

EUROPEAN ASSESSMENT DOCUMENT

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Prefabricated stair kits

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This European Assessment Document (EAD) has been developed taking into account up-to-date technical and scientific knowledge at the time of issue and is published in accordance with the relevant provisions of Regulation (EU) No 305/2011 as a basis for the preparation and issuing of European Technical Assessments (ETA).

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1 SCOPE OF THE EAD

1.1 Description of the construction product

The EAD covers the assessment of prefabricated stair kits.

A “kit” is a special form of a “construction product”. It consists of several “components” which are:

- placed on the market together with one common CE Marking
- assembled on site, and thus
- become an “assembled system” when installed in the construction works.

The EAD is applicable to prefabricated stair kits which are consisting, for example, of the following components:

- Steps, landings, strings, handrails, barriers, fixing elements and coverings.

The term prefabricated indicates that products are manufactured in industrial series production or at least similar to series production. By ‘Similar to series production’ is meant production on the basis of a pre-designed system.

Excluded from the scope are:

- Traditionally-made prefabricated stairs of solid wood for use inside individual buildings (see Annex 1),
- Loft ladders,
- Pre-cast monolithic concrete stairs,
- Stair kits which contribute to the overall stability of the works or to the strength of the structure including structural response of the building under earthquake actions,
- Outdoor stairs not linked to the building, e.g. stairs on playgrounds or in gardens,
- Auxiliary stairs used for such purposes that the authorities have no requirements in the sense of Basic work requirements,
- Stairs for special technical purposes in working areas or in industrial production areas (e.g. service stations and silos).

Components and materials are described by the manufacturer. For description harmonised European technical specifications shall be used, if possible. Components shall be precisely defined by reference to physical characteristics, such as materials, geometry and how the components are to be put together.

The steps of stairs are made of materials and components with the load-bearing capacity verified according to the relevant Eurocodes including the standard values given therein. If this is not the case, then determination of the load-bearing capacity of the stair kit shall be made by tests carried out on structural members, or the characteristic values of the materials shall be determined by testing for static calculation of the kit.

The product is not covered by a harmonised European standard (hEN).

Concerning product packaging, transport, storage, maintenance, replacement and repair it is the responsibility of the manufacturer to undertake the appropriate measures and to advise his clients on the transport, storage, maintenance, replacement and repair of the product as he considers necessary.

It is assumed that the product will be installed according to the manufacturer’s instructions or (in absence of such instructions) according to the usual practice of the building professionals.

Relevant manufacturer’s stipulations having influence on the performance of the product covered by this European Assessment Document shall be considered for the determination of the performance and detailed in the ETA.

1.2 Information on the intended use of the construction product

1.2.1 Intended use

The EAD covers stair kits for use as an indoor stair in buildings with following conditions:

- Temperatures between + 5 and +30 °C and
- Relative humidity between 30 and 70 %.

1.2.2 Working life/ Durability

The assessment methods included or referred to in this EAD have been written based on the manufacturer's request to take into account a working life of the stair for the intended use of 50 years (in general) or for 25 years (for easily replaceable stairs - for stair kits the intended use shall be limited to specific applications where the shorter durability is clearly stated, e.g. stairs for dwellings only) when installed in the works (provided that the stair is subject to appropriate installation (see 1.1)) These provisions are based upon the current state of the art and the available knowledge and experience.

When assessing the product the intended use as foreseen by the manufacturer shall be taken into account. The real working life may be, in normal use conditions, considerably longer without major degradation affecting the basic requirements for works¹.

The indications given as to the working life of the construction product cannot be interpreted as a guarantee neither given by the product manufacturer or his representative nor by EOTA when drafting this EAD nor by the Technical Assessment Body issuing an ETA based on this EAD, but are regarded only as a means for expressing the expected economically reasonable working life of the product.

1.3 Specific terms used in this EAD

In this EAD the terms "kit" and "product" are considered equivalent.

General terms used in this EAD are in compliance with EN 14076. The main terms are shown in Figure 1.

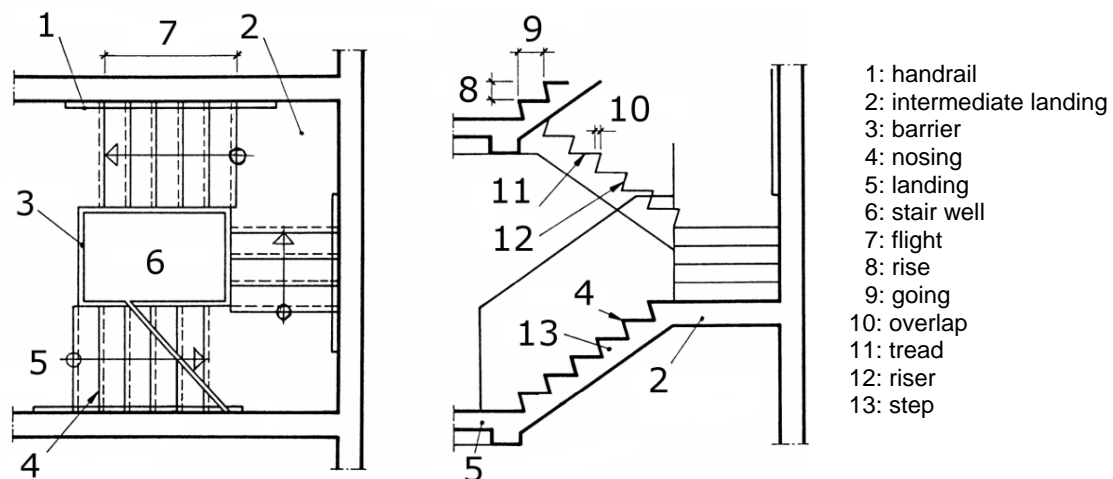


Figure 1: General terms

Following specific terms are used in this EAD:

Stair with strings

Steps are connected to each other - at least at one end of the steps - by load-bearing strings. The strings are inclined components that support the steps. They may be made of wood or steel. On the wall side, the steps are embedded in the wall or connected to the wall either directly or indirectly by wall fasteners.

Stair with load-bearing bolts

Steps are connected to each other - at least at one end of the steps - by load-bearing bolts. Examples are shown in Figures 2 and 3. On the wall side, the steps are embedded in the wall or connected to the wall either directly or indirectly by wall fasteners. The wall or part of the wall may be replaced by a load-bearing element (e.g. beam). In spiral stairs the steps are connected to the central post (Figure 4).

¹ The real working life of a product incorporated in a specific works depends on the environmental conditions to which that works is subject, as well as on the particular conditions of the design, execution, use and maintenance of that works. Therefore, it cannot be excluded that in certain cases the real working life of the product may also be shorter than referred to above.

Stair with load-bearing handrail

Steps are connected to each other on the wall-free side by a load-bearing bolt as well as being connected to the load-bearing handrail by balusters. On the side of the wall the steps are connected to the wall or embedded in a string made of wood or steel. The wall or string may also be replaced by a load-bearing handrail. An example is shown in Figure 5.

