

>>igVW Standards der Qualität *Standards of Quality*

>>SQP1
Trusses

Oct, 2010

Legend

Some explanatory notes regarding the structure of the standards:

| | |
|---------------------|---|
| SQ | Standard of Quality |
| O | Organisation |
| P | Code of practice/working procedure |
| Q | Qualification |
| 1, 2, 3, ... | consecutive numbering |

O Organisation/Documentation

Internal set-up and organisation of operations/
documentation and certification of processes

P Code of practice/working procedure

Supply and use of working materials

Q Qualification

Qualification of skilled workers and specialists

Preliminary note

SQ Standards are intended to define the quality levels required of services provided within the event technology industry.

SQ Standards take into consideration current legal positions and on that basis provide a description of the industry's specialised working procedures.

They contain a summary of the applicable legal norms and requirements in areas of industrial safety and health protection.

This Quality Standard has been developed by the responsible working group of the igvw (Entertainment Technology Industry Association) in cooperation with the DGUV (German Social Accident Insurance) and the working group of the safety engineers from the German public broadcasting organisations: ARD.ZDF medienakademie, ARTE, BR, Bavaria, DR, DW, HR, IRT, MDR, NDR, ORF, RB, RBB, RBT, RTL, SF, SR, Studio Hamburg, SWR, WDR and ZDF.

Notes on use:

This pdf file is annotated with interactive links and bookmarks.

In the table of contents a mouse click on an item leads straight to the corresponding chapter..

At the bottom of each page there is a link that leads back to the table of contents.

The links next to the illustrations open up a 3D view (needs Adobe Reader 8.x or newer). An internet connection is required.

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The solutions described in this igvw Standard do not rule out the validity of other solutions that guarantee the same standard of safety, as laid down within the technical regulations of other member nations of the European Union or Turkey, or other member states of the European Economic Area.

Please note:

Wherever possible gender-free nouns and pronouns have been used. Where this is not possible the male noun or pronoun has been used to improve readability, but also is meant to refer to females. .

1 Area of application

This standard applies to the supply and use of trusses and constructions made from trusses in event engineering.

2 Normative and informal references

BGI 638 edition 1998

Information regarding rope ladders

BGI 810 edition 03-2008

Safety at productions and events - guidelines

DIN 4113 – 1/A1: 2002-09

Aluminium constructions under predominantly static loading – Part 1: static analysis and structural design

DIN 4113 – 1/A1 Amendment 1: 2008-12

Aluminium constructions under predominantly static loading – Part 1: static analysis and structural design

DIN 4113 - 2: 2002-09

Aluminium constructions under predominantly static loading – Part 2: static analysis of welded aluminium constructions

DIN 4113 - 2 Amendment: 2008-12

Aluminium constructions under predominantly static loading – Part 2: static analysis of welded aluminium constructions

DIN V 4113 - 3: 2003-11

Aluminium constructions under predominantly static loading – Part 3: execution and qualification of constructors

DIN V 4113 – 3 Amendment: 2008-12

Aluminium constructions under predominantly static loading – Part 3: execution and qualification of constructors

DIN 18800 - 1: 2008-11

Steel structures – Part 1: design and construction

DIN 18800 - 2: 2008-11

Steel structures – Part 2: stability – bending of bars and skeletal structures

DIN 18800 - 7: 2008-11

Steel structures – Part 7: execution and qualification of constructors

igvw SQ Q2

competence in event rigging

DIN VDE 0100-540: 2008-01

low-voltage electrical installations Parts 5-54: selection and erection of electrical equipment – earthing arrangements, protective conductors and protective bonding conductors

3 Definitions

Truss

skeletal support element made of metal

Truss construction

a structure made by combining a number of trusses

Truss connector

component used to connect trusses

Truss adapter (Gizmo, Bracket, Loadbar)

load-carrying equipment of metal beams with a suspension point and pipe clips for connecting trusses and suspension- or load-bearing equipment

