for each wire, while at 120 degrees it is 0.86 for each wire.



While using handles (for example to transport formwork or steel sheets), the allowable angle of spread must be taken into account. It is specified in the instructions for use of these handles.



Protect the wires against sharp edges and rough surfaces. Strips and ropes are especially sensitive. Attempting to lift the load under such conditions results in immediate destruction of the slings. The WLL of the wire chains operating on the sharp edge should be reduced by 50%.



Lifting tied load should not exceed 80% WLL of crane sling.



While carrying the load and attaching the hook to the cable, the minimum spreading angle of cable is 120 degrees. It can be reduced, for example by use of a board.



Minimum spreading angle of the cable when the load is tied [16]



Crane slings which are damaged, worn out, incomplete, lack identification plate, should be removed immediately for service, then repaired or scrapped.



Reduction of the chain link or sling link by more than 10% of the nominal dimension disqualifies the element and the whole crane sling.



Bending the hook above 10% of the nominal value disqualifies the hook and the whole crane sling.



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Formwork assembly – Assembly

FORMWORK ASSEMBLY – ASSEMBLY



[Source: PERI]



Aims

This learning material will allow for review of the following issues related to assembly and disassembly of formwork. The purpose of this procedure is to acquaint the reader with important topics such as:

- Identification of key issues related to the installation of the formwork, in particular related to health and safety at work.
- The use of appropriate procedures to minimize the risk of an accident during formwork assembly and disassembly.



Key ideas

The primary source of health and safety requirements for installation and removal of formworks should be a "Technical Manual", which should be provided by the manufacturer of formwork system. Around the assembly and disassembly location should be organized designated danger zone surrounded by appropriate fence or barriers with the use of portable stands, at least 6 meters from the formwork projected to the ground surface. Installation and assembly can only be done by employees (technicians) trained and familiar with assembly instructions (Technical Instruction) of relevant formwork system and type.

Formwork components should be prepared for transportation in accordance with the manufacturer's factory compression requirements. After loading of components to a truck, all elements must be protected against moving and slipping under the influence of the inertia forces. Small items should be transported in containers designated for this purpose.



Fig. Transportation of formwork [Source: PERI]

Unloading should be carried out using mechanical devices or manually, depending on the requirements of the system, however, it is prohibited to discharge items from the truck directly onto the ground. It is recommended, that unloading of items should take place near the assembly site and formwork should be stacked in order of assembly and installation. Stored items may not intersect with each other or put in irregular piles causing a threat of falling and sliding, which could damage the components or cause accident.

Moving formwork elements manually should be done with the limitation of maximum weight carried periodically (to be understood by the manual handling of objects, loads or materials no more than 4 times per hour, if the total time of such work does not exceed 4 hours per day) by one employee, that does not exceed 50 kg (at constant work with loads - 30 kg). No people can be present under moving load, during loading and unloading of formwork by crane.

Assembly and disassembly of formwork after use should be performed by adequately trained personnel.

Formwork manufacturer should provide for each set of formwork a dedicated "Safety Instructions" and the "Technical Manual" for formwork assembly, and the user (Site Manager) is obliged to provide a proper training for staff (fitters) with the use of those instructions, and then make sure that fitters abide relevant safety requirements. Failure to comply with these instructions and security requirements can cause risks of severe accidents during assembly and disassembly, or lead to formwork and material damages or losses. Assembly and disassembly of the formwork should be executed in accordance with the procedure explained in "Technical Manual". If case of any doubts, supervisor of works should communicate with the service or the manufacturer (contact details should be given in the instructions).

Fitters who perform the formwork assembly should pass a course of 8-hour training, including information of technical skills needed in assembling of particular type of formwork. This theoretical and practical course should include:

- 1) Correct instruction of assembling and dismantling formwork.
- 2) Dangers when working with assembly of formwork and means of protection against risks.
- 3) Methods of safe performance of work.
- 4) Valid use of security equipment.

Instruction training should be carried out by a person in charge of workers and supervising future works, designated by the employer, with the relevant qualifications and professional experience in mounting formwork and trained in the methods of preparing such training. It may also be a designated person from authorized representative of manufacturer of formwork. Instruction training should end with a test of skills in secure assembly and disassembly of formwork, compliant with technical requirements of formwork manufacturer, confirmed by a certificate of completing the course. The certificate shall be kept in the personal file of the employee.