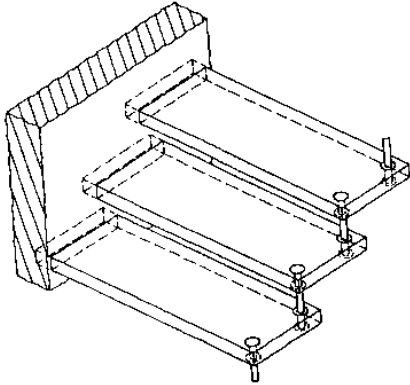


Figure 2: One-bolt stair

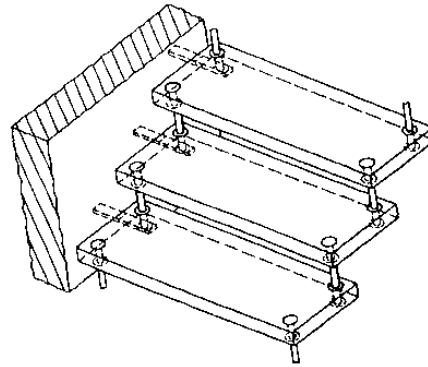


Figure 3: Two-bolt stair

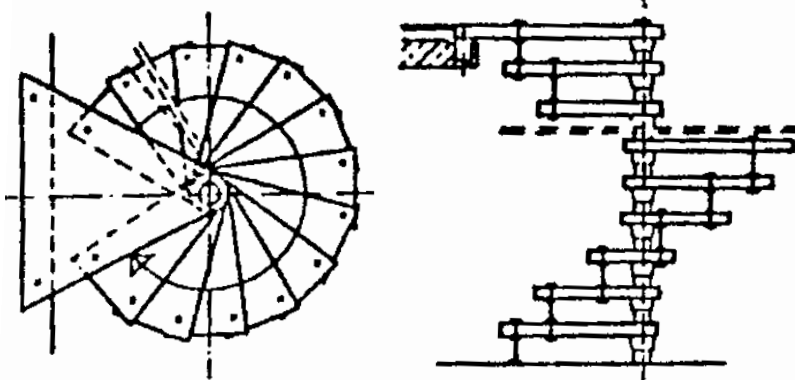


Figure 4: Spiral stair with load-bearing bolts

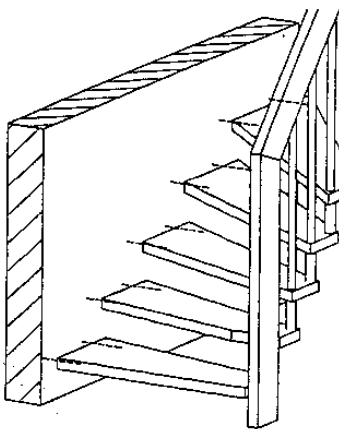


Figure 5: Stair with load-bearing handrail

Barrier

A protective element (e.g. railing or balustrade) designed to give a satisfactory degree of safety for someone falling down (Figure 6).

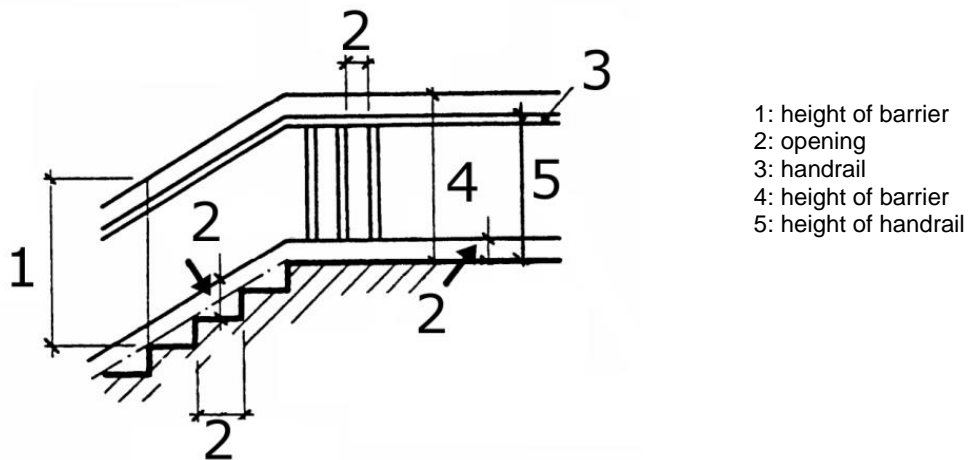


Figure 6: Barrier and handrail

Connections

A component to keep two elements of the stair kit together

Load-bearing bolts

Fixing elements used for the connection of the individual steps in a way that they are resistant to tension, compression and, if necessary, bending or they are used for their connection to the supports (landings).

Fixings

Components to attach the stair to the works

Wall fasteners

Metal elements connected to the step and embedded in the wall. It is also possible to use a supporting element such as an anchor or other fixing elements placed in the wall or in the load-bearing element (e.g. beam).

Constant pitch line

A line along the stair where the pitch is constant

Length of the step

Shortest possible distance (l) at right angles to the width of the step; various examples are shown in Figure 7 (for manufacturing purposes.)

Width of the step

Shortest possible distance (w) at right angles to the front edge of the step; various examples are shown in Figure 7 (for manufacturing purposes).

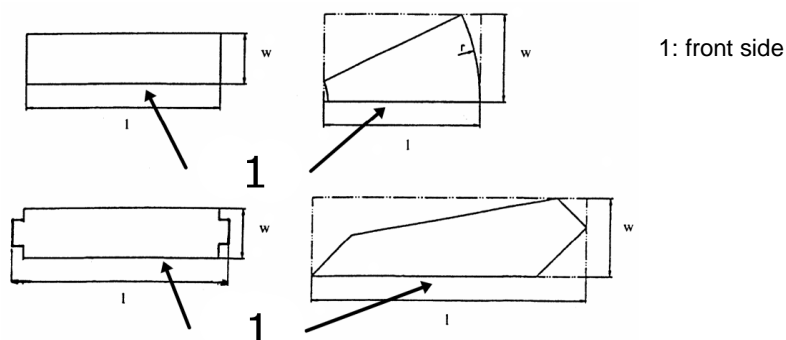


Figure 7: Length (l) and width (w) of steps

2 ESSENTIAL CHARACTERISTICS AND RELEVANT ASSESSMENT METHODS AND CRITERIA

2.1 Essential characteristics of the product

Table 1 shows how the performance of this stair kit is assessed in relation to the essential characteristics.

