ENGINEERING STANDARD

FOR

PERFORMANCE REQUIREMENTS

AND

GENERAL DESIGN OF SCAFFOLDS

FIRST EDITION

JULY 2014

FOREWORD

The Iranian Petroleum Standards (IPS) reflect the views of the Iranian Ministry of Petroleum and are intended for use in the oil and gas production facilities, oil refineries, chemical and petrochemical plants, gas handling and processing installations and other such facilities.

IPS is based on internationally acceptable standards and includes selections from the items stipulated in the referenced standards. They are also supplemented by additional requirements and/or modifications based on the experience acquired by the Iranian Petroleum Industry and the local market availability. The options which are not specified in the text of the standards are itemized in data sheet/s, so that, the user can select his appropriate preferences therein

The IPS standards are therefore expected to be sufficiently flexible so that the users can adapt these standards to their requirements. However, they may not cover every requirement of each project. For such cases, an addendum to IPS Standard shall be prepared by the user which elaborates the particular requirements of the user. This addendum together with the relevant IPS shall form the job specification for the specific project or work.

The IPS is reviewed and up-dated approximately every five years. Each standards are subject to amendment or withdrawal, if required, thus the latest edition of IPS shall be applicable

The users of IPS are therefore requested to send their views and comments, including any addendum prepared for particular cases to the following address. These comments and recommendations will be reviewed by the relevant technical committee and in case of approval will be incorporated in the next revision of the standard.

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GENERAL DEFINITIONS:

Throughout this Standard the following definitions shall apply.

COMPANY:

Refers to one of the related and/or affiliated companies of the Iranian Ministry of Petroleum such as National Iranian Oil Company, National Iranian Gas Company, National Petrochemical Company and National Iranian Oil Refinery And Distribution Company.

PURCHASER:

Means the “Company” where this standard is a part of direct purchaser order by the “Company”, and the “Contractor” where this Standard is a part of contract documents.

VENDOR AND SUPPLIER:

Refers to firm or person who will supply and/or fabricate the equipment or material.

CONTRACTOR:

Refers to the persons, firm or company whose tender has been accepted by the company.

EXECUTOR:

Executor is the party which carries out all or part of construction and/or commissioning for the project.

INSPECTOR:

The Inspector referred to in this Standard is a person/persons or a body appointed in writing by the company for the inspection of fabrication and installation work.

SHALL:

Is used where a provision is mandatory.

SHOULD:

Is used where a provision is advisory only.

WILL:

Is normally used in connection with the action by the “Company” rather than by a contractor, supplier or vendor.

MAY:

Is used where a provision is completely discretionary.

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APPENDICES:

0. INTRODUCTION

The purpose of a working scaffold is to provide a safe place of work with safe access suitable for the work being done. This European Standard sets out performance requirements for working scaffolds. These are substantially independent of the materials of which the scaffold is made. The standard is intended to be used as the basis for enquiry and design.

As a number of options are given to suit different applications, a choice has to be made between the various alternatives within this European Standard. All other requirements could be in an associated job specification.

This Standard includes rules for structural design, which are of particular relevance to scaffolds made of certain materials.

Because the dimensions of the working scaffold depend on the type of work and the method of execution, the corresponding national legal rules should be taken into account.

1. SCOPE

This Standard specifies performance requirements and methods of structural and general design for access and working scaffolds, referred to from hereon as working scaffolds.

The standard excludes:

- platforms suspended by ropes, whether fixed or movable;
- horizontally movable platforms including Mobile Access Towers (MAT);
- power-operated platforms;
- scaffolds used as protection for roof work;
- temporary roofs.

Note 1:

Most working scaffolds are formed from prefabricated components or from tubes and couplers. Some examples of working scaffolds are façade scaffolds, static towers and birdcage scaffolds, but details are not given for all of these.

Note 2:

False work and shoring may be made of the structural components described in this standard, but are not working scaffolds.

Note 3:

This is a revised version of the standard No: IPS-E-SF-400 (0) which is issued as revision (1)-2014 and will revise and issue as IPS-E-SF-400(1) and IPS-E-SF-410(1). Revision (0)-1997 of the said standard specification is withdrawn.

2. REFERENCES

Throughout this Standard the following standards and codes are referred to. The editions of these standards and codes that are in effect at the time of publication of this Standard shall, to the extent specified herein, form a part of this Standard.

The applicability of changes in standards and codes that occur after the date of this Standard shall be mutually upon by the Company and the Vendor/Consultant/Contractor.

IPS (IRANIAN PETROLEUM STANDARDS)

IPS-E-SF-400	"Engineering Standard for Industrial Stairs, Ladders and Platforms"
IPS-E-GN-100	"Engineering Standard for Units"

BSI (BRITISH STANDARDS INSTITUTION)

BS 2482	"Specification for Timbers Scaffold Boards"
BS 1139	"Tubes for Use in Scaffolding"
	Part: 1139-1, 1139-1.1, 1139-1.2
BS 5810	"Access for the Disabled to Buildings"
BS EN 12810-1	"Façade Scaffolds Made of Prefabricated Components Product Specifications"

EN 12810-2	"Façade Scaffolds Made of Prefabricated Elements – Part 2: Methods of Particular Design and Assessment"
BS EN 12811-1	"Temporary Works Equipment-Part 1: Scaffolds - Performance Requirements and General Design"
BS pr EN 12811-2	"Temporary Works Equipment-Part 2: Information on Materials"
BS EN 12811-3	"Temporary Works Equipment-Part 3: Load Testing"
BS pr EN 12812:1997	"Falsework-Performance Requirements and General Design"
BS EN 1993-1-1: 2005	"Design of Steel Structures, Part 1-1: General Rules and Rules for Buildings"
ENV 1993-1-1:1992	"Eurocode 3: Design of Steel Structures – Part 1-1: General Rules and Rules for Buildings"
ENV 1999-1-1:1998	"Eurocode 9: Design of Aluminium Structures – Part 1-1: Common Rules"
BS 5974	"Code of Practice for the Planning, Design, Setting up and Use of Temporary Suspended Access Equipment"
BS EN 74	"Couplers, Spigot Pins and Baseplates for Use in Falseqork and Scaffolds"
pr EN 74-1	"Couplers, Spigots and Baseplates for use in Falsework and Scaffolds – Part 1: Couplers for Tubes – Requirements and Test Methods"
BS 449	"Use of Structural Steel in Building"

NFPA (NATIONAL FLUID PROTECTION ASSOCIATION)

NFPA 101	"Life Safety Code"

OSHA (OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION)

3150	"A guide to Scaffold use in the construction industry"

3. DEFINITIONS AND TERMINOLOGY

3.1 Anchorage

Means inserted in, or attached to, the structure for attaching a tie member.

Note: The effect of an anchorage may be achieved by the tie being connected to a part of the structure primarily intended for other purposes, see 3.23.

3.2 Base Jack

Base plate, which has a means of vertical adjustment.

3.3 Base Plate

Plate used for spreading the load in a standard over a greater area.

3.4 Birdcage Scaffold

Scaffold structure comprising a grid of standards and a decked area usually intended for working or storage.

3.5 Bosun's Chair

A suspended safety chair suitable for one man use.

3.6 Box Tie

An assembly of tubes and couplers forming a frame round a part of buildings and industrial installations.

3.7 Brace

A tube placed diagonally with respect to the vertical or horizontal members of a scaffold and fixed to them to afford stability.

3.8 Bracing in Horizontal Plane

Assembly of components which provides shear stiffness in the horizontal planes, e.g. by decking components, frames, framed panels, diagonal braces and rigid connections between transoms and ledgers or other items used for horizontal bracing.

3.9 Bracing in Vertical Plane

Assembly of components which provides shear stiffness in the vertical planes, e.g. by closed frames with or without corner bracing, open frames, ladder frames with access openings, rigid or semi-rigid connections between horizontals and the vertical components, diagonal bracing, or other items used for vertical bracing.

3.10 Brick Guard

A brick or other fender filling the gap between the guardrail and toeboard and something incorporating one or both of these components.

3.11 Bridle

A horizontal tube fixed across an opening or parallel to the face of a building to support the inner end of a putlog transom or tie tube.

3.12 Butting Tube

A tube which butts up against the facade of a building or other surface to prevent the scaffold moving towards that surface.

3.13 Cage

A barrier, which may be referred to as a cage guard or basket guard, that is an enclosure mounted on the side rails of the fixed ladder or fastened to the structure to enclose the climbing space of the ladder in order to safeguard the employee climbing the ladder.

3.14 Castor

A swiveling wheel secured to the base of a vertical member for the purpose of mobilizing the scaffold.

3.15 Cladding

Material normally intended to provide weather and dust protection, typically sheeting or netting.

3.16 Coupler

Device used to connect two tubes.

3.17 Cradle

That portion of the assembly designed to carry the work people and their equipment.

3.18 Design

Conception and calculation to produce a scheme for erection.

3.19 Facade

Face of a building.

3.20 Forkhead

A U-shaped housing for assembly on the end of a tube to accept bearers.

3.21 Gin Wheel or Block

A single pulley for fiber ropes attached to a scaffold for raising or lowering materials.

3.22 Guy Anchor

A pin or tube driven into the ground at approximately 45ø to the horizontal to provide an anchorage for a rope.

3.23 Inside Board

A board placed between the scaffold and the building on extended transoms, or a hop-up bracket.

3.24 Landing

Any area such as the ground, roof, or platform that provides access/egress for a fixed ladder.

3.25 Lashing

A rope intended for joining two or more objects, such as scaffolding, at the points of intersection.

3.26 Ledger

Horizontal member normally in the direction of the larger dimension of the working scaffold.

3.27 Lift

The assembly of ledgers and transoms forming each horizontal level of a scaffold.

3.28 Lip Tie

An assembly of tubes forming L or J shaped hook round an inside surface of a building.

3.29 Modular System

System in which transoms and standards are separate components where the standards provide facilities at predetermined (modular) intervals for the connection for other scaffold components.

3.30 Movable Tie

A tie which may be temporarily moved for the execution of work.

3.31 Netting

Pervious cladding material.

3.32 Node

Theoretical point where two or more members are connected together.

3.33 Outrigger

The cantilevered portion of the rooting or roof trolley from which the cradle is suspended.

3.34 Parallel Coupler

Coupler used for connecting two parallel tubes.

3.35 Platform

One or more platform units in one level within a bay.

3.36 Platform Unit

Unit (prefabricated or otherwise) that supports a load on its own and which forms the platform or part of the platform and may form a structural part of the working scaffold.

3.37 Putlog Scaffold

A scaffold which has one line of vertical tubes to support the outside edge of the deck and utilizes the wall being built or the building to support the inside edges.

3.38 Raker

An inclined load-bearing tube.

3.39 Reveal Tie

The assembly of a reveal tube with wedges or screwed fittings, and pads, if required fixed between opposing faces of an opening in a wall together with the tie tube.

3.40 Right Angle Coupler

Coupler used for connecting two tubes crossing at a right angle.

3.41 Scaffold Board

A softwood board generally used with similar boards to provide access, working platforms and protective components such as toeboards on a scaffold.

3.42Sheeting

Impervious cladding material.

3.43 Side Protection

Set of components forming a barrier to protect people from the risk of falling and to retain materials.

3.44 Sleeve Coupler

Coupler used for joining two tubes located co-axially.

3.45 Standard

Upright member.

3.46 Suspended Scaffold

A scaffold hanging on ropes which is capable of being suspended or raised and lowered.