Chord (chord beam)

longitudinal member of a truss

Brace (cross-brace)

member running diagonally, vertically or horizontally

Sleeve Block

guide block used for moving trusses and truss constructions vertically on towers

Tower

vertical column

Manufacturer

maker of products, i.e. the person who buys materials or pre-fabricated elements and makes them into a product

Loading capacity

the load which a truss can safely carry

Truss node

joint connecting chord and brace

End plate

flat steel plate forming the end of a truss

Uniformly distributed load (UDL)

a load that is spread equally along the length of the member

Third point

positions of two loads placed symmetrically each at one third of the total length

Quarter point

positions of three loads placed symmetrically each at one quarter of the total length

Normal force

total internal force acting along the longitudinal axis of a truss or one of its parts (e.g. chord)

Shear force

total internal force acting laterally on a truss or one of its parts (e.g. chord)

Bending moment

total internal force which causes bending of a truss or one of its parts (e.g. chord)

Single-span girder

Truss with two supports

Multi-span girder

Truss with more than two supports

Jib or cantilever

Truss which projects beyond a support, thus basically a beam supported at only one end

4 Supply

If one is to supply suitable trusses it is necessary during the planning, choice and purchase phases to pay particular attention to the intended use, environmental influences, ergonomics, and the qualification and experience of the users.

The contractor may only supply trusses that conform to the specifications laid down in Part 4 “Supply” and Part 6 “Inspections”.

Only truss connectors and accessories may be used that are approved by the manufacturer. In general this means that only trusses from the same manufacturer may be joined together to form a truss construction.

4.1 Constructional requirements

In the construction, static analysis and production of trusses it is necessary to apply current legal norms, e.g. laws, regulations, work-safety regulations and the current state of technology rules. Since trusses are constructed mainly of aluminium, DIN 4113 - 1, “Aluminium constructions under predominantly static loading – Part 1: static analysis and structural design” and DIN 4113 - 2, “Aluminium constructions under predominantly static loading – Part 2: static analysis of welded aluminium constructions” are of particular importance. When other material are used, the appropriate state of technology rules are to be taken into account, for instance DIN 18800 for trusses made of steel. Companies that carry out welding operations on supporting elements must be properly certified.

Note:

The loading capacity of a truss depends on the construction, materials used, and production. For the static analysis of the admissible loading capacity, the appropriate state of technology rules must be applied for all parts of the truss (chords, braces, wall-thicknesses, connectors, welding seams).

– Aluminium trusses are normally welded constructions made from semi-finished products (tubes, plates and bars). The semi-finished products are often made of wrought aluminium alloy which was rolled out warm and which becomes softened under the influence of heat.

It is necessary to make allowance for the lower strength of the welding seams and heat affected zones in comparison with the basic material.

– When different alloys are welded together the specifications of the less stable material are to be considered relevant.

– Allowance must be made for additional bending moments caused by eccentricity of the centroidal axes of the lattice nodes and other relevant parts.

– The joint between two trusses must also be assumed to be the most vulnerable part of the whole construction, because the modular systems can

be put together in any combination by the user.

- A misalignment of the transmission of force due to end-plates at the joints of individual trusses causes local bending.*
- Bending moments must be taken into account that can be caused by the application of force or support or suspension outside the framework nodes..*
- Documented evidence must be provided about the normal force, bending moment and shear force of the truss connectors. No permanent distortion may occur for any load within the rated loading capacity.*

Note:

If trusses are used as a permanent part of physical structures, their construction is governed by building legislation. In such situations only trusses may be used that conform with EU building product guidelines and consequently with German building product laws. Written verification of this must be provided by the manufacturer of the trusses.

4.2 Information for users

The contractor may only provide trusses for which the manufacturer supplies a user manual and assembly instructions in German.