Table 1 Essential characteristics of the product and methods and criteria for assessing the performance of the product in relation to those essential characteristics

No	Essential characteristic	Assessment method	Type of expression of product performance
Basic Works Requirement 1: Mechanical resistance and stability			
1	Load-bearing capacity	2.2.1	Level (Q_{Rk} [kN], q_{Rk} [kN/m ²])
			Level (H_{Rk} [kN], h_{Rk} [kN/m])
			Level (M_{Rk} [kNm], V_{Rk} [kN], N_{Rk} [kN])
			Level (E [N/mm ²], G [N/mm ²])
			Level (f_{mk} [kNm], f_{vk} [kN])
2	Load-Displacement behaviour	2.2.2	Level (w_Q [mm])
			Level (w_q [mm])
3	Vibration behaviour	2.2.3	Level (f_1 [Hz])
			Level (w_{Q1} [mm])
4	Prevention of progressive collapse	2.2.4	Description
5	Residual load-bearing capacity	2.2.5	Description
6	Long-term behaviour	2.2.6	Description
7	Resistance to earthquake	2.2.7	Description
8	Durability against physical, chemical, biological agents	2.2.8	Description
Basic Works Requirement 2: Safety in case of fire			
9	Reaction to fire	2.2.9	Class
10	Resistance to fire	2.2.10	Class
Basic Works Requirement 3: Hygiene, health and environment			
11	Release of formaldehyde	2.2.11	Class
12	Release of pentachlorophenol	2.2.12	Class
13	Radioactive emissions	2.2.13	Level
Basic Works Requirement 4: Safety in use			
14	Geometry	2.2.14	Level
15	Slipperiness	2.2.15	Level
16	Safety equipment	2.2.16	Description
17	Safe breakage	2.2.17	Description
18	Impact resistance	2.2.18	Level

Note: Instead of using the methods given in Table 1 under numbers 4,6,15,16,17,18 the performance with regard to the characteristics concerned may also be established by long-term experience on site, provided that:

- 1 this long term experience is well documented, and
- 2 the kit/system for which the performance is established by this long-term experience is relevant for the ETA procedure.

2.2 Methods and criteria for assessing the performance of the product in relation to essential characteristics of the product

2.2.1 Load-bearing capacity

The stair shall have sufficient mechanical resistance and stability to withstand static and quasi static loads from the actions without reaching its ultimate limit state. The actions shall be in accordance with the laws, regulations and administrative provisions, applicable for the location where the product is incorporated in the works. The actions F_{EK} relevant to stair kits are permanent actions, variable actions and accidental actions.

The load-bearing capacity of the stair as a whole or of its parts (including fixings) shall be assessed according to the limit state design method as proposed in EN 1990. Load-bearing capacities may be determined by calculation or testing. The principle is the same as described in EN 1990. Also, for products with unknown material properties and complicated design, testing could be the only practical method.

If nationally determined parameters (NDPs) have been used in calculations, this shall be clearly indicated in the ETA and the parameters used shall be given.

Calculation

Calculations shall be performed for each type of plan using appropriate design models for the structural behaviour of the stairs. Load-bearing capacity shall be calculated as ultimate limit states.

The calculation of the internal forces and moments caused by the actions given in EN 1991-1 can be carried out using an idealised static system. When relevant, the system can be presented as a two-dimensional system. When EN 1992-1-1, EN 1993-1-1, EN 1994-1-1, EN 1995-1-1 or EN 1999-1-1 are applicable for the material of the stair kit, than calculation shall be done according to the relevant Eurocode by engineering practice. All relevant design situations and actions shall be considered. The horizontal load to the handrail shall only be taken into account as force acting from the stairs towards the outside.

String stairs may be calculated according to EN 16481:2014. Further specific calculation methods are given in Annex 4.

Testing

Where the calculation methods given in the Eurocodes listed above are not sufficient, testing shall be carried out to substantiate the performance of the stair. The TAB shall consider any available data derived from existing testing (e.g. on prototype samples).

The test procedures shall follow the relevant EN standards for testing components and materials. For prefabricated timber stairs the test methods according to CEN/TS 15680 shall be used.

If testing is used, the principles in Annex 2 shall be followed. The test results shall be adjusted to correspond to the minimum characteristic resistance of the materials.

If testing is used, it is not necessary to load the stair kit or part of it until failure, if a sufficient load level is reached before the failure.

Specific test methods are given in Annex 4.

Safety factors to be used in the calculations

If not specified in national regulations, the materials partial safety factor γ_M is to be used for the minimum value of three tests:

- | | |
|---|------------------|
| - wood and wood-based products | $\gamma_M = 1.5$ |
| - cement or resin bonded concrete stone | $\gamma_M = 1.6$ |
| - natural stone | $\gamma_M = 1.8$ |
| - polyamide | $\gamma_M = 2.0$ |

If not specified in national regulations, the materials partial safety factor γ_M to be used for the 5 %-fractile (for a confidence level of 75 %) of at least 10 tests:

- | | |
|---|------------------|
| - wood and wood-based products | $\gamma_M = 1.3$ |
| - cement or resin bonded concrete stone | $\gamma_M = 1.5$ |
| - steel | $\gamma_M = 1.1$ |

Load-bearing capacity of the stair

The load-bearing capacity of the stair can be derived directly as a result of the test of the whole stair system with the relevant loading or by calculation of the stair system.

By using static calculations the characteristic load-bearing capacity follows from the proof of ultimate limit state of all components and fastenings:

$$F_{Rk} = F_{Ek} \cdot \min \gamma_M \cdot \gamma_F \text{ (persistent designs situation with consideration of partial safety factors)}$$

The characteristic values of the following load-bearing capacity of the stair in ultimate limit state shall be given under following loadings:

- distributed load when all the steps and landings are loaded uniformly - q_{Rk} [kN/m²]
- distributed load when all the steps are loaded so that the unfavourable case for the torsion of -the stairs is encountered - q_{Rk} [kN/m²]
- line load acting on the barrier at the level of the handrail - h_{Rk} [kN/m]
- point load acting on the barrier at the level of the handrail in the most unfavourable position - H_{Rk} [kN]
- point load or a line load acting on a step in the most unfavourable position – Q_{Rk} [kN] or q_{Rk} [kN/m].

The following characteristics of components may also be given:

- Characteristic bending moment resistance - M_{Rk} [kNm]
- Characteristic shear resistance - V_{Rk} [kN]
- Characteristic tension or compression resistance - N_{Rk} [kN]
- Characteristic bending resistance - f_{mk} [N/mm²]
- Characteristic torsion resistance - f_{vk} [N/mm²]
- E-Modulus of the material – E [N/mm²]
- G-Modulus of the material – G [N/mm²]

Load-bearing capacity of fixings

The fixing to the supporting structure and the connection of the stair components to each other shall be designed in such a way that the actions from the different parts of the stairs shall be transferred to the works in an appropriate way.

The loads for the fixings shall be calculated according to Eurocodes. The resistance of fixings shall be proven according to Eurocodes or other harmonised technical specification or by testing. When testing, the principles in Annex 2 shall be followed.

The deformation of the fixings shall be taken into account when the load-bearing capacity and deformations of the stairs are determined.

The loads transferred to the works by the fixings shall be given by the following characteristic or design values in ultimate limit state shall be given:

- Tensile load of fixings in all directions N_k or N_d [kN,]
- Shear load of fixings in all directions V_k or V_d [kN],
- Bending loads in all directions M_k or M_d [kNm], if relevant.

2.2.2 Load-displacement behaviour

Load-displacement behaviour shall be calculated in serviceability limit states.

Calculation can be based on linear behaviour. The displacement shall be calculated or tested separately for the step and the bearing elements. The worst case shall be considered. Bending due to imposed horizontal load shall not be taken into account here. When assuming a realistic 3-D-representation, the function of the wall fastener as well as the shear resistance of the steps shall be taken into account. The influence of the barrier may be taken into account.