3.47 Swivel Coupler

Coupler used for connecting two tubes crossing at any angle.

3.48 Through Tie

A tie assembly through a window or other opening in a wall.

3.49 Tie Member

Component of the scaffold, which connects it with an anchorage at the structure.

3.50 Toeboard

An upstand at the edge of a platform, intended to prevent materials or operatives feet from slipping off the platform.

3.51 Transom

Horizontal member normally in the direction of the smaller dimensions of the working scaffold.

3.52 Walkway

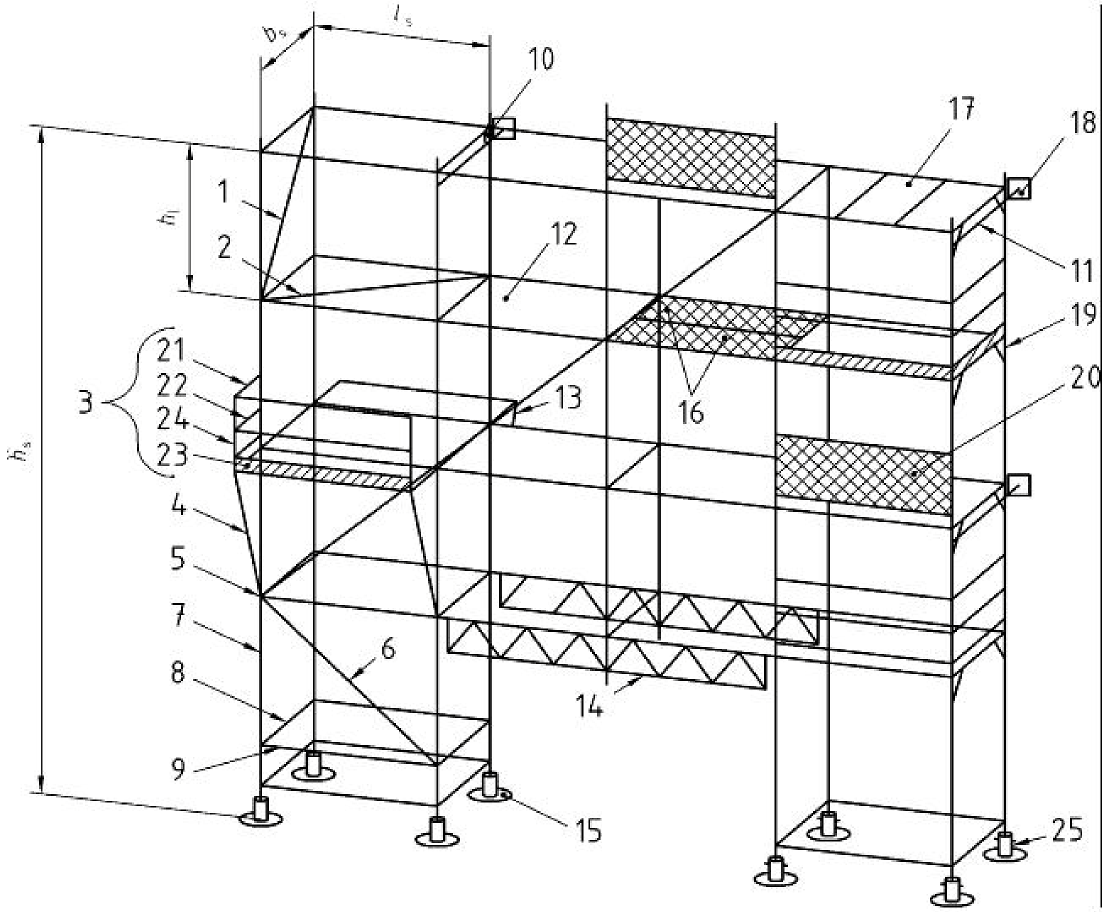
Lateral access, e.g. from one section of plant or equipment to another.

3.53 Working Area

Sum of the platforms in one level, to provide an elevated safe place for people to work on and to give access to their work.

3.54 Working Scaffold

Temporary construction, which is required to provide a safe place of work for the erection, maintenance, repair or demolition of buildings and other structures and for the necessary access.



Key

hs	Scaffold height	11	Tie member (3.49)
bs	Scaffold bay width, centre to centre of standards	12	Platform (3.35)
		13	Bracket (-)
ls	Scaffold bay length, centre to centre of standards	14	Bridging ledger (-)
		15	Base plate (3.3)
hl	Scaffold lift height	16	Platform unit (3.36)
1	Bracing in vertical plane ((transverse diagonal) (3.9)	17	Horizontal frame (-)
		18	Anchorage (3.1)
2	Bracing in horizontal plane (3.8)	19	Vertical frame (-)
3	Side protection (3.43)	20	Fencing structure (6.5.5)
4	Bracket brace (-)	21	Principal guardrail (6.5.2)
5	Node (3.32)	22	Intermediate guardrail (6.5.3)
6	Bracing in vertical plane (longitudinal diagonal) (3.9)	23	Toeboard (6.5.4)
		24	Post (-)
7	Standard (3.45)	25	Base jack (3.2)
8	Transom (3.51)		
9	Ledger (3.26)		
10	Coupler(3.16)		

Note 1: The Figure is for component identification purposes only and does not show any requirements.

Note 2: (-) These terms are not found in the text, but are useful to understand the various components that can be used with a working scaffold.

EXAMPLES OF TYPICAL COMPONENTS OF A FAÇADE SCAFFOLD SYSTEM

Fig. 1

4. UNITS

This standard is based on international system of units (SI), as per IPS-E-GN-100 except where otherwise specified.

5. MATERIALS

5.1 General

Materials shall fulfil the requirements given in Standards, where design data are provided.

Information for the most commonly used materials is given in prEN 12811-2. Material used shall be sufficiently robust and durable to withstand normal working conditions.

Materials shall be free from any impurities and defects, which may affect their satisfactory use.

5.2 Specific Material Requirements

5.2.1 Steel

5.2.1.1 General

Steels of deoxidation type FU (rimming steels) shall not be used.

5.2.1.2 Loose tubes

Loose tubes to which it is possible to attach couplers complying with prEN 74-1 (i.e. nominal 48,3 mm outside diameter) shall have a minimum nominal yield strength of 235 N/mm² and a minimum nominal wall thickness of 3,2 mm.

Note:

Loose tubes are usually found in tubes and couplers scaffolds but can also be used in façade scaffold made of prefabricated components e.g. to tie a working scaffold to the façade

5.2.1.3 Tubes for prefabricated components for scaffold systems

For tubes incorporated in prefabricated components for scaffold systems according to EN 12810-1 of nominal outside diameter of 48,3 mm the specifications of EN 12810-1 apply.

Tubes shall not be indented beyond the limits in prEN 74-1 when couplers are attached.

Tubes of external nominal diameter different from the range of 48,3 mm, other than side protection, shall have the following nominal characteristics:

- wall thickness ≥ 2,0 mm
- yield stress, $R_{eH} \geq 235$ N/mm2
- elongation, A ≥ 17 %

5.2.1.4 Side protection

Items used exclusively for side protection, other than toe-boards, shall have a minimum nominal wall thickness of 1,5 mm. For toeboards the minimum nominal wall thickness shall be 1,0 mm. A lesser thickness may be used if the serviceability and load bearing capacity is ensured for instance by the use of stiffening sections, bracing or shaping of the cross section.

5.2.1.5 Platform units

Platform units and their immediate supports shall have a minimum nominal thickness of 2,0 mm. A lesser thickness may be used if the serviceability and load bearing capacity is ensured for instance by the use of stiffening sections, bracing or shaping of the cross section.

5.2.1.6 Protective coating for components

Components shall be protected as determined in prEN 12811-2.

5.2.2 Timber and timber based materials

Timber shall be stress graded in accordance with EN 338.

If a protective coating is used, it shall not prevent the discovery of defects in the material.

Plywood for platform units shall have at least five plies and a minimum thickness of 9 mm.

Plywood platform units assembled ready for use shall be capable of retaining a circular steel bar of 25 mm diameter and 300 mm length falling endwise from a height of 1 m.

Plywood shall have a good durability with regard to climatic conditions.

6. GENERAL REQUIREMENTS

6.1 General

Every area for access and working shall be so arranged as to provide a convenient working place, and to:

- protect people from the risk of falling;
- provide safe storage of materials and equipment;
- protect those below from falling objects.

Attention shall be paid to ergonomic considerations.

The area shall be fully decked and shall be provided with appropriate side protection (see 6.5) when ready for use.

Connections between separate parts shall be effective and easy to monitor. They shall be easy to assemble and secure against accidental disconnection.

6.2 Width Classes

The width, w, is the full width of the working area including up to 30 mm of the toeboard, see Figure 2. Seven width classes are given in Table 1.

Note 1:

In some countries minimum widths are laid down for various types of work activity.

The clear distance between standards, c, shall be at least 600 mm; the clear width of stairways shall not be less than 500 mm.

Each working area, including the corners, shall have its specified width along its full length. This requirement does not apply in the immediate vicinity of a pair of standards, where there shall be a completely unimpeded area with a minimum width, b and p in accordance with the dimensions given in Figure 2.

Note 2:

When equipment or materials are placed on the working area, consideration should be given to maintaining space for work and access.

TABLE 1 - WIDTH CLASSES FOR WORKING AREAS

Width class	W in m
W06	$0,6 \le w < 0,9$
W09	$0,9 \le w < 1,2$
W12	$1,2 \le w < 1,5$
W15	$1,5 \le w < 1,8$
W18	$1,8 \le w < 2,1$
W21	$2,1 \le w < 2,4$
W24	$2,4 \le w$

6.3 Headroom

The minimum clear headroom, h_3, between working areas shall be 1,90 m.

The headroom requirements for the height h1a between working areas and transoms or for the height h_{1b} (see Figure 2) between working areas and tie members are given in Table 2.

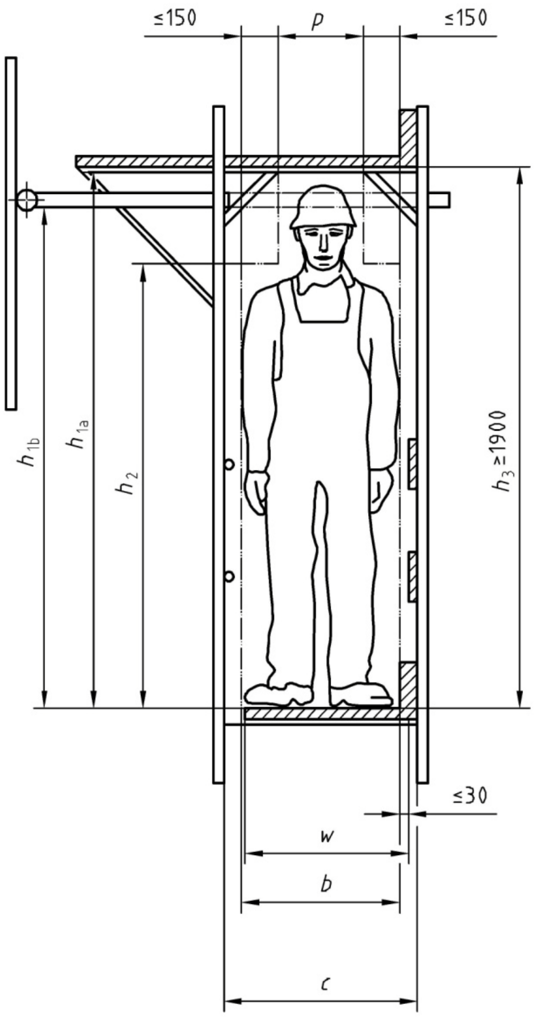
TABLE 2 - HEADROOM CLASSES

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	$h_3 \ge 1,90$ m	$1,75\ m \le h_{1a} < 1,90$ m $1,75\ m \le h_{1b} < 1,90$ m	$h_2 \ge 1,60$ m
H_2	$h_2 \ge 1,90$ m	$h_{1a} \ge 1,90$ m $h_{1b} \ge 1,90$ m	$h_2 \ge 1,75$ m

Note:

For side protection, see 6.5.