Working suit of fitters should be tight, comfortable and adapted to the silhouettes of the employee and the conditions (including the weather), in which the work will be performed. Fitters must be equipped with the following personal protective equipment: protective helmet, non-slip footwear, gloves and depending on the situation – equipment for working at heights.

Around the space for mounting the formwork and along the transportation road to the place designated for assembly and disassembly of formwork, there should be a dedicated hazardous zone surrounded by fence with a height of 1.1 m. That fenced danger zone should be located at a distance of at least 6 m. from the outer projection line to the terrain, from the constructed object.

The person carrying out the installation and removal of the formwork are required to use safety equipment against falls from a height. Work with ladders can only be performed to a height of 3 m. Assembly held at altitudes above 1 m can be performed by employees with up-to-date medical examination, specifically allowing them to perform work at heights. Formwork installation should be carried out from scaffoldings intended for that purpose, or should be preassembled on the ground and transported by crane or manually, to assembly point. If the area of work is situated on the height of more than 1 m. there should be installed a railing consisting of protective handrails placed on the height of at least 1.1 m and at least 15 cm toe boards. Between the handrail and toe board there should be placed a bar half between, or this space should be filled in another way preventing workers from falling (such as nets etc.).



Fig. Protective handrails and assembled formwork fragment [Source: PERI]

If that is possible, all works considering assembly and disassembly should be carried out on the ground level to ensure secure installation conditions. To lift the formwork segments there should be used slings of the same type of adequate strength and of such length that the angle between slings was not greater than 60° . It is also possible to use a horizontal beam to attach slings vertically (called also a “traverse”).



Fig. Transportation of assembled formwork fragment [Source: PERI]

The use of formwork is allowed after its acceptance by the construction manager or authorized person. Formwork commissioning should be confirmed by an entry in the official protocol acceptance.

Do not mount or dismount the formwork at dusk without artificial lighting that provides good visibility, during dense fog or heavy rain, storm and strong wind exceeding 10 m/s, and when ground is covered with black ice.

Safety requirements when dismantling formwork are the same as during mounting. Striking should be carried out in the reverse order to assembly. Throwing of the removable formwork elements is prohibited. Detachable elements should be segregated according to their intended purpose, and put in place enabling loading without unnecessary additional transfer.

The user is obliged to review and maintenance formwork after each use. Damaged items must be stored separately and reported to the manufacturer for replacement or repair. Before each use of formwork, all elements should be examined and checked.



Dangers during assembly and disassembly of formwork



- Falls caused by a lack of order on the construction site and in the place of assembly/disassembly of formwork.



- Falls from unsecured formwork.



- The risks associated with lifting and transporting of items to the place of assembly/disassembly.



- Fall of tools from heights during assembly and disassembly works.



- Loss of stability or falling of the formwork as a result of the improper removal of structural elements (locks, supports), loss of stability caused by incorrect assembly, influence of the wind.



- Risks associated with assembly/disassembly conducted during inappropriate weather conditions (strong wind, heavy rain, ice, dense fog, etc.).



- Injuries caused by improper lifting and moving elements that are too heavy.



Key safety rules during assembly and disassembly of formwork:

- Construction site should be secured, fenced and organized to prevent accidents.
- Climbing directly onto formworks is prohibited.
- Use of ladders should be reduced to a minimum and only with specialized safety equipment, if there is no other ways of carrying out works in a safer way.
- Assembly and disassembly should be carried out according to Technical and Safety Instructions, by qualified personnel.
- Assembly and disassembly of formwork should be carried out with a special regards to weather and atmospheric conditions.



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Formwork use – Concreting

FORMWORK USE – CONCRETING



[Source: PERI]



Aims

After the study of this learning unit, training participants will be able to:

- Identify the most significant risks arising from the use of formwork, especially during the concreting works e.g. concreting speed.
- Know the safety and preventive measures generally applied to control those risks.



Key ideas

Formwork is mainly used to concrete columns, walls and other components. The formworks users have to follow the given instructions on the use and maintenance of formwork in order to carry out the works in conditions of safety.

Defects on the side protector or on the flooring of the concreting platform as well as unsafe traffic routes can lead to accidents during the concreting. It is recommended to use system solutions. These are safer than an assembled system of different parts.



[Source: BG BAU]

To ensure safe working and a good quality of the components, the concrete pressure must be determined and observed prior to concreting depending on the formwork. The concreting pressure depends on:

- concrete consistency,
- climbing speed,
- end of solidify,
- concreting height,
- concrete density,
- fresh concrete temperature,
- outside temperature.