For the barrier, a proof of bending due to imposed horizontal loads will not be required. However, to fulfil the requirements of safety in use, the bending of the barrier shall be less than a suitable limit.

Under service loads, the deflection of the stairs on the wall free side the decisive deflection w_q or w_Q shall be given related to the median line of the flight. Furthermore the deflection of a single step under service loads w_Q shall be given related to the median line of the step.

2.2.3 Vibration behaviour

Vibrations shall be assessed via the displacement caused by a single point load of $F = 1$ kN. The deflection of the stairs w_{Q1} on the wall free side under a single load of $F = 1.0$ kN acting on the most unfavourable point shall be given.

The proper oscillation frequency f_1 of stairs exposed to dead load as well as to an additional single load of 1 kN acting on the most unfavourable point shall be evaluated and shall be given in the ETA.

The effect of the barrier as far as its mass and rigidity may be taken into account.

2.2.4 Prevention of progressive collapse

TAB has to assess that the failure of one step does not lead to the failure of the whole kit, such as chain failure of further steps or failure of the load-bearing capacity of the whole stair. The assessment of the functioning of the stair kit should be evaluated by engineering practice.

2.2.5 Residual load-bearing capacity

Residual load-bearing capacity is the resistance of a partially destroyed system (caused by accidental loads) to complete failure of the whole stair system.

For brittle materials, the construction of the stair kit shall be such that the failure of one step shall not lead to total loss of load-bearing capacity of the stair causing the user to fall to a lower level.

For brittle materials, the residual resistance shall be determined by testing. The residual load-bearing capacities may be determined by calculation or testing according to 2.2.1. The minimum residual load-bearing capacity shall be:

$$F_{Rk} = F_{Ek} \quad (\text{accidental design situation without consideration of partial safety factors})$$

2.2.6 Long-term behaviour

TAB has to assess the long-term behaviour of the materials of the stair kit for the intended working life. The load-bearing capacity shall retain its original value or the decrease in the load-bearing capacity shall be considered.

Assessment of long-term behaviour of the materials may be done according to EN 1992-1-1, EN 1993-1-1, EN 1994-1-1, EN 1995-1-1 or EN 1999-1-1 for the relevant material.

For certain products (e.g. plastics) it is necessary to carry out long-term tests. In these tests, the behaviour under sustained loading as well as the effect of prevailing environmental conditions (e.g. effect of UV) shall be determined. In the same way, pulsating loads and recurrent loads have to be taken into account.

2.2.7 Resistance to earthquake

The stair kit shall be assessed to resist the seismic action and its combination with the relevant permanent and variable actions. The assessment shall be made according to EN 1998-1.

2.2.8 Durability against physical, chemical, biological agents

To retain their properties during the working life, the components of the stairs and surfaces may need regular maintenance. Serviceability (durability) may be assessed empirically. If there is not enough experience, the following procedures shall be used.

Durability against physical agents

The durability against physical agents shall be assessed by engineering judgement of the materials and the construction taking into consideration

- Variations of temperature of the environment,
- Variations of relative humidity of the environment,
- Radiation of the sun, e.g. through the windows.

When relevant, a calculation of the effects shall be made. Hence, the variation limits for the environment shall be assumed to be as defined in the Eurocodes or in the national standards, according to the manufacturer's specified use conditions or as follows:

General conditions (heated environment):

- Temperature +5°C to +30 °C
- Relative humidity 30 % to 70 %

Because of the radiation of the sun, some materials may have an uneven temperature distribution causing distortion of the structural parts of the stair kit. Radiation of the sun can cause excessive warming of some surfaces the effects of which shall be assessed by engineering judgement. Radiation of the sun can cause ageing of the materials or surface treatments, the effects of which shall be assessed by engineering judgement, and, when relevant, by testing.

The effect of physical agents shall be described in qualitative terms with regard to the potential risk that the stairs will lose their integrity and cease to fulfil the relevant Basic Works Requirements. The use conditions as intended by the manufacturer should be taken into account.

Durability against chemical agents

The durability against chemical agents shall be assessed by engineering judgement of the materials and the construction taking into consideration the effects of

- Cleaning agents,
- Water, carbon dioxide, oxygen and other naturally occurring corrosives and
- Pollution agents in the air.

When relevant, testing shall be used, e.g. for materials of unknown composition or performance, or if the manufacturer makes specific claims.

The effect of chemical agents shall be described in qualitative terms with regard to the potential risk that the stairs will lose their integrity and cease to fulfil the relevant Basic Works Requirements.

Durability against biological agents

The durability against biological agents shall be assessed by engineering judgement of the materials and the construction taking into consideration the effects of

- Fungi, bacteria, algae and
- Insects.

When relevant, testing shall be used, e.g. for materials of unknown composition or performance, or if the manufacturer makes specific claims.

The natural durability of wood or wood based materials shall be assessed according to EN 460 and EN 350-2 in relation to the appropriate hazard class described in EN 335-2 and EN 335-3.

The effect of biological agents shall be described in qualitative terms with regard to the potential risk that the stairs will lose their integrity and cease to fulfil the relevant Basic Works Requirements.

Regarding the decay of wooden parts, it shall be proven that the use conditions are such that there will be no risk of decay, or that the parts are adequately treated.

The intended hazard class for wooden components shall be given as defined in EN 335 all Parts.

2.2.9 Reaction to fire

The stair or its components shall be tested, using the test method(s) relevant for the corresponding reaction to fire class, in order to be classified according to EN 13501-1.

The stair or its components are considered to satisfy the requirements for performance classes of the characteristic reaction to fire in accordance with the relevant EC Decision without the need for testing on the basis of it fulfilling the conditions set out in that Decision and its intended use being covered by that Decision. The evaluation according to following Commission Decisions is possible without testing:

- Components from steel, natural stone and cement bonded artificial stone: according to Commission Decision 96/603/EC, amended by 2000/605/EC (Euroclass A1),
- Components from solid wood panels or other wood-based product: according to Commission Decision 2007/348/EC,
- Components from structural timber: according to Commission Decision 2003/593/EC,
- Upper side of steps and landings: according to Commission Decision 2006/213/EC for steps like floorings.

Components of plastic or rubber (e.g. sleeve for wall ties without load-bearing capacity or intermediate layer of 2 mm at maximum) are considered as a small component described in TR 021 that do not need to be tested. The end use application is such, that the reaction to fire class of the whole element is not influenced by the small component.

2.2.10 Resistance to fire

The part of the works or assembled system in which the stair kit is intended to be incorporated, installed or applied shall be tested, using the test method relevant for the corresponding fire resistance class, in order to be classified according to the appropriate part of EN 13501-2.

2.2.11 Release of formaldehyde

The test method shall be performed according to EN 717-1 or EN 717-2 (if applicable) and stated as class E1 or E2 in the ETA. Formaldehyde classification shall be assessed as described in EN 13986 Annex B.