The following information in particular must be included to ensure proper utilisation:

- a definition of the assembly and operating positions
- instructions on the correct assembly of the system elements
- guidance on set-up, dismantling and operation
- instructions on rigging and support (input and output of forces)
- information on the loading capacity of statically indeterminate systems (for instance lines with more than two supports, or frame structures)
- information on the loading capacity of jibs
- information on the use of trusses as vertical supports
- information on which dynamic factors were taken as the basis for the data on loading capacity
- information on protective earthing in particular with regard to trusses that are hanging or inserted or that have coated surfaces
- instructions on handling, storage and transport
- instructions for maintenance (overhauling, servicing, inspections)
- information on the carrying out of regular inspections and criteria for removal from service
- information on the acquisition of spare parts

4.3 Technical documentation

The contractor may only provide trusses for which the manufacturer has supplied, for each type of truss which he manufactures, German-language documentation with all safety-relevant information.

The technical documentation must in particular include the following information:

4.3.1 Technical data

- a list of all the parts of the truss type
- technical drawings
- dead weight
- materials used in construction
- a list of accessories

4.3.2 Loading capacity

- maximum uniformly distributed load
- maximum point load in midspan
- maximum point load at the one-third span points
- maximum point load at the one-quarter span points

These values are to be given including details of possible combinations of trusses as foreseen by the manufacturer, their installation position, the type of support, suspension and load application.

4.3.3 Static analysis

The contractor may only provide trusses for which the manufacturer can supply written evidence in German of a certified static analysis (see *section 6.2.1*) with specification of the criteria of calculation and the norms used.

In addition the following information is also required:

- maximum normal force in the chord profiles (max. n)
- maximum bending moment (max. m)
- maximum shear force (max. s)

4.4 Labelling

The following must be permanently and visibly affixed to the truss:

- manufacturer
- month and year of construction (mm/yy)
- model type
- serial no.
- dead weight in kg

5 Use

Only those trusses may be used that conform with the specifications laid down in section 4 “Use”. Trusses must be used in accordance with the specifications listed below. “Use” means the operation, transport, storage, maintenance, and inspection of working equipment.

5.1 Qualification and responsibility

The job and responsibilities of each participating person must be exactly defined.

The operator of a building is in particular responsible for the quality, loading capacity and the condition of the suspension points provided by him within the building and for the load carrying capacity of the floor. He must provide the relevant documentation (e.g. a loading capacity plan).

The contractor decides on the qualification required for planning, assembly and operation according to the results of his danger analysis. See also igvw SQ Q2 “competence in event rigging”.

5.2 Choice of trusses

A decision on which trusses are suitable must be made on the basis of the following criteria:

- the static system (e.g. single span or multi span beams)
- the width of the span between the supports
- main loads (dead weight + payload), static for installation without hoisting equipment
- main loads (dead weight + payload), static and if necessary dynamic for installation with hoisting equipment
- live loads (e.g. wind or snow)
- load distribution (point load, uniform load, area load)
- additional loading due to persons working on trusses / truss constructions
- additional loading due to measures taken to prevent persons falling
- handling

For types of construction and loading not covered by the user manual, additional static analysis is required (particularly with regard to stability and load carrying capacity). Static analysis should be carried out by persons who have completed a relevant degree course and who can show that they have at least three years experience in construction, static analysis or inspection of event technology equipment.

5.3 Installation of trusses

During installation all set-up and utilisation instructions ensuing from the planning must be adhered to.

Stability and load-bearing strength must be guaranteed at all times.

All constructional elements (trusses, connectors etc.) must be subjected to a visual inspection before assembly begins. If there are any obvious defects, such as plastic deformation or material reduction of main chords and struts, any kind of fissure, slot formation at joints or their mountings and deformation of connectors, these parts may not be used and must be clearly labelled as defective, in order to prevent them being used by mistake at a later date.

Trusses must be installed using appropriate tools and in the assembly position planned by the manufacturer.

The supervisor in charge of installation clears the truss construction for further use. The handover to other users or the operator should be documented in writing (see Appendix IV Handover Protocol).

Protective earthing for trusses

Trusses which in the case of a defect could take on dangerous contact voltages are to be incorporated into a collective protective earthing system. This applies to all elements made from material that conducts electricity, upon which equipment is placed or attached to, or through which wires and cables run, which in the case of a defect could come into contact with metal parts. Connections and joints can be made with belt clamps, pipe clamps, bolted connections, or with special unipolar locked socket connections.