If the concrete pressure is too high, the formwork may collapse or deform very strongly. There are several apps available for the calculation.



Common hazards



- Falls on the same level resulting from the lack of order and cleanliness at workplace.
- Falls from the formwork if these are used in an inappropriate manner.
- Risk of moving suspended loads (e.g. concrete buckets).



- Other risks from exposure to adverse weather conditions (strong winds, heavy rain and snow, storms, etc.).



Safety basic rules and preventive measures

- Arrange workstations so that all working areas can be safely reached without additional ladders.
- Climbing on formwork is prohibited.
- Work on ladders is to be minimized and only permitted if safer work equipment cannot be used.
- The work area must be kept clean and tidy.



Do not release the slings until the formwork is securely supported.(1)



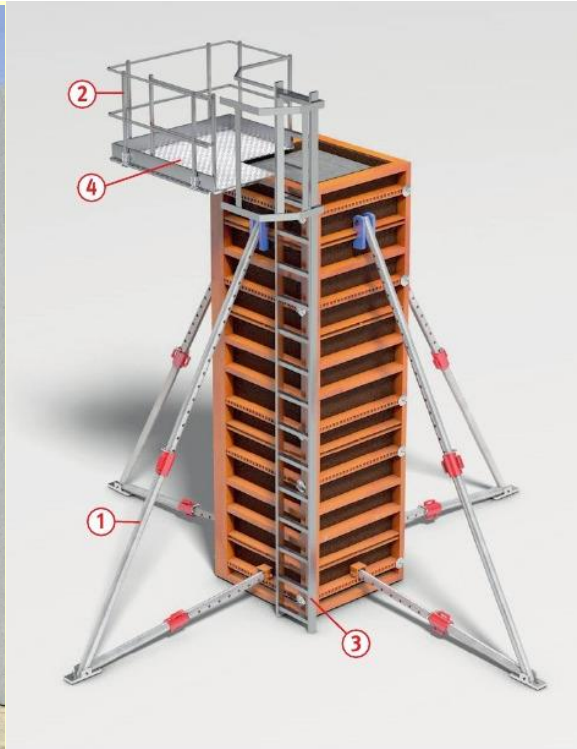
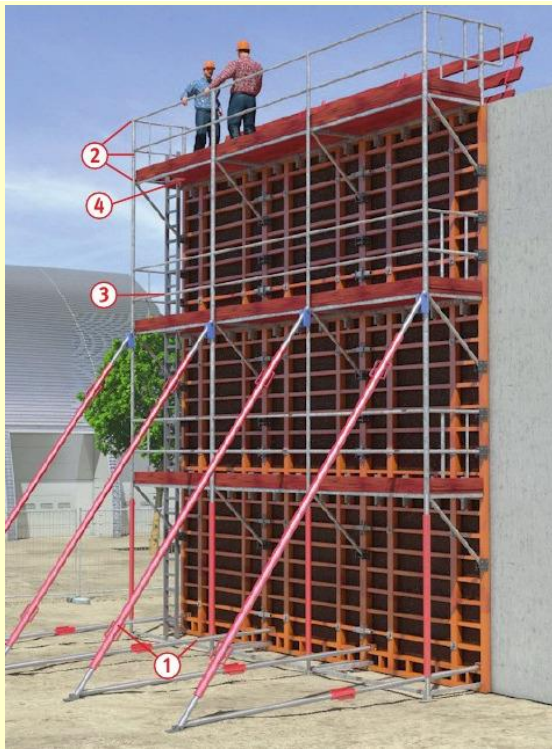
Place the concreting scaffolding and the side protector.(2)



Access to workplaces by facilities provided by the manufacturer (e.g. system-linked ladders or stair towers).(3)



The width of the concreting platform must be at least 0,60 m.(4)



[Source: PERI]



Interrupt the work on the scaffolds when the weather conditions suppose a risk for workers safety.



Augmented reality

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Formwork use – Maintenance

FORMWORK USE – MAINTENANCE



[Source: PERI]



Aims

After the study of this learning unit, training participants will be able to:

- Identify the most significant risks arising from the use of formwork, especially with the release agent application.
- Know the safety and preventive measures generally applied to control those risks.
- Know and use the personal protective equipment for concrete release agent application.



Key ideas

Formwork is mainly used to cast concrete columns, walls and other components. The formworks users have to follow the given instructions on the use and maintenance of formwork in order to carry out the works in conditions of safety.