2.2.12 Release of pentachlorophenol

The assessment of pentachlorophenol shall be performed in accordance with EN 13986 and as described in CEN/TR 14823. The content of pentachlorophenol shall be stated in the ETA (\leq or \geq 5 ppm). Other biocides have to be assessed in accordance with the 'Biocides Regulation (EU) No 528/2012'.

2.2.13 Radioactive emissions

The activity concentrations of the radionuclides are assessed in accordance with the 'Council Directive 2013/59/EURATOM' and the corresponding activity concentration index shall be stated in the ETA.

2.2.14 Geometry

The following dimensions and tolerances shall be given by the manufacturer in accordance with EN 14076.

Going

The going shall be assessed as horizontal distance between two consecutive nosing measured on the walking line. Tolerances between actual value and nominal value of going within one flight and of consecutive steps shall be given.

Minimum and maximum going for tapered steps

The minimum and maximum going shall be assessed as the minimum/maximum unobstructed horizontal distance between the nosing of two consecutive tapered steps projected on plan. Tolerances between actual value and nominal value within one flight and of consecutive steps shall be given.

Rise

The distance shall be assessed vertically from the tread of a step to the tread of the consecutive step. The rise of all steps in one flight shall be assessed. When there is more than one designed value for rise within the same flight, e.g. for the first step, this shall be declared. Tolerances between actual value and nominal value of rise within one flight shall be given.

Pitch

The pitch of the stair shall be expressed as the angle in degrees between the pitch line and the horizontal plane. The pitch of all steps in one flight shall be assessed.

The TABs shall verify the constant pitch line taking into account the regulations on the walking line in those Member States in which the manufacturer intends his product to be used. The location of the constant pitch line shall be indicated on the plan drawing of the stairs in the ETA.

Overlap

The dimension of the overlap shall be assessed horizontally on plan between the nosing of a step and the rear edge of the tread of the consecutive step below.

Number of rises between landings

The rises within one flight shall be counted.

Maximum openings

The size and shape of the openings shall be such that a person is prevented from falling from the stair or being trapped. The following openings shall be considered when relevant:

- between barrier and other parts of stair ,
- between parts of stair kit and relevant parts of the works,
- between consecutive steps (open riser),
- in the barrier.

The size of the openings shall be tested with a cube with a fixed edge length. The length of the edges of the cube shall be such that the cube cannot be put through the opening in any position. The edge length of this cube can also be calculated from the three-dimensional geometry of the opening.

In addition to the cube test, a similar test may be carried out with a sphere. However, the cube edge length shall always be given in the ETA. Additionally, if a sphere has been used for the test, then the diameter may be given.

It shall be noted that the measured dimension by cube and by sphere are not equivalent. Depending on the shape of the opening, the sphere might be the one that can be fitted inside the cube or the one that embraces the cube or something in between.

Minimum and maximum clear width of the stair

The distance shall be assessed perpendicular to the walking line on plan between (restricting) elements.

Minimum headroom

In cases when relevant, the distance shall be assessed in vertical planes above the nosing.

In cases where the minimum headroom is relevant for the stair kit itself (e.g. spiral stair kit) this performance characteristic shall be considered.

2.2.15 Slipperiness

Following test method for resistance to slip shall be used:

- CEN/TS 15676:2007 Wood flooring – Slip resistance – Pendulum test
- EN 14231:2003 Natural stone test methods – Determination of the slip resistance by means of the pendulum tester
- EN 1339:2003 Concrete paving flags – Requirements and test methods

For all other materials following test method shall be used:

- CEN/TS 16165:2012 Determination of slip resistance of pedestrian surfaces, Annex C: Pendulum test for determination of slip resistance

2.2.16 Safety equipment

Handrail

The height of the handrail shall be measured vertically from the nosing of the step or upper surface of the landing to the upper surface of the barrier. Geometry of handrails and the gap between wall and handrail shall be assessed.

Barrier

Stair kits without a barrier shall be able to transmit the loads from a possible barrier, which is not part of the kit. Therefore the marginal conditions for addition of a barrier shall be defined in the ETA or in the technical documentation (e.g. maximum height of the barrier because of the resultant moment from the horizontal handrail loading on the step, the maximum distance of the baluster and the construction for the connection between baluster and step).

The minimum and maximum height of the relevant part of the barrier shall be measured vertically from the nosing of the step or upper surface of the landing to the upper surface of the barrier.

The openings in the barrier and the filling elements themselves shall be measured in the vertical direction. The minimum and maximum height of the relevant part of the barrier shall be measured vertically from the nosing or upper surface of the landing to the upper surface of the barrier.

Dimensions of the height of the barrier, dimensions of the minimum and maximum height of the part of the barrier without openings shall be given.

For climbability for infants the maximum dimensions shall be assessed giving the dimensions on the basis of measurement.

2.2.17 Safe breakage

Any elements of the stair kit liable to brittle fracture failure shall not, when accidentally broken, be a danger to users. Glazing or corresponding materials shall be such that, when broken, the pieces are kept in place and not detached in a way which would endanger users and those passing by.

The breaking properties of the flat components of brittle materials such as glass or plastics shall be proven according to EN 12600:2002.

For materials other than glass, the test requirements for safe breakage shall be formulated in a comparable way:

- a) No shear or opening develops within the test piece through which a 76 mm diameter sphere can pass freely
- b) When disintegrated, the sum of the mass of the 10 largest particles shall not weigh more than 0.1 kg.

The result for the barrier filling shall be given on the basis of EN 12600:2002, Clause 6.

2.2.18 Impact resistance

The impact resistance of a stair kit and its components shall be assessed giving the type of impact test, angle of the impact and the impact point, the type and mass of the impact body and the drop height without damage.

Test methods for impact resistance are given in Annex 3.

3 ASSESSMENT AND VERIFICATION OF CONSTANCY OF PERFORMANCE

3.1 System of assessment and verification of constancy of performance to be applied

For the products covered by this EAD the applicable European legal act is: Decision 1999/89/EC

The system is: 2+

In addition, with regard to reaction to fire for products covered by this EAD the applicable European legal act is: Decision 2001/596/EC

The systems are: 1, 3 and 4

3.2 Tasks of the manufacturer

The cornerstones of the actions to be undertaken by the manufacturer of the product in the procedure of verification of constancy of performance are laid down in Table 4.

Table 4 is an example only; the control plan depends on the individual manufacturing process and has to be established between notified body and manufacturer for each product

Table 2 Control plan for the manufacturer of the fastener; cornerstones

No	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
Factory production control (FPC) [including testing of samples taken at the factory in accordance with a prescribed test plan]					
1	e.g. Metal parts: dimensions	Measuring or optical	Laid down in control plan		
2	e.g. Metal parts: strength class	Check the delivery notes			
3	e.g. Wooden parts: wood moisture	Measuring			
4	e.g. Wood-based products: gluing	Specific test acc. to the control plan			

3.3 Tasks of the notified body

The cornerstones of the actions to be undertaken by the notified body in the procedure of verification of constancy of performance for the product are laid down in Table 5.