The protective earthing system, laid out in radial form, should at a central point be connected to the earth of the mains supply.

The minimum cross-section must be calculated in accordance with DIN VDE 0100 Part 540. Experience has shown following cross-sections to be successful

- up to 50 m, 16 mm² Cu (fine stranded copper wire)
- up to 100 m, 25 mm² Cu (fine stranded copper wire).

In tower systems with movable parts ("sleeve blocks") the castors or rollers built into the sleeve block have an insulating effect on the moveable truss construction. Therefore this must be fitted with an additional protective earthing system. The effectiveness of the protective measures must be proved.

Lightning protection

When the topography, type of construction or the installation site are such that lightning could strike easily or have serious consequences, truss constructions must be fitted with an effective lightning conductor. The effectiveness of the protective measures must be proved.

If effective lightning protection cannot be guaranteed, the endangered area must be evacuated during a thunderstorm.

5.4 Load transmission in trusses

Load transmission means all forms and measures with which the loads that actually occur are either transmitted to a truss or from it to a support or suspension point.

The nature and type of load transmission in trusses has a determining influence on the actual loading capacity of the trusses that are being used. Load transmission must take place in accordance with the manufacturer's instructions.

When loads are transmitted, it is important to ensure that they are distributed symmetrically on the chords. Lopsided loading can reduce the loading capacity of the trusses and must be taken into account. When horizontal and vertical forces occur simultaneously, an applicable static analysis must be produced.

5.5 Lifting trusses

The lifting of trusses (type and manner of load transmission) determines whether the loading capacity of the truss and the stability of the truss construction are maintained, and may only be done by suitably qualified persons.

See igvw SQ Q2 "Competence in event rigging".

5.5.1 Equipment for lifting and load suspension

Lifting and load suspension equipment is used to support trusses or to introduce loads into trusses (See also BGI 810-3 – "Safety at productions and events – loads over persons")

Lifting equipment is for instance:

- round slings made from synthetic fibre
- round slings with a wire rope core
- lifting straps
- steel ropes (lifting ropes)
- steel chains (lifting chains)
- shackles
- oval suspension devices
- quick-connection swivel-nut devices
- disconnectable rope end-joints

Load suspension equipment is for instance:

- beam clamps
- truss adapters (gizmo, bracket, loadbar)
- hanging clamps

The manufacturer's instructions for the correct use of lifting and load suspension equipment must always be followed.

When the loading capacity of lifting and load suspension equipment for a particular field of use has not been verified, it may not be loaded with more than 0.5 times the loading capacity specified by the manufacturer.

When trusses are put up using synthetic or natural fibre lifting equipment, a safety back-up of wire rope or lifting chain must be used.

To protect trusses it is permissible to use wire rope with a loose plastic casing, provided a visual inspection of the wire rope is still possible.

5.5.2 Methods of lifting trusses

When flexible lifting equipment is used the corresponding load lifting factor is determined by the lifting method used.

The loading capacities, calculated on the basis of the lifting method, must be halved when persons are underneath the loads.

A distinction is drawn between the following lifting methods:

- Single Fall – (or Drop, Straight, Stinger)

The Single Fall lifting method does not cause a reduction of the lifting equipment's loading capacity

Load lifting factor 1.0



[Link to the 3D view](#)

- Basket-

The Basket lifting method brings about an increase in the loading capacity of the lifting equipment.