Dimensions in millimetres



Key

b = free walking space, which shall be at least the greater of 500 mm and (c - 250 mm)

c = clear distance between standards

h_{1a}, h_{1b} = clear headroom between working areas and transoms or tie members respectively

h_2 = clear shoulder height

h_3 = clear headheight between working areas

p = clear headheight width, which shall be at least the greater of 300 mm and (c - 450 mm)

w = width of the working area in accordance with clause 6.2

REQUIREMENTS FOR HEADROOM AND WIDTH OF WORKING AREAS

Fig. 2

6.4 Working Areas

a) It shall be possible to secure platform units against dangerous displacement e.g. unintended dislodging or uplifting by wind forces.

b) Platform units should have a slip-resistant surface.

Note:

A timber surface normally meets the requirements for slip-resistance. The risk of tripping from any method used to secure the platform unit or from overlapping should be minimised.

c) The gaps between platform units shall be as small as possible but not exceeding 25 mm.

d) Working areas shall be as level as practicable. If the slope exceeds 1 in 5, securely attached full width footholds shall be provided. Except that, where necessary, there may be gaps not exceeding a width of 100 mm in the centre of the footholds to facilitate the use of wheelbarrows.

6.5 Side Protection

6.5.1 General

Working and access areas shall be safeguarded by a side protection consisting of at least a principal guardrail, intermediate side protection and a toeboard. See Figure 3. The toeboard may be dispensed with on stairways.

Side protection shall be secured against unintended removal.

For structural design requirements, see clause 7.

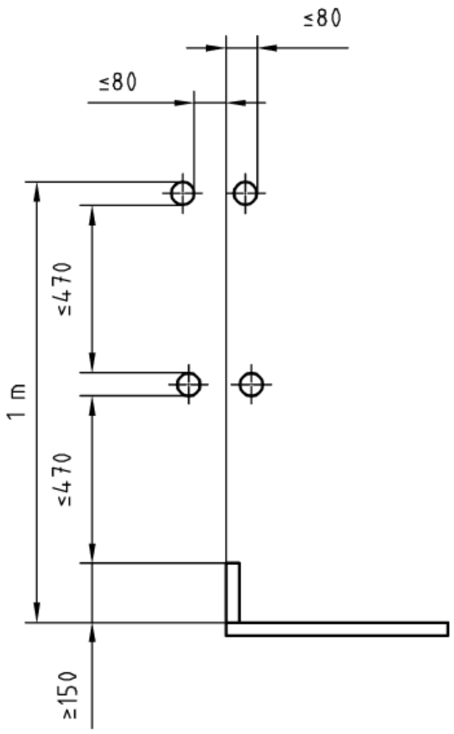
Note 1:

The side protection should not be provided by cladding on its own.

Note 2:

For special cases e.g. use of working scaffolds in vertical formwork there may be a need of inclined side protection, which is outside the field of application of this standard.

dimensions in millimeters



DIMENSIONS FOR VERTICAL SIDE PROTECTION WITH ONE INTERMEDIATE GUARDRAIL

Fig. 3

6.5.2 Principal guardrail

The principal guardrail shall be fixed so that its top surface is 1 m or more above the adjacent level of the working area everywhere (absolute minimum height 950 mm).

6.5.3 Intermediate side protection

Intermediate side protection shall be fixed between the principal guardrail and the toeboard.

Intermediate side protection may consist of:

- one or more intermediate guardrails, or
- a frame, or
- a frame of which the principal guardrail forms the top edge, or
- a fencing structure

Openings in the side protection shall be so dimensioned that a sphere with a diameter of 470 mm will not pass through them.

6.5.4 Toeboard

A toeboard shall be fixed so that its top edge is at least 150 mm above the adjacent level of the working area.

Holes and slots in a toeboard shall, except for handling holes be no larger than 25 mm in one direction.

6.5.5 Fencing structures

The area of each hole or slot in fencing structures shall not exceed 100 cm^2. In addition, the horizontal dimension of each hole or horizontal slot shall not exceed 50 mm.

6.5.6 Location of the components of the side protection

The horizontal distance between the outer face of the toeboard and the inner face of the guardrail and all the components of the intermediate side protection shall not exceed 80 mm.

6.6 Cladding

Where cladding of the working scaffold is required, this standard assumes that the scaffold will be clad with either netting or sheeting.

6.7 Base Plates and Base Jacks

6.7.1 General

The strength and rigidity of the base plates and base jacks shall be sufficient to ensure that it can transmit the maximum design load from the working scaffold to the foundations. The area of the end plate shall be a minimum of 150 cm^2. The minimum width shall be 120 mm.

6.7.2 Base plates

Base plates made of steel shall conform to EN 74.

6.7.3 Base jacks

Base jacks shall be provided with a centrally positioned adjusting spindle of such dimensions that, in the unloaded condition, the greatest inclination of the axis of the shaft from the axis of the standard does not exceed 2,5 %. The minimum overlap length at any position of adjustment shall be 25 % of the total length of the shaft, or 150 mm whichever is greater. The thickness of the endplate shall be at least 6 mm. Shaped endplates shall have at least the same rigidity.

6.7.4 Joints between standards with hollow sections

The overlap length in joints between standards shall be at least 150 mm. It may be reduced to a minimum of 100 mm if a locking device is provided.

6.8 Access between Levels

6.8.1 General

Safe and ergonomic means of access shall be provided.

The scaffold system shall include provision for access between the different levels. This shall be by inclined ladders or stairs. It shall be within the platform, within a widening of the working scaffold at one bay or in a tower immediately adjacent.

Ladders in accordance with IPS-E-SF-400 may be assumed to satisfy the requirements for access in this standard.

The stairways and ladders shall be secured against unintentional loosening and shall have a slip resistant surface.

Note 1:

When extensive work is carried out, stairways should be provided for access.

Note 2:

For taller scaffolds consideration should be given to the use of a passenger hoist.

Note 3:

For access between levels, vertical ladders are implicitly excluded.

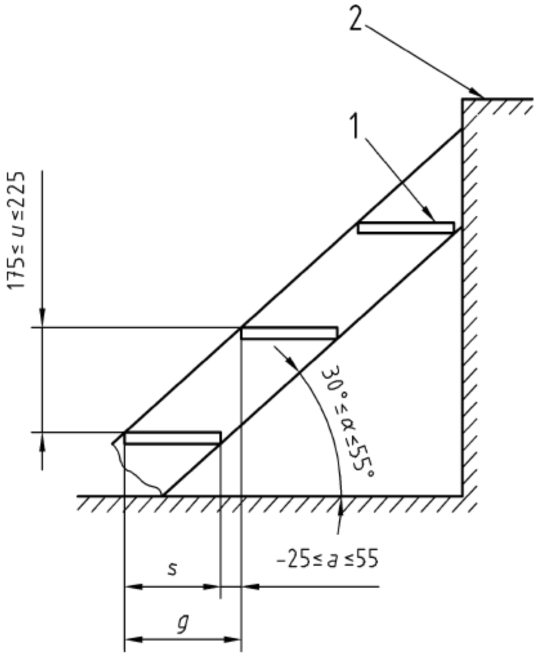
6.8.2 Stairways

To cater for different requirements for stairways this Standard specifies two classes of stairway dimensions. The dimensions of stair flights shall be in accordance with Figure 4 and the following:

The combination of values for the rise, u, and the going, g, shall be in accordance with expression (1):

$$540 \leq 2u + g \leq 660 \text{ in mm}$$

Stairway dimensions		
Dimension	**Class**	
	A mm	**B** mm
s	125 ≤ s < 165	s ≥ 165
g	≥ 150 ≤ g < 175	g ≥ 175
Minimum clear width 500 mm		



Key

1 Tread

2 Landing

STAIRWAY DIMENSIONS

Fig. 4

7. REQUIREMENTS FOR STRUCTURAL DESIGN

7.1 Basic Requirements

7.1.1 General

Each working scaffold shall be designed, constructed and maintained to ensure that it does not collapse or move unintentionally and so that it can be used safely. This applies at all stages, including erection, modification and until fully dismantled.

The scaffold components shall be designed so they can be safely transported, erected, used, maintained, dismantled and stored.

7.1.2 External support

A working scaffold shall have a support or foundation capable of resisting the design loads and limiting movement.

Lateral stability of the scaffold structure as a whole and locally shall be verified when subjected to the different design forces, for example from the wind.

Note 1:

Lateral stability can be provided by tie members to the adjacent building or structure. Alternatively other methods, such as guy ropes, kentledge or anchors may be used.

Note 2:

It may be necessary to remove individual ties temporarily in order to carry out work on the permanent structure. In such a case removal of the ties should be taken into consideration in the design and a method statement prepared specifying the sequence for removal and replacement of ties.

7.1.3 Load classes

To cater for different working conditions, this Standard specifies six load classes and seven width classes of working areas. The service loads are set out in Table 3.

The load class for working areas shall correspond to the nature of work.

Note:

In exceptional cases, where it is impractical to adopt one of the load classes or the activity is more onerous, different parameters may be adopted and specified after analysis of the use to which the working scaffold will be put. Consideration should be given to the actual activities to be undertaken. Some examples of items to be considered are:

a) The weight of all equipment and materials stored on the working area,

b) Dynamic effects from material placed on the working area by powered plant and

c) Load from manually operated plant such as wheelbarrows.

Storage of materials on working scaffolds of load class 1 is not covered by the service loads specified in Table 3.

TABLE 3 - SERVICE LOADS ON WORKING AREAS

Load class	Uniformly distributed load q_1 kN/m₂	Concentrated load on area 500 mm x 500 mm F_1 kN	Concentrated load on area 200 mm x 200 mm F_2 kN	Partial area load	
				q_2 kN/m₂	Partial area factor a_p [1]
1	0,75 [2]	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

1 See 7.2.2.4
2 See 7.2.2.1

7.2 Actions

7.2.1 General

The values specified in 7.2 shall be treated as characteristic values of the actions (loads).

There are three main types of loading which need to be considered:

a) Permanent loads; these shall include the self weight of the scaffold structure, including all components, such as platforms, fences, fans and other protective structures and any ancillary structures such as hoist towers.

b) Variable loads; these shall include service loads (loading on the working area, loads on the side protection) and wind loads and, if appropriate, snow and ice loads (see 7.2.6).

c) Accidental loads; the only accidental load specified in this Standard is the loading according to 7.2.5.1.

Loadings given in 7.2.2 and 7.2.5 do not cover actions from people jumping or falling down from a height onto the platform or onto the side protection.

Note:
Basic scaffold design is based on the UDL. Normally the additional criteria will only be used to justify generic solutions. Only the UDL is to be carried to the base of the scaffold.