Table 3 Control plan for the notified body; cornerstones

Nr	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
Initial inspection of the manufacturing plant and of factory production control					
1	Ascertain that the factory production control with the staff and equipment are suitable to ensure a continuous and orderly manufacturing of the fastener	-	Laid down in control plan	-	1
Continuous surveillance, assessment and evaluation of factory production control					
2	Verifying that the system of factory production control and the specified automated manufacturing process are maintained taking account of the control plan.	-	Laid down in control plan	-	1/year

4 Reference documents

As far as no edition date is given in the list of standards thereafter, the standard in its current version at the time of issuing the European Technical Assessment is of relevance.

General

ISO 3880-1	Building construction; Stairs; Vocabulary – Part 1: Bilingual edition
ISO 12491	Statistical methods for quality control of building materials and components

Mechanical resistance and stability

Load-bearing capacity

EN 1990	Eurocode 0: Basis of structural design
EN 1991-1-1	Eurocode 1: Actions on structures – Part 1-1: General actions – Densities, self-weight, imposed loads for buildings
EN 1991-1-3	Eurocode 1: Actions on structures – Part 1-3: General actions – Snow loads
EN 1991-1-4	Eurocode 1: Actions on structures – Part 1-4: General actions – Wind actions
EN 1992-1-1	Eurocode 2: Design of concrete structures – Part 1-1: General rules and rules for buildings
EN 1993-1-1	Eurocode 3: Design of steel structures – Part 1-1: General rules and rules for buildings
EN 1994-1-1	Eurocode 4: Design of composite steel and concrete structures - Part 1-1: General rules and rules for buildings
EN 1995-1-1	Eurocode 5: Design of timber structures – Part 1-1: General – Common rules and rules for buildings
EN 1998-1	Eurocode 8: Design of structures for earthquake resistance – Part 1: General rules, seismic actions and rules for buildings
EN 1999-1-1	Eurocode 9: Design of aluminium structures – Part 1-1: General structural rules
CEN/TS 15680	Prefabricated timber stairs – Mechanical test methods
EN 338	Structural timber – strength classes
EN 408	Timber structures – Structural timber and glued laminated timber
EN 789	Timber structures - Test methods - Determination of mechanical properties of wood based panels
EN 13986	Wood-based panels for use in construction - Characteristics, evaluation of conformity and marking
EN 16481	Timber stairs – Structural design – Calculation method

Durability

EN 335-1	Durability of wood and wood-based products - Definition of use classes – Part 1: General
EN 335-2	Durability of wood and wood-based products - Definition of use classes – Part 2: Application to solid wood
EN 335-3	Durability of wood and wood-based products - Definition of hazard classes of biological attack – Part 3: Application to wood-based panels
EN 350-2	Durability of wood and wood-based products - Natural durability of solid wood - Part 2: Guide to natural durability and treatability of selected wood species of importance in Europe
EN 351-1	Durability of wood and wood-based products - Preservative- treated solid wood - Part 1: Classification of preservative penetration and retention
EN 460	Durability of wood and wood-based products - Natural durability of solid wood - Guide to the durability requirements for wood to be used in hazard classes

Safety in case of fireReaction to fire

EN 13501-1	Fire classification of construction products and building elements – Part 1: Classification using data from reaction to fire tests
1996/603/EC amended by 2000/605/EC, 2003/424/EC	Commission Decision of 4 October 1996 establishing the list of products belonging to Classes A 'No contribution to fire' provided for in Decision 94/611/EC implementing Article 20 of Council Directive 89/106/EEC on construction products
2003/43/EC	Commission Decision of 17 January 2003 establishing the classes of reaction-to-fire performance for certain construction products
2003/593/EC	Commission Decision of 7 August 2003 amending Decision 2003/43/EC establishing the classes of reaction-to-fire performance of certain construction products
2007/348/EC	Commission Decision of 15 May 2007 amending Decision 2003/43/EC establishing the classes of reaction-to-fire performance for certain construction products as regards wood-based panels
2006/213/EC	Commission Decision of 6 March 2006 establishing the classes of reaction-to-fire performance for certain construction products as regards wood flooring and solid wood panelling and cladding

Resistance to fire

EN 13501-2	Fire classification of construction products and building elements – Part 2: Classification using data from fire resistance tests, excluding ventilation systems
EN 1991-1-2	Eurocode 1: Actions on structures - Part 2: General actions - Actions on structures exposed to fire
EN 1992-1-2	Eurocode 2: Design of concrete structures - Part 1-2: General rules - Structural fire design
EN 1993-1-2	Eurocode 3: Design of steel structures – Part 1-2: General rules - Structural fire design
EN 1994-1-2	Eurocode 4: Design of composite steel and concrete structures - Part 1-2: General rules - Structural fire design
EN 1995-1-2	Eurocode 5: Design of timber structures - Part 1-2: General rules - Structural fire design

Hygiene, health and environment

EN 13986	Wood-based panels for use in construction - Characteristics, evaluation of conformity and marking
EN 717-1	Wood-based panels - Determination of formaldehyde release - Part 1: Formaldehyde emission by the chamber method
EN 717-2	Wood-based panels - Determination of formaldehyde release - Part 2: Formaldehyde release by the gas analysis method
CEN/TR 14823	Durability of wood and wood products. Determination of pentachlorophenol number in the wood. Gas chromatography
2013/59/EURATOM	Council Directive 2013/59/EURATOM of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom
Biocides Regulation (EU) No 528/2012	Regulation (EU) No 528/2012 of the European Parliament and of the Council of 22 May 2012 concerning the making available on the market and use of biocidal products

Safety in useSlipperiness

EN 14231:2003	Natural stone test methods - Determination of the slip resistance by means of the pendulum tester
CEN/TS 15676:2007	Wood flooring – Slip resistance – Pendulum test
EN 1339:2003	Concrete paving flags – Requirements and test methods
CEN/TS 16165:2012	Determination of slip resistance of pedestrian surfaces, Annex C: Pendulum test for determination of slip resistance

Impact resistance

ISO 7892:1988	Vertical building elements - Impact resistance tests - Impact bodies and general test procedures
EN 12600:2002	Glass in building – Pendulum test – Impact test method for flat glass

Specification Clarification

EN 13353	Solid wood panels (SWP) - Requirements
EN 13354	Solid wood panels (SWP) – Bonding quality –Test method
EN 204	Classification of thermoplastic wood adhesives for non-structural applications
EN 13307-1	Timber blanks and semi-finished profiles for non-structural uses - Part 1: Requirements
EN 14076:2013	Timber stairs - Terminology; Trilingual version

ANNEX 1 CLARIFICATIONS (INTERPRETATION OF TERMS)

TRADITIONALLY-MADE PREFABRICATED STAIRS OF SOLID WOOD

General

The exclusion from the scope, as mentioned above, is referred to a situation that all of the stated criteria (traditionally-made, prefabricated, solid wood, individual request) need to be met.

Interpretation of terms

Stairs of solid wood

The term “stairs” is used synonymously for “stair kit” and related to all parts (steps, strings, guarding/barrier etc.) which contribute to the fulfilment of mechanical resistance and stability (vertical and horizontal).

Prefabricated

The word “prefabricated” refers to the fact that the parts of the stairs are allowed to be manufactured in advance in the production premises and not only on site (of the works). The degree of prefabrication is not a reason to exclude stairs from the scope of this EAD.