The loading capacity is calculated, by multiplying the clamping angle α of the ropes by the corresponding load lifting factor:

$$0^\circ < \alpha \leq 12^\circ$$

Load lifting factor 2.0



[Link to the 3D view](#)

$$12^\circ < \alpha \leq 90^\circ$$

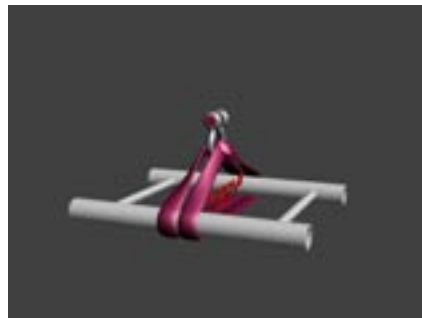
Load lifting factor 1.4



[Link to the 3D view](#)

$$90^\circ < \alpha \leq 120^\circ$$

Load lifting factor 1.0



[Link to the 3D view](#)

- Choke -

The choke lifting method causes a reduction of the lifting equipment's loading capacity.

If one lifting rope is used the reduced loading capacity is calculated by multiplying it by the load lifting factor 0.8.



[Link to the 3D view](#)

If two ropes are used the loading capacity is calculated depending on the clamping angle α of the ropes by multiplying it by the corresponding load lifting factor:

$$0^\circ < \alpha \leq 12^\circ$$

$$\text{Load lifting factor } 0.8 \times 2.0 = 1.6$$



[Link to the 3D view](#)

$$12^\circ < \alpha \leq 90^\circ$$

$$\text{Load lifting factor } 0.8 \times 1.4 = 1.12$$



[Link to the 3D view](#)

$$90^\circ < \alpha \leq 120^\circ$$

$$\text{Load lifting factor } 0.8 \times 1.0 = 0.8$$



[Link to the 3D view](#)
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Lifting methods using clamping angles of $\alpha > 120^\circ$ must be measured individually.

In addition to the Basket and Choke methods chord tubes may be wrapped around the lifting equipment without reducing the loading capacity. This wrapping is done to secure the position of straight truss sections.

5.6 Safety precautions during assembly and operation

In situations when work with trusses involves risks of injury and damage to health that cannot be eliminated by technical or organisational measures, the contractor must provide suitable personal protective equipment and other aids that employees must use in the intended manner.

Technical measures:

The use of scaffolding, hydraulic platforms, ladders or rope ladders made of metal

Note:

When rope ladders are used during operation their length may not exceed 5 m and when they are provided as a means of emergency escape or rescue they may not exceed 10 m in length (BGI 638: information regarding rope ladders). Longer rope ladders may only be used in connection with personal protective equipment against falls. Rope-assisted lifting and dismantling: this method may only be used by experienced and qualified persons..

Organisational measures:

Instruction, restricted access, signs

Person-related measures / personal protective equipment (PPE):

Safety shoes, gloves, protective headgear, hearing protection, PPE against falls (cf. BGR 198, BGR199 personal protective equipment against falls), fall-arresting equipment in accordance with DIN EN 341 or DIN EN 1496 in combination with a safety harness, abseiling devices.

The use of PPE against falls requires particular qualification and ability (see also igvw SQ Q2).

Additional loads applied to the truss constructions through use of PPE against falls must be taken into account.

6 Inspections

The contractor is obliged to provide safe trusses.

In order to ensure that only trusses are put to use that are in a proper condition, an inspection is necessary, not only before they are first put on the market, but also before each one is used for the first time.

To ensure that the trusses are safe during set-up and use, they must be inspected within the framework of their operational use. This way possible deficiencies or damage can be detected soon enough to be corrected.

Repeated inspections are necessary in order to recognise and correct in due time deficiencies and damage that can occur during the operation of trusses.

After significant modification or an overhaul, an inspection is necessary to check that the truss has been restored to a proper condition.

If, as a result of the inspection, doubts arise about the safety of a truss, this truss may not be put into use until the defects have been rectified and a second inspection has shown the truss to be safe.

6.1 Basic principles of inspections

The manufacturer of trusses must make inspections on the basis of DIN 4113 Part 1, DIN 4113 Part 2 and DIN 18800 Part 1.

6.2 Inspections before use

Each purchase leads to a handing-over to the buyer and is concluded with a formal (commercial or administrative) inspection as to whether the contractual agreement has been complied with, and with a technical inspection and the handing-over of the documentation required from the manufacturer or intermediary.