7.2.2 Loading on the working area

7.2.2.1 General

The service loads shall be as specified in Table 3. Each working area shall be capable of supporting the various loadings, q_1, F_1 and F_2, separately but not cumulatively. Only the uniformly distributed load, q_1, has to be carried down to the support of the scaffold structure, for birdcage scaffolds the partial area loads also, see Figure 5d.

For the purposes of structural design, service loads on the working area shall be applied over an area determined as follows:

- Where there are contiguous platforms along or across the working scaffold, the dividing edge shall be taken as a centreline between the supporting standards.

- At any outer edge the dimension, w, shall be taken to the actual edge or, where there is a toeboard, as it is defined in 6.2. See Fig. 2.

For working scaffolds of load class 1, all platform units shall be capable of supporting class 2 service load, but this shall not apply to the scaffold structure in its entirety.

7.2.2.2 Uniformly distributed service load

Each working area shall be capable of supporting the uniformly distributed load, q_1, specified in Table 3.

7.2.2.3 Concentrated load

Each platform unit shall be capable of supporting the load, F_1, specified in Table 3, uniformly distributed over an area of 500 mm x 500 mm and, but not simultaneously, the load, F_2, specified in Table 3, uniformly distributed over an area of 200 mm x 200 mm.

The load path shall be capable of transferring the forces caused by the loads to the standards. The position of each load shall be chosen to give the most unfavourable effect.

When a platform unit is less than 500 mm wide, the load, F_1, according to Table 3, may be reduced for this unit in proportion to its width, except that in no case shall the loading be reduced to less than 1,5 kN.

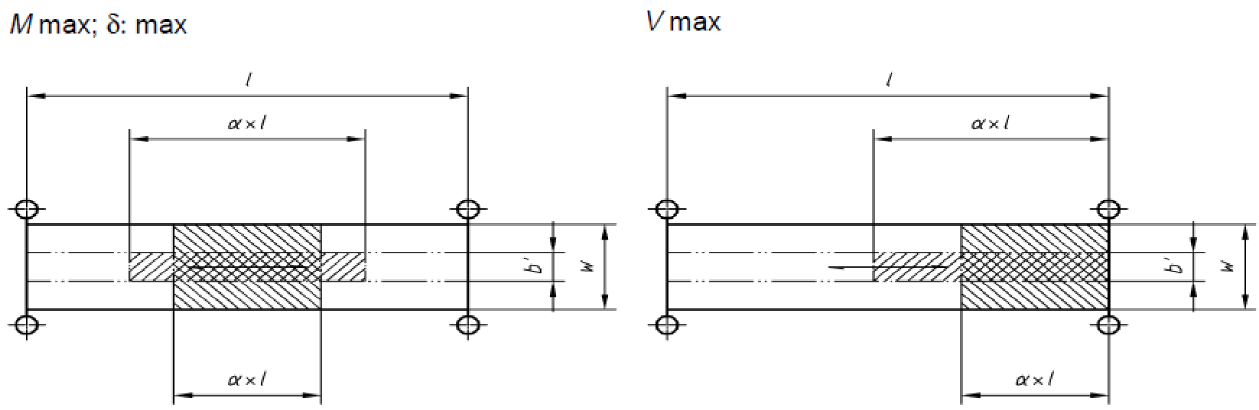
7.2.2.4 Partial area load

Each platform of load class 4, 5 and 6 shall be capable of supporting a uniformly distributed partial area loading, q_2, which is a loading greater than the uniformly distributed service load. The partial area is obtained by multiplying the area of the bay, A, by the partial area factor a_p. Values of q_2 and a_p are given in Table 3. The area A is calculated from the length, l, and the width w, of each platform, see Figure 5.

The load path shall be capable of transferring the forces caused by the loads to the standards.

Where there are more than two standards in both directions, as in a birdcage, the partial area loads of four contiguous bays shall be considered for the verification of the respective supporting standard, see Figure 5d).

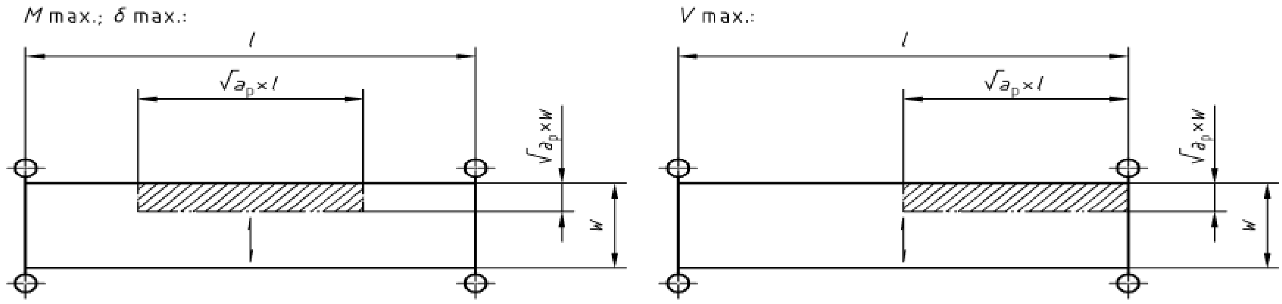
The dimensions and position of the partial area shall be chosen to give the most unfavourable effect. Some examples are shown in Figure 5.



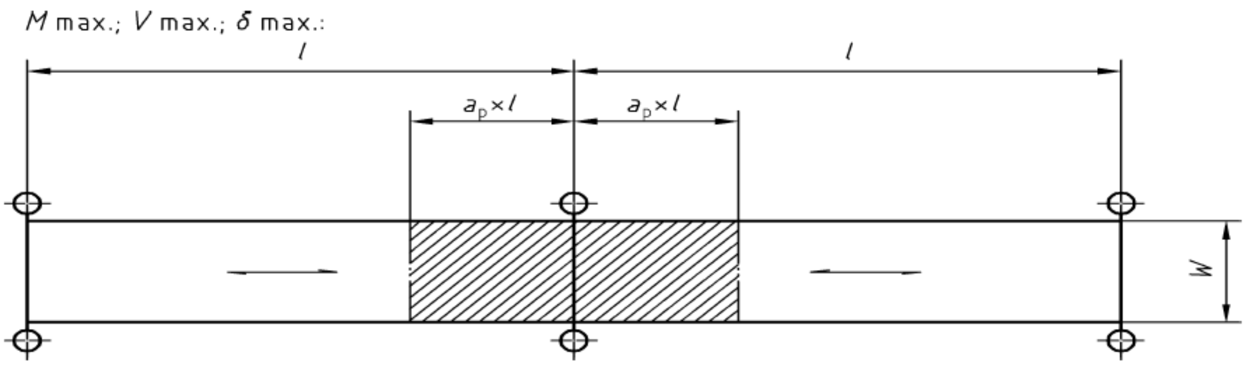
$$b' \leq a_p \times w: \qquad \alpha = 1$$

$$a_p \times w \leq b' \leq w: \quad \alpha = a_p \times \frac{w}{b'}$$

a) Platform *) or platform unit **): longitudinal span



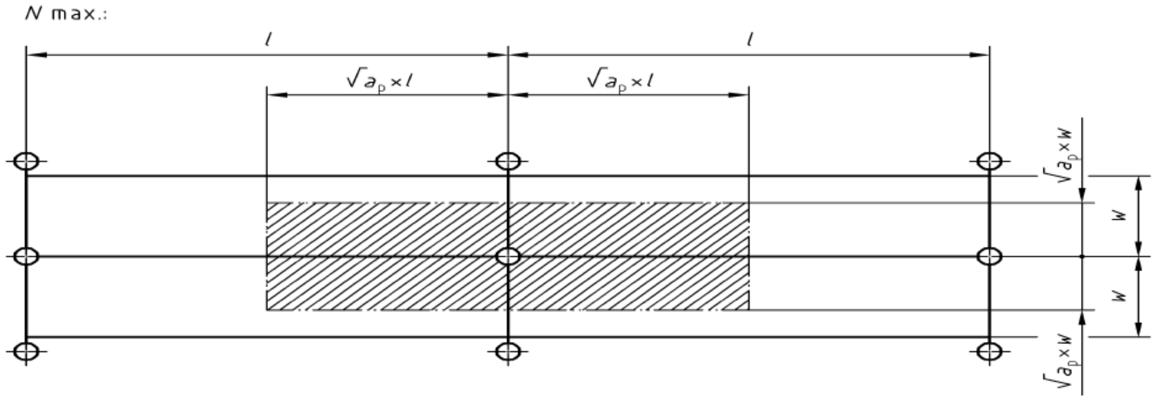
b) Ledger: transverse span of the platform



c) Transom: longitudinal span of the platform

(to be continued)

(Continued)



d) Central standard of a birdcage scaffold

Key

ℓ	system length	M max	maximum bending moment
w	width of the platform	V max	maximum shear force
a_p	partial area factor, see Table 4	N max	maximum axial force
b'	width of the platform unit	δ max	maximum deflection

EXAMPLES FOR THE POSITIONING OF THE PARTIAL AREA LOAD FOR THE CALCULATION OF SOME STRUCTURAL COMPONENTS
Fig. 5 (a-d)

7.2.2.5 Cantilevered portions of a working area

All cantilevered portions of a working area shall be capable of supporting the service load specified for the main working area (see 7.2.2.2, 7.2.2.3 and 7.2.2.4).

If the levels of the cantilevered portions and the main working area differ by 250 mm or more, they may be of different load classes, according to Table 3.

7.2.2.6 Birdcage scaffolds

The load on the supporting components of a birdcage scaffold shall be calculated by assuming that the uniformly distributed load q_1 specified in Table 3 acts on an area of maximum 6,0 m^2 in combination with a load of 0,75 kN/m^2 over the remaining area.

7.2.3 Horizontal working load allowance

In the absence of wind the working scaffold shall be capable of supporting a notional horizontal working load, representing operations during use, acting at all of the levels where the working area is loaded.

For each bay considered the notional horizontal load shall be not less than 2,5 % of the total of the uniformly distributed load, q_1, specified in Table 3, on that bay, or 0,3 kN, whichever is the greater. The load shall be assumed to act at the level of the working area and shall be applied separately parallel and perpendicular to the bay.

7.2.4 Access routes

Except for class 1 working scaffolds, horizontal access routes shall be capable of supporting at least the class 2 service loading, specified in Table 3.

When a part of an access route is to be used for working, it shall be capable of supporting the relevant service load prescribed in Table 3. Normally a landing, which is at the same level as a working area but outside of it, need not be capable of supporting the same load.

For stairways built for access to a working scaffold, each tread and landing shall be designed to support the more unfavourable of: either

a) a single load of 1,5 kN in the most unfavourable position, assumed to be uniformly distributed over an area of 200 mm x 200 mm or over the actual width if it is less than 200 mm, or

b) an uniformly distributed load of 1,0 kN/m^2.

The structure of the stairways shall be capable of supporting a uniformly distributed load of 1,0 kN/m^2 on all treads and landings within a height of 10 m.

Note:
For access stairways, detailed loadings including 1 kN/m^2 are specified. However, a concentrated (point) load of 1,5 kN is required in the design of individual components.

7.2.5 Loads on the side protection

7.2.5.1 Downward loading

Any principal guardrail and intermediate guardrail, regardless of its method of support, shall be capable of resisting a point load of 1,25 kN. This also applies to any other side protection component, which replaces principal guardrails and intermediate guardrails such as a fencing structure, which has gaps in excess of 50 mm width.

This load shall be considered as an accidental load and shall be applied in the most unfavourable position in a downward direction within a sector of ± 10° from the vertical.