For the quality of the concrete surfaces and the life of the formwork, the cleaning and maintenance of the formwork is very important. Concrete release agent protects and maintains the formwork.

After every pouring and striking, the formwork must be cleaned immediately. Use gentle cleaning equipment for this purpose (e.g. metal scrapers, brushes, etc.). The use of sandblasting equipment, angle grinders, wire brushes and pointed tools causes damage.



1. Remove nails



2. Remove concrete residues with a metal scraper.



3. Remove concrete residues with a broom.

[Source: E. Boska (TUDA)]

After cleaning the formwork, the release agent should be applied. Concrete release agents are colored liquids with a weak odor and consist of mineral oils. They are applied to the formwork before concreting to allow easy striking. The dosage and the necessary occupational safety measures are to be carried out according to the manufacturer and in compliance with the rules for occupational health and safety. There are different types and classes of concrete release agents. In Germany the BG BAU differentiates between „Produkt-Code für Betontrennmittel“.

BTM 10	not marked
BTM 15	unlabeled, disaromatized
BTM 20	low viscosity
BTM 30	disaromatized
BTM 40	low aromatic content
BTM 50	flammable, disaromatized
BTM 60	flammable, low aromatic content

Differentiation concrete release agents [Source: BG BAU]

The concrete release agent should be applied evenly to a dry surface before concreting. The application can be done by hand or with a sprayer. The use of sprayers is recommended. For pulling off rubber sliders or cloths should be used. After application, the formwork should be protected from the weather.



[Source: E. Boska (TUDA)]



Common hazards



- May be fatal if swallowed and enters airways.
- Inhalation of concrete release agents can lead to health damages.
- Skin contact leads to irritation and inflammation.
- Avoid entry into the soil, stretch of water and sewers.
- The product is flammable.



Safety basic rules and preventive measures

- When working in rooms, provide fresh air (open doors).
- Do not spray against the wind in the open air.
- When spraying, use an extension tube to avoid the inhalation of spray mist.
- Do not spray overhead.
- Keep away sources of ignition, avoid open flames.
- Do not leave vessels open.
- Thoroughly clean hands after work and before each break.
- Change heavily contaminated clothing.
- Keep street clothes and work clothes separate from each other.
- Do not eat, drink or smoke in the work area.
- Avoid contact with skin, eyes and clothing.
- Always wear protective clothing; creamed uncovered body parts with greasy-free skin protection cream.

Depending on which concrete release agent is used and how it is applied, further measures must be taken in addition to the usual personal protective alignment



Independently of the product code and the way the concrete release agent is applied, always wear gloves.



When spraying, always wear glasses or a visor helmet; when applying by hand if the product code is BTM 50 or higher.



When spraying, always wear a respirator with particle filter; when applying by hand if the product code is BTM 40 or higher.



When spraying, always wear a plastic apron; when applying by hand if the product code is BTM 40 or higher.

- Always use specific personal protective equipment; use them according to the manufacturer's instructions.
- Collaborate in the maintenance of personal protective equipment you use to ensure efficiency and proper state. To do this, see the manufacturer's instructions. The personal protective equipment must be accompanied by information concerning the storage, use, cleaning, maintenance and expiration.
- Do not modify the conditions or characteristics of the original personal protective equipment as they may lose their protective effectiveness
- Use personal protective equipment that are appropriate to your personal characteristics (size, protection glasses prescription, etc.) and make sure they fit you properly.
- Communicate those responsible for the work if you observe any deficiency in the personal protective equipment conditions (cracks, breaks, expiry date, etc.).

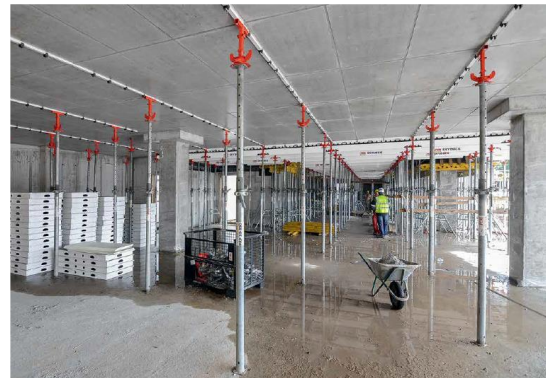


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Formwork disassembly - Dismantling

FORMWORK DISSASSEMBLY – DISMANTLING



[Source: PERI]



Aims

Once this unit has been studied, the trainee should be able to:

- Identify the most important hazards associated with the time of formworks dismantling.
- Know the safety standards and preventive measures that should generally be applied to control those hazards.
- Comply with the basic H&S rules to be followed during formworks dismantling.