6.2.1 Inspections before manufacture

The contractor may only provide trusses for which the manufacturer can supply the following inspection results and documents:

- Manufacturing plant and process DIN V 4113-3 Aluminium constructions under predominantly static loading – Part 3: execution and qualification of constructors and DIN 18800-7 Steel constructions – Part 7: execution and qualification of constructors.

- Construction and manufacturing documentation, in particular functional description, danger and risk analysis, construction and manufacturing documentation and proof of specifications, static inspection by a certified test centre for equipment and product safety or a certified civil engineering test centre, compliance with the product documentation, in particular construction and loading capacity, safety features (protective earthing connection) and user manuals.

6.2.2 Inspections before entry into service

Before putting a truss into service the contractor must make the necessary inspections. Truss constructions must be inspected by a person who has suitable qualifications.

Necessary inspections can be:

- completeness,
- proof of previous inspections,
- declarations of compliance,
- labelling,
- suitability for the designated operational conditions and environmental influences,
- assembly and operating instructions,
- manufacturer's testing instructions and criteria,
- static analysis and/or certification,
- blueprint drawings.

The contractor makes sure that the results of the inspections carried out before entry into service are documented and kept available.

6.3 Inspections during use

The safe status of the truss should be sustained during use.

Within the framework of the type of use the contractor carries out danger assessments. In this connection he must determine and evaluate the influences that cause damage, taking into account the different kinds of operating mode, and then devise and implement suitable measures to counteract them.

As a result the contractor decides on the type and extent of the inspections

- after set-up and dismantling,
- after any unusual occurrences,
- as well as on the deadlines for recurring inspections
- and the qualifications demanded of the person who is commissioned to carry them out.

6.3.1 Inspections during set-up and use

During set-up (on-site assembly) and each time before use, the safe condition of the truss must be established through a visual inspection and functionality test (see section 5.3).

The visual inspection and functionality test include:

- a check for external damage or wear
- provision for the particular circumstances of the surroundings
- protective earthing
- lightning protection
- the documentation of previous inspections (see 6.4)

The qualifications required of the tester depend on the complexity of the truss construction and the risks related to its use.

6.3.2 Regular inspections

Trusses and truss constructions are to be inspected according to the type and frequency of their use, so that defects and damage can be detected in proper time. The deadlines for inspection are laid down by the contractor as part of the danger assessment, taking into account

- existing information from the manufacturer,
- influences which may cause damage,
- operative experience,
- other information on the latest state of technology.

During inspections any defects are assessed and decisions made on further use before the next regular inspection.

An inspection every 12 months by an **expert has proved in practice to be ideal.**

The results of the regular inspections must be documented (see section 6.4).

6.3.3 Extraordinary inspections

Extraordinary inspections are necessary in particular:

- in the event of damage
- after a long period of disuse
- after substantial modification of the truss

The replacement of parts with ones of the same type is not considered to be a substantial modification.

The truss may not be used again until an inspection has proved that safe operation can be guaranteed.

6.4 Documentation

The results of all inspections are to be documented and available on-site. For the purpose of depicting the complete history of a truss, it is advisable to keep all inspection documents together in one file.

The documentation must be adequate and can contain the following:

- declaration of compliance of the manufacturer
- inspection instructions and criteria of the manufacturer
- confirmation of inspections made by the manufacturer
- confirmation of inspections made before entry into service
- inspections made after substantial modification
- assessments of danger upon divergence from established inspection deadlines
- proof of regular inspections
- results of re-examinations

If the documentation is compiled electronically, suitable quality assurance measures are required.

If inspection stickers are used, company regulations must ensure that the complete inspection procedure is made transparent.

Appendix

Appendix I – Lifting trusses

The general rule is that lifting a truss outside its framework nodes causes local bending strain that can lead to a reduction in the loading capacity. This fact must be taken into account in particular with trusses which have a large profile geometry and a correspondingly large distance between the framework nodes. The lifting gear should be placed as near to the framework nodes as possible.