7.2.5.2 Horizontal loading

All components of the side protection, except toeboards, shall be designed to resist a horizontal point load of 0,3 kN in each case in the most unfavourable position. This load may be distributed over an area of maximum 300 mm x 300 mm, for example when applied to the grid of a fencing structure. For toeboards, the horizontal point load is 0,15 kN.

7.2.5.3 Upward loading

To check the fixing of all side protection components, except the toeboard, a point load of 0,3 kN shall be applied vertically upwards in the worst position.

7.2.6 Snow and ice loads

An allowance for snow and ice loading on a working scaffold may be required by Iranian code for minimum loads on structure (INBC-part6).

7.2.7 Wind loads

7.2.7.1 General

Wind loads shall be calculated by assuming that there is a velocity pressure on a reference area of the working scaffold, which is in general the projected area in the wind direction. The resultant wind force, F, in kN, is obtained from equation (2):

$$F = C_s x \sum_i (C_{f,i}\, x A_i x q_i) \qquad (2)$$

Where:

F is the resultant wind force;
$c_{f,I}$ is the aerodynamic force coefficient for the scaffold component i (see 7.2.7.2);
A_i is the reference area of the scaffold component i;
q_i is the velocity pressure acting on the scaffold component i;
c_s is the site coefficient (see 7.2.7.3).

Shielding effects shall not be taken into account.

The following subclauses 7.2.7.2 and 7.2.7.3 relate to unclad working scaffolds only. For wind loads on clad working scaffolds see Appendix A.

7.2.7.2 Aerodynamic force coefficient, c_f

Aerodynamic force coefficients, c_f, appropriate for some cross sections of scaffold components given in ENV 1991-2-4 shall be used when calculating the wind force on a working scaffold.

For other cross-sections the aerodynamic force coefficients may be taken from Iranian code for minimum loads on structure (INBC-part6) or may be determined by wind tunnel testing.

The value of the aerodynamic force coefficient, c_f, shall be taken as 1,3 for all projected areas including platforms, toeboards and the nominal area defined in 7.2.7.4.1 or 7.2.7.4.2 respectively.

7.2.7.3 Site coefficient, c_s

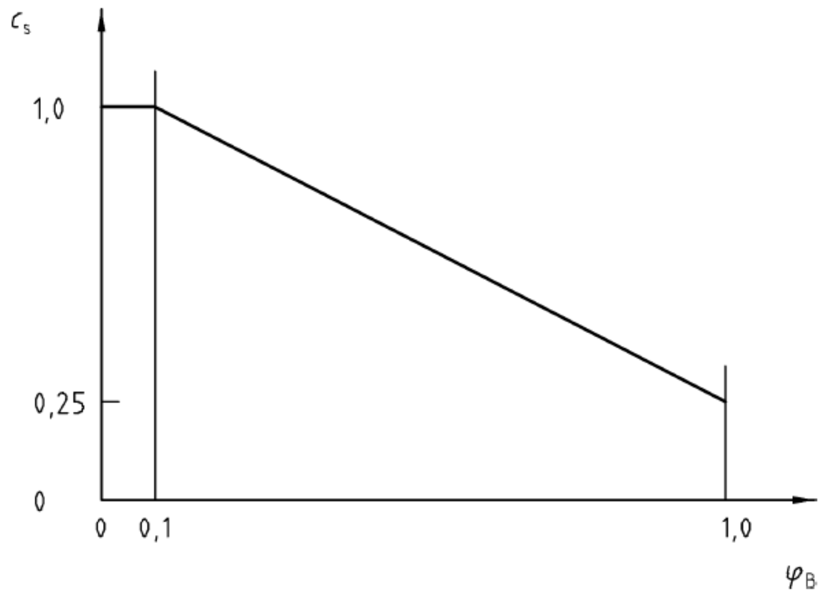
7.2.7.3.1 The site coefficient, c_s takes into account the location of the working scaffold in relation to a building, for example in front of a façade. The site coefficient c_s according to 7.2.7.3.2 and 7.2.7.3.3 applies to a facade with openings, which are distributed regularly over its area.

7.2.7.3.2 For wind forces normal to the façade, the value of $c_{s\perp}$ is to be taken from Figure 6. It depends on the solidity ratio, φ_B, which is given by equation (3):

$$\varphi_B = \frac{A_{B,n}}{A_{B,g}} \qquad (3)$$

Where:

$A_{B,n}$ is the net area of the façade (with the openings deducted);
$A_{B,g}$ is the gross area of the facade.



SITE COEFFICIENT $C_{S\perp}$ FOR WORKING SCAFFOLDS IN FRONT OF A FAÇADE FOR WIND FORCES NORMAL TO THE FAÇADE

Fig. 6

7.2.7.3.3 For wind forces parallel to the façade, the value of c_{s-} shall be taken as 1,0.

7.2.7.4 Velocity pressure

7.2.7.4.1 Maximum wind loading

The maximum wind loading for the region shall take into account the type and location of the site. When the European Standard for wind loads is available it shall be used. Pending its availability, data shall be taken from national standards. A statistical factor considering the period of time from the erection to the dismantling of the working scaffold may be taken into account. This factor shall be not less than 0,7 and shall be applied to the wind velocity pressure for a 50-year return period.

Note:

For the purposes of structural design of façade scaffolds made of prefabricated components, design velocity pressures are given in EN 12810-1. The actual wind conditions should be checked.

To make allowance for equipment or materials which are on the working area, a nominal reference area shall be assumed at its level over its full length. This area shall be 200 mm high measured from the level of the working area and includes the height of the toeboard. The loads resulting from the wind pressure on this area shall be assumed to act at the level of the working area. Iranian code for minimum loads on structure (INBC-part6)

7.2.7.4.2 Working wind load

A uniformly distributed velocity pressure of 0,2 kN/m^2 shall be taken into account. To make allowance for equipment or materials being on the working area, a nominal reference area as defined in 7.2.7.4.1, but 400 mm high, shall be used in calculating working wind loads.

7.2.8 Dynamic loading

The following figures may be taken as equivalent static loads to represent the excess loading caused by dynamic effects in service conditions.

a) The dynamic effect of the load from an individual item, except people, moving vertically by powered means shall be represented by a 20 % increase in the weight of the item.

b) The dynamic effect of a load from an individual item moving horizontally, except people, shall be represented by an equivalent static force of 10 % of the weight of the item, acting in any of the practical possible horizontal directions.

Note 1:

For dynamic loading resulting from people falling down from a height on platforms of facade scaffold made of prefabricated components see EN 12810-1.

Note 2:
BS 5973 specified 25 % vertically.

Note 3:

For cantilever beams known impact loads were doubled and added to the load. It was recommended that steel bolts have a minimum safety factor of 3,3.

7.2.9 Load combinations

7.2.9.1 General

Each working scaffold structure shall be capable of resisting the worst combinations of loads to which it is likely to be subjected. The conditions on site shall be established and load combinations determined accordingly.

For façade scaffolds load combinations are given in 7.2.9.2. These load combinations may also be appropriate for types of working scaffold different from facade scaffolds.

7.2.9.2 Facade scaffolds

The combinations a) and b) shall be used for the structural design of facade scaffolds unless reliable information on the manner of use of the scaffold is available.

In each individual case the service condition and the out of service condition shall be considered.

a) The service condition

1) The self weight of the scaffold, see 7.2.1.

2) Uniformly distributed service load appropriate to the class of the working scaffold specified in Table 3, column 2, acting on the working area of the most unfavourable decked level.

3) 50% of the load specified in a) 2) shall be taken to act on the working area at the next level above or below if a working scaffold has more than one decked level.

4) Working wind load specified in 7.2.7.4.2 or horizontal working load allowance specified in 7.2.3.

b) The out of service condition

1) The self weight of the scaffold, see 7.2.1.

2) A percentage of the uniformly distributed load, specified in Table 3, column 2, acting on the most unfavourable decked level. The value depends on the class:

class 1: 0 %; (no service load on the working area);
classes 2 and 3: 25%; (representing some stored materials on the working area);
classes 4, 5 and 6: 50%; (representing some stored materials on the working area);

3) The maximum wind load specified in 7.2.7.4.1.

In cases a) 2) and b) 2), the load shall be taken as zero, if its consideration leads to more favourable results; for example in the case of overturning.

7.3 Deflections

7.3.1 Elastic deflection of platform units

When subjected to the concentrated loads specified in Table 3, columns 3 and 4 the elastic deflection of any platform unit shall not exceed 1/100 of its span.

Furthermore, when the appropriate concentrated load is applied, the maximum deflection difference between adjacent loaded and unloaded platform units shall not exceed 25 mm.

7.3.2 Elastic deflection of the side protection

Each principal or intermediate guardrail and toeboard, regardless of its span, shall not have an elastic deflection greater than 35 mm, when subjected to the horizontal load specified in 7.2.5.2.

This is measured with reference to the supports at the points where the component is fixed.

7.3.3 Deflection of fencing structures

When subjected to the horizontal load specified in 7.2.5.2, the grid of a fencing structure shall not deflect more than 100 mm with reference to its supports.

When a fencing structure is combined with a guardrail, the requirements for a guardrail shall be satisfied separately.

8. PRODUCT MANUAL

For prefabricated components and systems a manual shall be made available to enable the product to be used safely. For façade scaffolds made of prefabricated components see EN 12810-1.

9. INSTRUCTION MANUAL

For each type of prefabricated scaffold system the relevant instruction manual should be available on site, and shall include at least the following:

a) procedure during erection and dismantling the working scaffold, describing the correct sequence of working steps. This instruction procedure shall include drawings and text;

b) scheme and its details;

Note :

These requirements may be met by standard data, specially prepared information, or a combination of the two.

c) loads imposed by the working scaffold on its foundation and on the building structure;

d) information about the class of working scaffold, the number of working areas which may be loaded and the permitted height for different conditions;

e) detailed information about fixing and dismantling of the components;

f) information about tying in working scaffolds.

g) any other limitations.

For requirements regarding an instruction manual for façade scaffolds made of prefabricated components see clause 9 of EN 12810-1:2003.

10. WORK ON SITE

10.1 Basic Assumption

The design will assume that the erection, use, modification and dismantling will be in accordance with the prepared scheme (drawings, specification and other instructions) and that maintenance of the scaffold structure including its tying and foundations will be provided and will be in a condition to meet the requirements of the design. (See 1.3 of ENV 1991-1:1994 for more details).

10.2 Actions on Site

The ability of the foundations to support the load calculated in the design shall be verified. Where lateral support is to be provided by the structure served both the structural adequacy of that structure and the attachment of the anchorages shall be verified.

Note:

Verification should be carried out by a person who has the competence to do so and who is normally either responsible for the design or the erection.

11. STRUCTURAL DESIGN

11.1 Basic Design Principles

11.1.1 Introduction

Working scaffolds shall be designed for stability and serviceability. This includes load-bearing capacity and positional stability against sliding sideways, uplift and overturning.

Global or detail testing may be carried out to supplement calculation. The testing shall be carried out in accordance with EN 12811-3.

11.1.2 Structural design of components

11.1.2.1 Steel

The structural design shall be in accordance with ENV 1993-1-1.

11.1.2.2 Aluminium

The structural design shall be in accordance with ENV 1999-1-1.

11.1.2.3 Timber

The structural design shall be in accordance with ENV 1995-1-1.

11.1.2.4 Other materials

The structural design shall be in accordance with related Standards.

11.1.3 Limit states

The limit states are classified into:

- ultimate limit states;

- serviceability limit states.