Solid wood

According to 3.1 in EN 335-2 solid wood is understood as “*wood, sawn or otherwise machined which may include finger jointed and/or laminated wood*”. With respect to this definition solid wood means massive wood, glulam, solid wood panel or other prefabricated components comparable with those defined in EN 13307-1. They may be sawn, planed or shaped by (computerized) machine tool. Other wood-based panels are not considered as solid wood (e.g. MDF, LVL or plywood). A decorative veneering may be used if the hidden parts are made of solid wood as defined previously. Note: According to the definition in 3.1 in EN 335-2 layers of timber connected together in another way, e.g. by means of nails, are not considered as solid wood.

Traditionally-made

The term “traditionally-made” is related to already experienced and well-known design principles (dimensioning of strings, steps; embedding in the string, guarding/barrier and the fixing of it) with respect to mechanical resistance and stability. Having in mind these principles, the term “traditionally-made” needs to be restricted to the manufacturing of stairs made of solid wood with steps housed on both ends in strings (outer and wall string respectively), either close string(s) and/or cut string(s). This restricts the design of steps to the design principles for single-span beam. For the definition of “string”, “outer string”, “wall string”, “closed string”, “cut string” see EN 14076:2013.

Individual request

Individual request is related to individual (non-series) production of products according to 4.9.3 in Guidance Paper M of the EC (GP M final text April 2005 - edition May 2005) and Art. 5a of the Regulation (EN) No 305/2011.

CONSTRUCTION SYSTEM

The ETA covers a construction system. In the ETA are defined the minimum and maximum values of geometry and the possibilities of construction details. For the specific case of use the corresponding type of stair is manufactured within the maximum and minimum values defined in the ETA. Thus, the values apply to all types of stairs for which the real dimensions (e.g. going, rise and pitch chosen for the particular end use) are between these maximum and minimum values. If the values of national legislation are within the scope of the values defined in the ETA, the stair can be manufactured and used accordingly.

WOODEN LOAD-BEARING PARTS

For stairs with wooden load-bearing parts special graded woods are used. The properties of the load-bearing capacity are much better than the values generally defined in standards for structural timber (EN 338). The characteristic values of materials are tested according to Annex 4. The type and execution of the tests are comparable with the methods according to EN 789 or EN 408. The tested values shall be reported in the technical documentation. The values have to be reported in the evaluation report.

SOLID WOOD PANEL / KIND OF GLUING:

The harmonised product standard EN 13986 refers to EN 13353 and EN13354. EN 13353 paragraph 4.3.4 requires that thermosetting adhesive shall be used in structural applications for load-bearing structures.

Otherwise, according to EN 204, thermoplastic wood adhesives may be used for non-structural parts of stairs, which is different from what is required by EN 13353, Concerning gluing, it is accepted that stairs can be considered as non-structural applications, because the loads are low compared to other timber structures.

Generally the solid wood panels are produced by using the glue quality D3 (thermoplastic adhesive) according to EN 204. The quality of the gluing is provided by regular tests. These are described in the control plan for the FPC. This design principle is used over 30 years for traditionally made timber stairs. There is no information about any failure of these components. For these reasons it can be concluded that D3 glue is sufficient for components of stairs.

ANNEX 2 GENERAL TEST PRINCIPLES FOR STRUCTURAL TESTING OF STAIR KITS AND THEIR COMPONENTS AND MATERIALS

Sampling

When a harmonised European technical specification is not available for a component or a material to be used in a stair kit, the specification of the component or material can be made by testing. A similar method can be used to test the mechanical properties of the whole stair kit.

The stair kits, components or materials to be tested shall be a representative sample of the kits manufactured.

Testing

If a material is to be tested, the shape and size of the specimen shall be similar to that of the component to be used in the stair kit, if practicable. The actions considered shall correspond to the actions on the component and of the static system. Thus, e.g. for natural stone intended to be used in steps for stairs with load bearing bolts, bending, shear and torsion tests shall be carried out.

If a component is to be tested, the component shall be fixed in the same manner as it will be in the stair kit. Thus, e.g. for a connection intended to be used between a step and a string, the specimen shall be made as a fragment of a step and a string, and shear, bending and pull out shall be considered, if relevant.

If a complete stair kit is to be tested, the kit shall be installed according to the manufacturer's instructions and the loading shall be planned to fit the stair type. The worst case shall always be considered. Simplified calculations can be used to find out the worst case. Before loading in worst case, the different parts may be loaded sequentially e.g. to find the deflection values. If some parts are broken during these preceding loadings, they may be repaired in such a way that the overall function of the stair kit is not essentially changed.

The kind of testing to be carried out depends on the material, the structure of the stair and the strain of the component or the connecting part of the components. Specific tests for stairs with load-bearing bolts are given in Annex 4. The testing of steps according to Annex 4 applies analogously to similar construction systems. For each test series 3 specimens have to be tested.

The tests in general shall be carried out under normal environmental conditions of the EAD.

For materials like wood and wood-based products the moisture content of the samples after execution of the tests shall be determined.

The characteristic values of the relevant material properties shall be checked and the test result shall be reduced to correspond to the minimum guaranteed values of the materials properties.

Evaluation of the test results

The 5 % fractile characteristic value shall be given as the 5 % fractile value determined using an unknown confidence level of 75 %.

For a normal distribution the characteristic value x_k is given by:

$$x_k = x_{mean} - k_n x_{stdev} \quad (A2.1)$$

Where x_{mean} is the mean value and x_{stdev} is the standard deviation of the material property; k_n depends on the number of tests. Values for k_n are given in Table A2.1.

Table A2.1. Values for k_n to be used in Equation (1), ISO 12491.

Number of tests	3	4	6	8	10	20	30	40	50	100	∞
k_n	3.15	2.68	2.34	2.19	2.10	1.93	1.87	1.83	1.81	1.76	1.64

For a log-normal distribution the characteristic value x_k is given by:

$$x_k = e^{(\ln x)_{mean} - k_n (\ln x)_{stdev}} \quad (\text{A2.2})$$

When it is reasonable to assume that a material or component property is better described by a log-normal distribution function than by a normal distribution function the logarithm of the material property may be used instead of the material property itself for determination of the 5 % fractile characteristic values.

If it is impossible to test a representative sample of the product, the value of the standard deviation shall not be taken as less than 20 % of the value for the mean value. For example, this is the situation when the product to be tested is produced at a pilot production line. This value shall be checked against the factory production control results.

The characteristic values determined according to this method are the highest values that may be declared as the characteristic values. It may be advisable to declare lower values to avoid an unreasonable amount of rejections during the evaluation of conformity process.

ANNEX 3

IMPACT RESISTANCE TEST METHODS

General

The testing shall be carried out on sample stair kit parts representative of those to be supplied and/or erected in practice fitted into an appropriate test rig. Whenever possible the installation of the test sample shall be carried out by those who ordered the test.

The test methods used are mainly based on ISO methods but certain elements are modified or amended.