Flexible types of lifting gear, such as round slings, generate vertical and horizontal forces when used as double strands. This can lead to a reduction of the loading capacity of the truss.

Flexible lifting gear must be directed in such a way that no bending load is generated on the cross braces.

Illustrations of typical lifting methods:



[Link to the 3D view](#)



[Link to the 3D view](#)



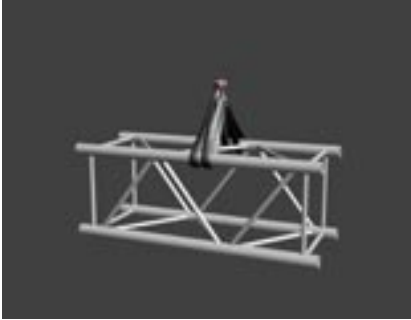
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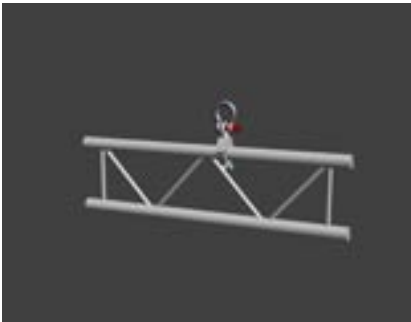
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[Link to the 3D view](#)

Infobox:

Two-chord trusses may only be lifted by the upper chord. Attention must be paid to the lateral bending behaviour of the two-chord truss.



[Link to the 3D view](#)



[Link to the 3D view](#)



[Link to the 3D view](#)

Appendix II – A sample list of contents for a static analysis

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Appendix

Computer calculation ground support:

Computer calculation bridges:

Drawings

Appendix III – A sample handover protocol

Declaration concerning the correct construction and readiness for use of trusses

manufacturer:

place of manufacture:

customer:

company:

address:

person responsible:

supplier:

company:

address:

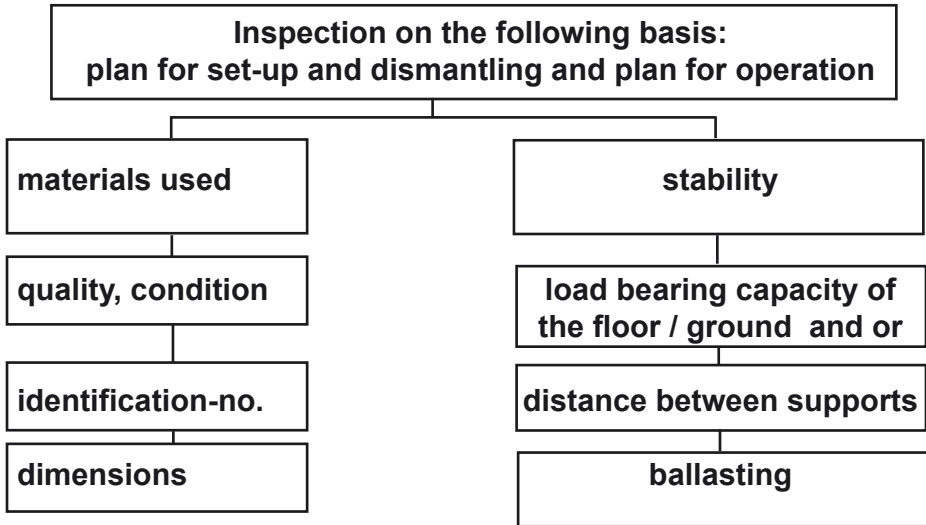
person responsible:

The supplier herewith declares to the customer that all equipment and materials utilised by him conform with the corresponding regulations and accepted technical standards. He furthermore declares that the complete assembly of the trusses has been carried out in accordance with the corresponding regulations and accepted technical standards and that the truss is handed over to the customer as being ready to use. The required documents and individual certificates are to be enclosed. These include for instance material certificates, static calculations or protocols of necessary inspections which have been carried out.

date: _____ signature of supplier: _____

date: _____ signature of customer: _____

Appendix IV – Scope of inspection after assembly



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