At ultimate limit state the design value for the effect of actions, that is the design value of an internal force or moment, E_d, shall not exceed the design value of the corresponding resistance, R_d, in accordance with the expression (4)

$$E_d \leq R_d \qquad (4)$$

The design value, E_d, for the effect of actions is calculated from the characteristic values of the actions specified in 7.2 by multiplying each by the corresponding partial safety factor, γ_F.

The design value of the resistances, R_d is calculated from the characteristic resistance values specified in 11.2.4 by dividing by a partial safety factor, γ_M.

At serviceability limit state the design value of the effect of actions specified in the serviceability criterion shall not exceed the limiting design value of the corresponding serviceability criterion, C_d, see expression (5). This applies, for example, to deflections.

$$E_d \leq C_d \qquad (5)$$

11.2 Structural Analysis

11.2.1 Choice of model

The models adopted shall be sufficiently accurate to predict the structural behaviour level taking into account the imperfections given in 11.2.2.

The analysis carried out by checking separate planar systems shall consider the interaction.

The connection between the ties and the façade shall be modelled so that the ties are free to rotate about axes in the plane of the façade and shall not be assumed to transmit vertical forces.

11.2.2 Imperfections

11.2.2.1 General

The effects of practical imperfections, including residual stresses and geometrical imperfections, such as out of vertical, out of straight and unavoidable minor eccentricities shall be taken into account by suitable equivalent geometric imperfections.

The method of application shall be in accordance with the respective specifications of the relevant design standards, for example, for steel ENV 1993-1-1and for aluminium ENV 1999-1-1. Deviating from these specifications, the assumptions concerning imperfections in global frame analysis shall comply with 11.2.2.2.

11.2.2.2 Inclinations between vertical components

Frame imperfections by angular deviations at the joints between vertical components shall be taken into account.

For a joint in a tubular standard, the angle of inclination, Ψ, either between a pair of tubular components connected by a spigot permanently fixed to one of the components (see Figure. 7) or between a base jack and a tubular component (see Figure. 8), may be calculated from equation (6):

$$\tan\psi = \frac{D_i - d_0}{l_0} \qquad (6)$$

tan Ψ may not be less than 0,01.

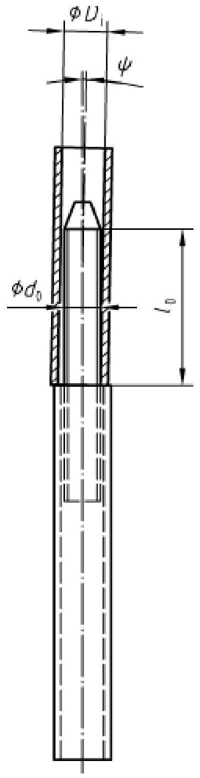
Where:

D_i is the nominal inner diameter of the tubular standard;

d_0 is the nominal outer diameter of the spigot or base jack;

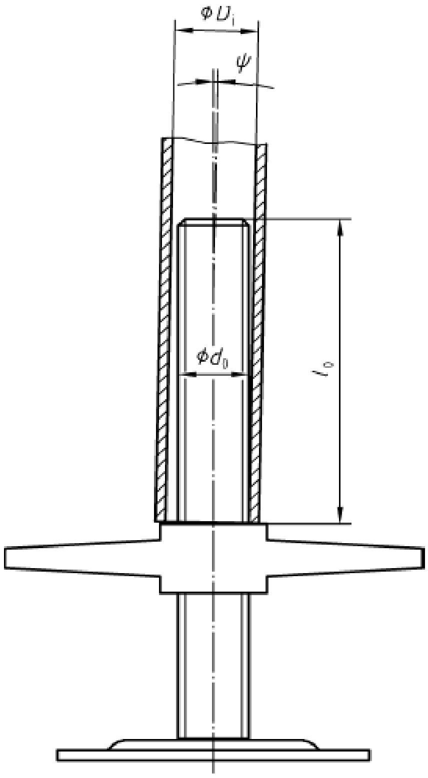
l_0 is the nominal overlap length.

Ψ see Figure 7 and Figure 8 respectively.



ANGLE OF INCLINATION BETWEEN TUBULAR STANDARDS

Fig.7



ANGLE OF INCLINATION BETWEEN A BASE JACK AND A TUBULAR STANDARD

Fig.8

When there are a number, n, of standards with such joints side by side and when planned pre-deflections are excluded, a reduced value for Ψ, represented by ψ_n, may be calculated from equation (7):

$$\tan\psi_n = \sqrt{0.5 + 1/n}\,\tan\psi \qquad (7)$$

Where:

tan Ψ is given in equation (6) and n is greater than 2

This applies to working scaffolds where the length of the ledgers are not predetermined by connecting devices, for example for tubes and coupler scaffolds.

In the case of a façade scaffold made of prefabricated components, the value of tan ψ for a closed frame in its plane may be taken as 0,01 if the vertical overlap length is at least 150 mm; and as 0,015, if the overlap length is less, see 6.7.4.

Requirements of 11.2.3.1 also apply.

11.2.3 Rigidity assumptions

11.2.3.1 Joints between tubular members

The joints between tubular members may be assumed to be rigid connections if the spigot is permanently fixed to one standard and if:

- the overlap length of the spigot is at least 150 mm or, in the case of locking device, at least 100 mm; and - the play between the nominal inner diameter of the tube and the nominal outer diameter of the spigot is not greater than 4 mm.

This assumption applies only to tubular members with external diameters not exceeding 60 mm.

Where neither of these requirements are met, for example if spigots according to EN 74 are used, the joints shall be modelled as ideal hinges. In this case frame imperfections, i.e. the angle between the linked standards (see 11.2.2.2) may be omitted. Alternatively, a detailed check on the spigot and the standard may be done (see 11.3.3.3).

11.2.3.2 Base jacks

The stiffness of base jacks made of steel and with trapezoidal or round shaped rolled threads shall, in the absence of any other data, be determined using, the formula in Appendix B.

The point of support of the base jacks with fixed end plates may be modelled by a bi-linear spring in accordance with the moment-rotation characteristic shown in Figure 9.

The value for the ultimate bending resistance, M_u, shall be in accordance with the following equation (8):

$$M_u = N \times e_{max} \leq M_{pl,n} \qquad (8)$$

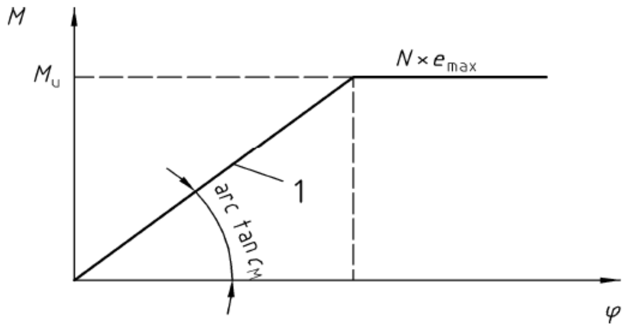
Where:

N is the axial force;

e_{max} is 0,5 d (maximum eccentricity of the axial force);

$M_{pl,N}$ is the reduced plastic resistance moment of the shaft allowing for axial force;

d is the external diameter of the shaft of the base jack where it is attached to the end plate.



MOMENT (M)-ROTATION (φ) CHARACTERISTICS OF THE POINT OF SUPPORT OF BASE JACKS

Fig. 9

Key

1 spring stiffness c_M = 2 000 kNcm/rad

M is the Moment

φ is the angle between base jack and sole plate respectively ground

In joints between base jacks and standards the deformation component that results from bending in the overlap zone shall be taken into account.

11.2.3.3 Base plates

The point of support of base plates complying with EN 74 shall be assumed as an ideal hinge.

11.2.3.4 Connecting devices

11.2.3.4.1 General

The realistic load-deformation behaviour of the connecting devices is to be incorporated in the model for the analysis. Alternatively joints may be modelled by assumptions which are on the safe side.

Note: ENV 1993-1-1 and EN 12811-3 give some information on semi-rigid connections.

For the determination of the relevant parameters for semi-rigid connecting devices in facade scaffold made of prefabricated components, see EN 12810-2.

Where the connections to standards are made by prefabricated joints, for example in a modular system, the design moment-rotation characteristic of ledger-to-standard or transom-to-standard connections shall be determined.

11.2.3.4.2 Right angle couplers (prEN 74-1, class B)

The cruciform stiffness c_φ, that is the relationship between the cruciform bending moment (M_B) and angle of cruciform rotation φ, of class B right angle couplers attached to steel or aluminium tubes is shown in Figure C.1.

Design values to be used in Figure C.1 are given in Table C.2. This relationship corresponds to the mean value of the cruciform stiffness, which may be applied to the evaluation of forces and moments of the overall scaffold system.

Note1:

Figure C.1 and the values in Table C.2 also allow the use of class B couplers complying with EN 74:1988.

In some cases the rotational resistance of right angle couplers will be used, for example in the connection between standard and tie member. The rotational stiffness c_ϑ, that is the relationship between rotational moment, M_T, and angle of rotation ϑ, of class B right angle couplers attached to steel or aluminium tubes is shown in Figure C.2.

This only applies to couplers, which are secured by screwed means. Design values to be used in Figure C.2 are given in Table C.3. Wedge couplers and class A couplers may not be assumed to transmit rotational forces.

In special cases, where deformations have a major effect on stability of a scaffold structure, for example in freestanding working scaffolds, the axial deformations of the coupler joints shall be taken into account by a longitudinal spring with an appropriate stiffness.

Note 2:

The values of Table C.1 also allow the use of class B couplers complying with EN 74:1988.

11.2.4 Resistances

11.2.4.1 General

The characteristic values of the resistances shall be calculated using the characteristic values of the mechanical properties (for example the yield strength $f_{y,\,k}$) which are given in prEN 12811-2 or may be taken from relevant standards.

For steel or aluminium members the resistances shall be determined in accordance with 5.4 of ENV 1993-1-1:1992 or 5.3 of ENV 1999-1-1:1998 respectively.

11.2.4.2 Connecting devices

To establish the characteristic values of resistances for

a) connections covered by the scope of structural engineering regulations: see relevant design standards;

b) semi-rigid connection devices for facade scaffold made of prefabricated components: see EN 12810-2 and EN 12811-3;

c) couplers complying with prEN 74-1: See Appendix C;

Note: The values of Table C.1 also allow the use of class B couplers complying with EN 74:1988

d) other connection devices, which do not comply with a standard: tests shall be carried out.

See e.g. EN 12810-2.

11.2.4.3 Base jacks

The characteristic values of the resistances of base jacks made of steel with trapezoidal or round shaped rolled threads shall be calculated in accordance with Appendix B.

The connection between the collar-nut providing adjustment and the shaft shall be in accordance with a relevant thread standard. Otherwise its load bearing capacity shall be verified by testing.

The verification of the load bearing capacity of the jack shall be carried out as part of the calculation of the whole working scaffold.

11.3 Verification

11.3.1 General

For the determination of internal forces and moments, elastic methods shall be used (exception see 11.2.3.2). For example for steel see ENV 1993-1-1:1992, clause 6.2.1.3.

The influence of the deflections on the internal forces and moments shall be taken into account; the equilibrium of the displaced system shall be calculated by the use of a second-order analysis or by the use of a first-order analysis with amplification factors.

Transfer paths for the loads specified in Table 3 to the vertical members shall be verified.

For façade scaffold made of prefabricated components systems, EN 12810-1 and EN 12810-2 apply.