Key ideas

The determination of the stripping time of formwork and falsework is of high relevance both from the technological as well as from the construction-economic point of view. In case, if the designers do not give any advice, the falsework, the formwork and the auxiliary supports may only be stripped, when the concrete has attained sufficient strength to support itself and the applied loads [5].

The site management determines the time of stripping of formworks and falsework, which underlines the responsibility for the occupational safety of the processes at the construction site, the load-bearing capacities and usability of the elements of the construction, as well as the importance for the economic and temporal success of the construction project [5].

For the determination of the stripping times for in situ concrete construction components under bending stress, the DBV-Instruction *Formwork and stripping timelines (Betonschalungen und Ausschulfristen)* [6] provides three methods:

- Determination of the stripping time according to experience,
- Tabular indications of the stripping time for typical building construction,
- Determination of the stripping time based on concrete performance.

The determination of the stripping time according to experience is dependent on the qualification of the site management or company's experience in total. Not less than State of the Art, general acknowledged Rules of Technique as well as the valid standards are to be applied [5].

For concrete and reinforced concrete components in typical building constructions and without special requirements for the serviceability (for example deflection limitation), restricted to beams and slabs up to 6 m span as well as for lintels and ring beams, the stripping timelines are defined in [6] (see table below). It is assumed, that the effects of actions at the stripping time point t_0 only consist of dead loads

and effective vertical loads, which results in an effect of actions of approximately 70% of the final state with $E_{d0} = 0,70 \cdot E_{d28}$ ($\alpha_0 = 0,70$).

Tab.: Reference values of the stripping time t_0 for typical building construction and $\alpha_0 = 0,70$ [6]

	1	2	3	4
	Component temperature ²⁾ ϑ in °C	Strength development of concrete $r = f_{cm2}/f_{cm28}$ ¹⁾		
		Fast $r \geq 0,50$	Intermediate $r \geq 0,30$	Slow $r \geq 0,15$
1	$\vartheta \geq 15$	4	8	14
2	$15 > \vartheta \geq 5$ ³⁾	6	12	20
¹⁾ The strength development of the concrete is determined by the ratio of the mean values of the concrete compressive strengths after 2 days and after 28 days. The strength development must be declared by the concrete supplier or can be taken from the concrete delivery ticket. ²⁾ The actual temperature of the component ϑ during the discharge of the hydration heat and in the formwork is generally higher than the air temperature. Instead of the temperature of the component ϑ , the mean air temperature ϑ_m can be applied. The mean air temperature ϑ_m is the mean value of the highest and lowest day air temperature close to the structure. ³⁾ In the case of air temperatures $\vartheta_m < 5^\circ\text{C}$, it is necessary to extend the time required for stripping by the days, on which the component temperature $\vartheta < 5^\circ\text{C}$ was.				

If the above mentioned methods are not applicable, the stripping time point t_0 must be defined by the required compressive strength of concrete f_{cm0} or the minimum concrete strength class in the planning process (participation of structural engineers, work preparation and site management). The strength f_{cm0} at stripping time point is to be demonstrated on the basis of hardening tests, maturity tests or other concrete performance monitoring methods [5].

Back propping is often used in construction. The process involves replacement of concrete slab formwork with temporary props. This allows the slab to gain strength while construction continues on and around it, while formwork can be reused on additional slabs.



Hazards:



- Risk of crushing a person or an object by not properly hanged load.



- The risk of injuring or death due to falling formwork system components.



- The risk of the formwork collapse due to the lack of a suitable support structure during its disassembly.



- The risk of the suspended element of the formwork system hitting a hardly visible worker who might be in the working range of the crane slings.



Safety basic rules and preventive measures



It has to be ensured that the concrete has reached the required strength, before disassembling the formwork.



In case of low temperatures or strong winds, it is necessary to prolong the ripening time of the elements in the formwork.



Disassembling of the formwork should be carried out in accordance with the procedure set in the "Technical Manual".



Workers who assemble and disassemble the formwork are obliged to use fall protection equipment.



Disassembling of the formwork should be carried out in the reverse order of assembling.



Throwing of disassembled formwork elements is forbidden.



The disassembled components should be sorted according to their intended purpose and laid in a place where they can be loaded without unnecessary additional transfer.



Store damaged items separately and consult the manufacturer's service for replacements or repairs.



Storing small formwork components [Source: PERI]



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