11.3.2 Partial safety factors

11.3.2.1 Partial safety factors for actions, γ_F

Except where stated otherwise, the partial safety factors, γ_F, shall be taken as follows:

Ultimate limit state

- γ_F = 1,5 for all permanent and variable loads

- γ_F = 1,0 for accidental loads

Serviceability limit state

- γ_F = 1,0

Note:
Simplified partial (safety) factors are used, resulting in an overall factor for steel of 1,65 (1,1.1,5), little different from permissible stress.

11.3.2.2 Partial safety factors for resistance γ_M

For the calculation of the design values of the resistances of steel or aluminium components the partial safety factor, γ_M, shall be taken as 1,1. For components of other materials the partial safety factor, γ_M, is to be taken from relevant standards.

For the serviceability limit state, γ_M, shall be taken as 1,0.

11.3.3 Ultimate limit state

11.3.3.1 General

At ultimate limit state it has to be verified that the design values of the effects of actions do not exceed the design values of the corresponding resistances.

11.3.3.2 Tubular members

For the combination of internal forces, the interaction equation (9) may be used, provided that the design value of the actual shear force V ≤ 1/3 $V_{pl,\,d}$.

$$\frac{M_{pl,N,d}}{M_{pl,d}} = cos\left[\frac{\pi}{2} x \frac{N}{N_{pl,d}}\right] \qquad (9)$$

Where:

$N_{pl,\,d}$ is the design value of the resisting axial force and equals $N_{pl,\,k}/\gamma_M$;

$M_{pl,\,d}$ is the design value of the resisting bending moment and equals $M_{pl,\,k}/\gamma_M$;

$V_{pl,\,d}$ is the design value of the resisting shear force and equals $V_{pl,\,k}/\gamma_M$.

$M_{pl,N,d}$ is the design value of the resisting bending moment at interaction with actual normal force N

N is the design value of the actual force

For the value of the partial safety factor, γ_M, see 11.3.2.2.

11.3.3.3 Joints between tubular members

When the requirements of a rigid connection between tubular members according to 11.2.3.1 are met, the spigot only needs to be verified for the design bending moment at the joint.

When the overlap is less than 150 mm and the joint is not treated as a hinge, see 11.2.3.1, the detailed structural design check shall include the bending stresses, shear stresses and local bearing stresses.

11.3.3.4 Side protection

Components of the side protection shall withstand the accidental load specified in 7.2.5.1 without failing or disconnecting. A displacement from the original line of more than 300 mm at any point is to be taken as failure.

Where necessary the displacement may be calculated by assuming a plastic hinge, which transfers the plastic bending resistance of the component.

11.3.3.5 Couplers

It has to be verified that the design values of the forces acting on the couplers do not exceed the corresponding design values of the resistances according to Appendix C taking into account the partial safety factor in accordance with 11.3.2.2. If couplers are subjected to a combination of actions, in addition it has to be verified that the expression (10) and or (11) is met.

Right angle couplers:

$$\frac{F_{s1}+F_{s2}}{2F_{s.d}} + \frac{F_p}{F_{p,d}} + \frac{M_B}{2{,}4M_{B,d}} \leq 1 \qquad (10)$$

Sleeve couplers:

$$\frac{F_s}{2F_{s,d}} + \frac{M_B}{M_{B,d}} \leq 1 \qquad (11)$$

Where:

F_{s1}, F_{s2}, F_s, F_p and M_B	are the design forces acting on the coupler
$F_{s,d}$	is the design resisting force ; where $F_{S,d} = F_{S,k}/\gamma_m$ (See Table C.1)
$M_{B,d}$	is the design resisting cruciform bending moment; where $M_{B,d} = M_{B,k}/\gamma_m$ For symbols and values to be used in the formulae, see Appendix C, Figures C.3 and C.4 and Table C.1 respectively.
γ_m	is given in 11.3.2.2.

11.3.4 Serviceability limit state

It shall be verified that the deflection requirements specified in 7.3 are met.

11.4 Positional stability

Free–standing working scaffolds as a whole shall be checked against sliding sideways, uplift and overturning.

Working scaffolds shall be verified for local sliding.

Verification methods are given in prEN 12812.

APPENDICES

APPENDIX A
WIND LOADS ON CLAD WORKING SCAFFOLDS

A.1 General

The wind load on a clad working scaffold is calculated from equation (A.1):

$$F = C_s x \sum_i \left(C_{f,i} x A_i x q_i\right) \quad \text{(A.1)}$$

Where:

F is the resultant wind load;

$c_{f,\,i}$ is the aerodynamic force coefficient for the cladding i (see clause A.2);

A_i is the reference area of the cladding i (see clause A.3);

Q_i is the velocity pressure acting on the section i of the cladding (see 6.2.7.4);

c_s is the site coefficient (see clause A.4).

The aerodynamic force coefficients are specified separately for both directions, normal ($c_{f\perp}$) and parallel ($c_{f\,||}$) to the plane of the cladding. They may be considered as independent cases.

This method may not be applied to a clad scaffold structure, which completely encloses a building.

A.2 Aerodynamic force coefficient, C_f

A.2.1 Netting

Where values for the aerodynamic force coefficients, c_f, for a type of netting are not available from a wind tunnel test, the values below should be adopted:

$c_{f\perp} = 1{,}3$

$c_{f\,||} = 0{,}3$

A.2.2 Sheeting

The aerodynamic force coefficients, c_f, for sheeting should be assumed as follows:

$c_{f\perp} = 1{,}3$

$c_{f\,||} = 0{,}1$

A.3 Reference area, A

For wind actions both normal and parallel to the plane of the cladding the overall area of the cladding forms the reference area, A. For both cases of clad and unclad sides at the end of a run of a working scaffold the reference area of the cladding for the calculation of the wind forces acting parallel to the plane of the working scaffold is the surface of only one side of the cladding. For wind acting normal to the plane of the cladding areas of scaffold components or objects behind the cladding (sheeting or netting) may not be considered.

A.4 Site coefficient, c_s

The site coefficient, c_s, (see 7.2.7.3) depends on the solidity ratio, φ_B, which is given by equation (A.2):

$$\varphi_B = \frac{A_{B,n}}{A_{B,g}} \qquad \text{(A.2)}$$

Where:

$A_{B,n}$ is the net area of the façade (with the openings deducted);

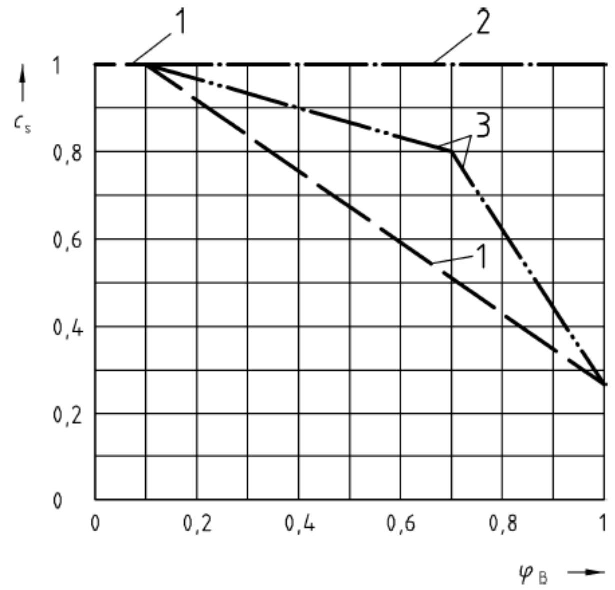
$A_{B,g}$ is the gross area of the façade.

The value of c_s should be taken from Figure A.1. For netting, in both parallel and normal directions, refer to curve 1. Where $c_{f\perp}$ for the netting is greater than 0,8, that netting should be considered as sheeting in respect of site coefficient.

For sheeting in both parallel and normal directions, refer to curve 2, that means c_s = 1,0.

The factor, c_s, to calculate the tensile anchoring forces of the scaffold ties on the lee side, may be taken from curve 3.

For calculation of wind loads on the area of the end of a run of a working scaffold, the value of c_s should be taken as 1,0.



Key

1 netting in both normal and parallel directions;

2 sheeting in both normal and parallel directions;

3 for sheeting, but only for calculation of the tensile anchoring forces normal to the façade;

c_s site coefficient;

φ_B the solidity ratio.

SITE COEFFICIENT, C_S, FOR CLAD WORKING SCAFFOLDS IN FRONT OF A FAÇADE

Fig. A.1

APPENDIX B

BASE JACKS; DATA FOR CALCULATION

B.1 General

This Appendix gives methods of calculation for characteristic resistances and deformations of base jacks (see Figure B.1) with trapezoidal or round shaped cold rolled threads made of steel tubes conforming to European Standards. It applies, when the dimensions are within the following parameters.

$$\frac{P}{b_2} \geq 1{,}22$$

$$h_1 \geq 1{,}65mm$$

$$\frac{d}{t} \geq 4$$

30 mm ≤ d ≤ 60 mm

Where (see Figure B.2 and Figure B.3)

b_2 width of the thread at the bottom;

d diameter of the outer most part of the thread;

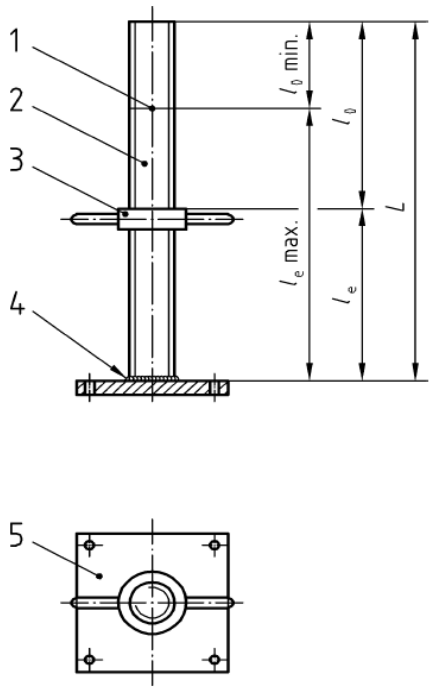
h_1 depth of the thread;

p pitch of the thread;

t wall thickness of the tube before rolling.

Rounding of corners with a radius less than 0,5 mm may be ignored when calculating the cross sectional values.

The following calculation method applies to both types of thread (trapezoidal or round shaped), but different yield strengths have to be assumed (see Table B.1).

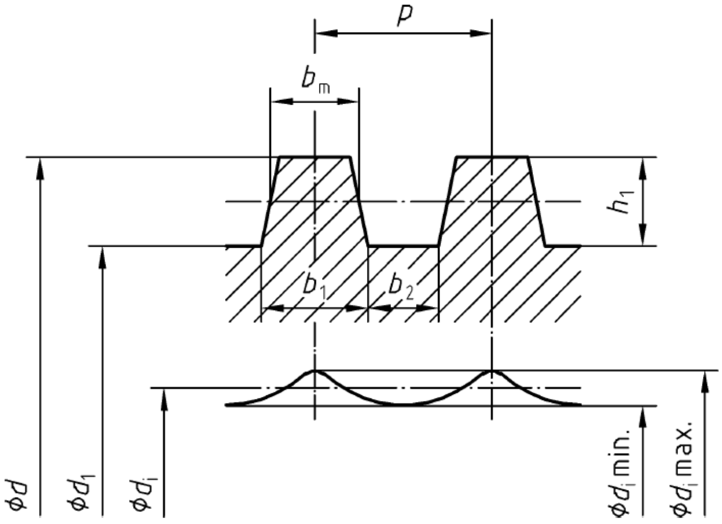


Key

1 stop to limit collar nut travel
2 shaft
3 collar nut
4 welding
5 end plate
l_0 overlap length
l_e extension length
L length of the shaft

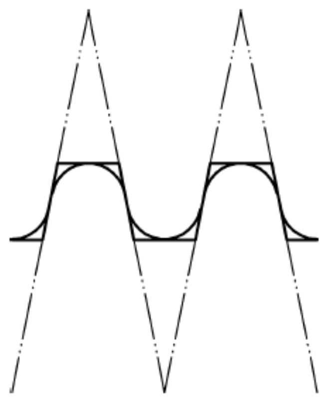
BASE JACK

Fig. B.1



TRAPEZOIDAL SHAPED THREAD

Fig. B.2



IDEALISATION OF ROUND SHAPED THREAD

Fig. B.3

B.2 Characteristic values of the yield strength

The characteristic values given in Table B.1 shall be used in the calculation.

TABLE B.1 - CHARACTERISTIC VALUES OF YIELD STRENGTH, $F_{Y, K}$, FOR SHAFTS OF STEEL JACKS WITH COLD ROLLED THREADS

	Steel type	
	S 235	S 355
	Yield strength, $f_{y, k}$ in N/mm^2	
1 Original material	235	355
2 Trapezoidal threads	320	450
3 Round threads	280	400

The values of lines 2 and 3 of Table B.1 are valid only in conjunction with the idealised cross sectional values of clause B.3 to calculate the characteristic values of the plastic resistance according to clause B.4. In welded parts of the shaft only the yield strength of the original material given in line 1 of Table B.1 shall be used.

B.3 Idealised cross sectional values

The idealised cross sectional values for threaded tubes for the calculation of stresses as well as deformations have to be determined from the equations (B.1) to (B.9).

Cross sectional area, A: $A = \frac{\pi}{4}(d_A^2 - d_i^2)$ (B.1)

Elastic section modulus, W_{el}: $W_{el} = \frac{\pi(d_w^4 - d_i^4)}{32 d_w}$ (B.2)

Plastic section modulus, W_{pl}: $W_{pl} = \frac{\pi(d_w^3 - d_i^3)}{6}$ (B.3)

Second moment of area, I_d: $I_d = 0.95\frac{A}{16}(d_1^2 + d_i^2)$ (B.4)

Where:

$d_A = d_1 + \psi_A(d - d_1)$

$\psi_A = \frac{11 x b_m}{d_1 x p}$ (the factor 11 has the dimension millimetre, where p is defined in clause B.1 and all (B.6)

three quantities are in millimetres)

$d_i = 0{,}5$ (max. d_i + min. d_i) (B.7)

Note: di is the average internal diameter of the shaft.

If the diameters d and d_1 are known, the value of d_i may be determined from the weight

$d_w = d_1 + \psi_A(d - d_1)$ (B.8)

$\psi_w = \psi_A + 0.22\frac{b_m}{p}$ (B.9)

For the explanation of d, d_1, and b_m see Figure B.2.

B.4 Characteristic values of the plastic resistances

The characteristic values of the plastic resistances of the cross section of the shaft may be calculated from the equations (B.10) to (B.12):

Axial force: $N_{pl,k} = A \times f_{y.k}$ (B.10)

Bending moment: $$M_{pl,k} = \alpha_{pl} \times W_{el} \times f_{y.k} \quad \text{(B.11)}$$

Shear force: $$V_{pl,k} = \frac{2}{\pi} x A x \frac{f_{y,k}}{\sqrt{3}} \quad \text{(B.12)}$$

Where:

$f_{y,k}$ is the characteristic value of the yield strength given in Table B.1;
α_{pl} is the lesser of 1,25 and W_{pl}/W_{el};

A, W_{el}, W_{pl} are idealised cross sectional values calculated in accordance with clause B.3.

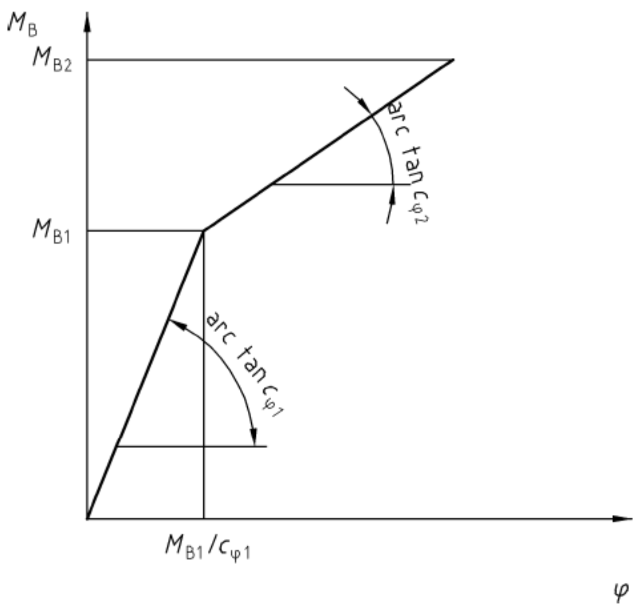
APPENDIX C

CHARACTERISTIC VALUES OF THE RESISTANCES FOR COUPLERS

Characteristic values of the resistances for couplers complying with prEN-74-1 and connecting Ø 48,3 mm steel tubes are given in Table C.1. Corresponding design values of stiffnesses are given in Tables C.2 and C.3.

TABLE C.1 - CHARACTERISTIC VALUES OF RESISTANCES FOR COUPLERS

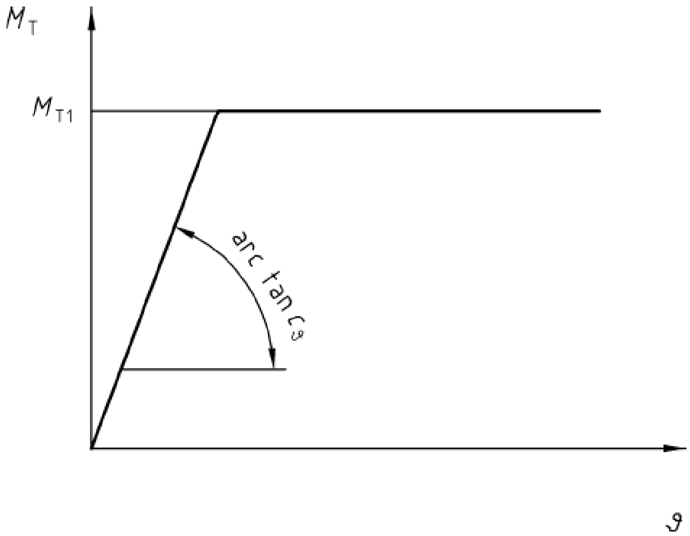
Coupler type	Resistance	Characteristic value				
		class A	class B		class AA	class BB
Right-angle coupler (RA)	Slipping force Fs,k in kN	10,0	15,0		15,0	25,0
	Cruciform bending moment MB,k in Nm	---	0,8		---	---
	Pull-apart force Fp,k in kN	20,0	30,0		---	---
	Rotational moment MT,k in kNm	---	0,13		---	---
Friction type sleeve coupler (SF)	Slipping force Fs,k in kN	6.0	9.0		---	---
	Bending moment MB,k in kNm	---	2,4		---	---
Swivel coupler (SW)	Slipping force Fs,k in kN	10,0	15,0		---	---
Parallel coupler (PA)	Slipping force Fs,k in kN	10,0	15,0		---	---
For symbols see Figures C.3 and C.4						



Key

M_B is the cruciform bending moment (kNm/rad);
φ is the angle of rotation (rad);
$c_{\varphi 1}, c_{\varphi 2}$ are the cruciform stiffnesses ;

M_B-φ RELATIONSHIP FOR CLASS B RIGHT ANGLE COUPLERS
Fig. C.1



Key

M_T is the rotational moment (kNm)
ϑ is the angle of rotation (rad)
c_ϑ is the rotational rigidity

M_{T}-ϑ RELATIONSHIP FOR CLASS B AND C RIGHT ANGLE COUPLERS SECURED BY SCREWED MEANS

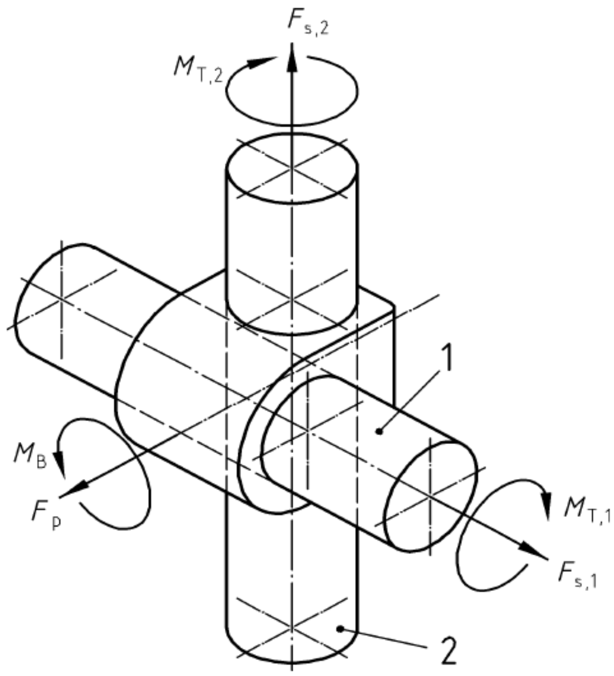
Fig. C.2

TABLE C.2 - DESIGN VALUES $C_{\varphi 1}$ And $C_{\varphi 2}$ OF CRUCIFORM STIFFNESSES FOR CLASS B RIGHT ANGLE COUPLERS ATTACHED TO STEEL TUBES

	Steel Tube			
	$c_{\varphi 1}$ [kNm/rad]	M_{B1} [kNm]	$C_{\varphi 2}$ [kNm/rad]	M_{B2} [kNm]
	15,0	0,48	6,0	0,8
For symbols see Figure C.1				

TABLE C.3 - DESIGN VALUES C_ϑ OF ROTATIONAL STIFFNESS FOR CLASS B RIGHT ANGLE COUPLERS

	$c\vartheta$ [kNm/rad]	M_{T1} [kNm]
	7,5	0.13
For symbols see Figure C.2		

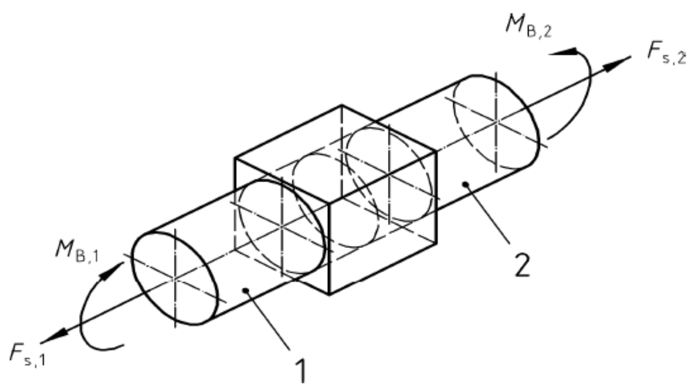


Key

1	tube 1
2	tube 2
s	slipping force
p	pull apart force
B	cruciform bending moment
T	rotational moment

LOADS ON A RIGHT-ANGLE COUPLER

Fig. C.3



LOADS ON A FRICTION TYPE SLEEVE COUPLER

Fig. C.4