Unless otherwise stated in the test methods, loads and forces shall be accurate to within $\pm 2\%$, dimensions to within $\pm 1\%$, temperatures to within $\pm 5\text{ }^{\circ}\text{C}$ and relative air humidity to within $\pm 5\%$ of the stated values.

Sample

The selection of the sample needs careful consideration to ensure that it fully represents the stair kit to be tested. Normally, the sample shall be a part of a stair kit fabricated in strict accordance with the manufacturer's drawings, specifications and installation instructions.

The number and position of connections between panels and other parts of a stair kit shall also be considered.

Test rig

For the pendulum tests, (for example barrier, riser and handrail) the test rig shall be as identified in ISO 7892:1988. For the drop tests (for example steps) the test rig shall give appropriate support for the sample.

Pendulum tests

Sequence of tests

The procedures of ISO 7892:1988 shall be applied with the following modifications:

Testing to determine the impact resistance for the barrier shall follow the sequence given below:

- Hard body impact load – 0,5 kg steel ball – Functional failure test
- Soft body impact load – 50 kg bag – Functional failure test
- Hard body impact load – 1 kg steel ball – Structural damage test
- Soft body impact load – 50 kg bag – Structural damage test.

Testing to determine the impact resistance for the handrail shall follow the sequence given below:

- Soft body impact load - 30 kg bag

Testing to determine the impact resistance for the riser shall follow the sequence given below:

- Hard body impact – 3,5 kg steel ball

Test Methods

- Hard body impact load – 0,5 kg steel ball
The load shall be applied at least ten times, each time in a new position.
The diameter of any indentation shall be reported. Note shall be made of any damage caused.
- Hard body impact load – 1 kg steel ball
The load shall be applied at all points considered weak, once at each position.
The diameter of any indentation shall be reported. Note shall be made of any damage caused.
- Hard body impact load – 3,5 kg steel ball
The load shall be applied at all points considered weak, once at each position.
Any fracture, puncture, deformation or loss of integrity shall be reported. The maximum deformation shall be recorded.
- Soft body impact load – 30 kg bag
The centre of the impact shall be at the handrail. The test shall be repeated three times.
Any damage shall be recorded.

- Soft body impact load – 50 kg bag
The impact load shall be applied in the centre of a middle module of the barrier above the steps unless this interferes with a member in a frame construction. However, the point of impact can be chosen by the TAB to be as severe as possible.
The deflection transducers shall be fixed to the back of the test sample immediately opposite the point of impact.
The structural damage impact is carried out at a new point and this shall be at the weakest part of the barrier. The impact may need to be repeated if the weakest point is not obvious. The maximum deflection during each impact and the residual deflection after each impact shall be reported. The residual deflection shall be measured five minutes after the impact.

Drop tests

Sequence of tests

Testing to determine the impact resistance for steps shall follow the sequence given below:

- Hard body impact load – 4,5 kg steel rod \varnothing 25 mm – Functional failure test
- Soft body impact load – 50 kg bag – Structural damage test.

Test Methods

- Hard body impact load – 4,5 kg steel rod
Increase the drop height until the step is broken. Record the drop height in mm causing failure and the extent of the damage.
- Soft body impact load – 50 kg bag
This type of test is only necessary for materials tending to sudden failure in case of pulsating loading or overloading (e.g. natural stone).
The impactor is dropped from a height of 200 mm. Any damage is recorded.
Impact tests might be followed by a static test to show that the load-bearing capacity has not been changed.

ANNEX 4

SPECIFIC PROVISIONS REGARDING STAIRS WITH LOAD-BEARING BOLTS

General

This annex applies to the installation of stairs with load-bearing bolts with straight or newelled flights or parts of flights (e.g. winding stairs and helical stairs) as well as to spiral stairs. In this annex, the calculation methods and test information are given.

Simplified calculation method for one-bolt stairs

Steps of one-bolt stairs are embedded in the wall or connected to the wall by two wall fasteners. On the wall-free side they are connected to one another by one load-bearing bolt each.

If a more detailed static calculation is not carried out the following may be assumed:

- The load-bearing bolts are connected to the steps as hinged connections.
- The steps are fixed to the wall under torsion - not bending.

With these approximations, in general, a simple statically indeterminate structural system is obtained.

Simplified calculation method for two-bolt stairs

Steps of two-bolt stairs are connected to one another on the wall side and on the wall-free side by a load-bearing bolt each. On the side of the wall, each step is connected to the wall by means of a wall fastener.

If a more detailed verification is not carried out, the following may be assumed:

- The load-bearing bolts are connected to the steps as hinged connections.
- The wall fasteners are connected to the step in a way resistant to bending; fixing to the wall shall be freely supported.

Calculation method for other load-bearing bolt stairs

If the steps are connected to one another by two load-bearing bolts each (double bolts) or by prestressed deflection resistant load-bearing bolts on the side of the wall as well as on the wall-free side (four-bolt stairs), or by a load-bearing bolt each on the wall-free side (three-bolt stairs); or if the barrier is taken into account for assessment of the load resistance of the stairs, the calculation shall assume a 3-D representation of the system. The connection, e.g. between steps and barrier or load-bearing bolt and step, shall be taken into account in a realistic way. The design of the components and their connections shall be based on the relevant technical specifications (Eurocodes) or on the results of tests carried out on structural members.

Load/displacement behaviour

The deflection of the stairs in the area of the bolts on the free side shall be assessed.

Testing of steps

General

The thickness of steps depends on the requirements for load-bearing capacity, load/displacement behaviour and impact resistance.

The minimum values of spacing between load-bearing bolts and edges of steps shall be determined from tests. Sufficient safety against failure shall be assessed by torsion, bending and shear tests carried out on individual steps.

Steps may be made of materials whose properties are defined in the relevant technical specifications including Eurocodes and therefore their stability and load/displacement behaviour (e.g. reinforced concrete, steel) can be calculated.

They may also be made of materials whose properties deviate from those defined in the technical specifications including Eurocodes due to a particular choice (e.g. timber). For these materials, the characteristic material values such as modulus of elasticity, G-modulus, torsion and bending strength, shall be determined from tests.

A third group of materials to be used are materials whose properties are not defined in the relevant technical specifications including Eurocodes. Such products are for example slabs made of natural stone or cement or resin bonded concrete slabs bonded to form steps. For these materials, the characteristic material values such as modulus of elasticity, G-modulus, torsion and bending strength, shall be determined from tests.

Resistance to torsion and to bending shall be determined from at least three tests carried out on single steps. E- and G-modulus shall be determined from at least three tests each, carried out with application of about 50 % of service load (imposed load). The shear resistance in the area of the load-bearing bolts shall be determined in a realistic way, for example by shear tests carried out on single steps.

Torsion test

Shear modulus, torsion stress at failure as well as residual load resistance shall be determined by short-term tests carried out on single rectangular steps (for spiral stairs on single trapezoidal steps). The steps shall be fixed on one side and the free end torqued. Load is applied, for example, on the wall-free side via the load-bearing bolts. An example of test equipment is shown in Figure A4.1. The displacements due to torsion shall be determined at the longitudinal edge of the steps. The shear modulus shall be determined at about 50 % of service load.

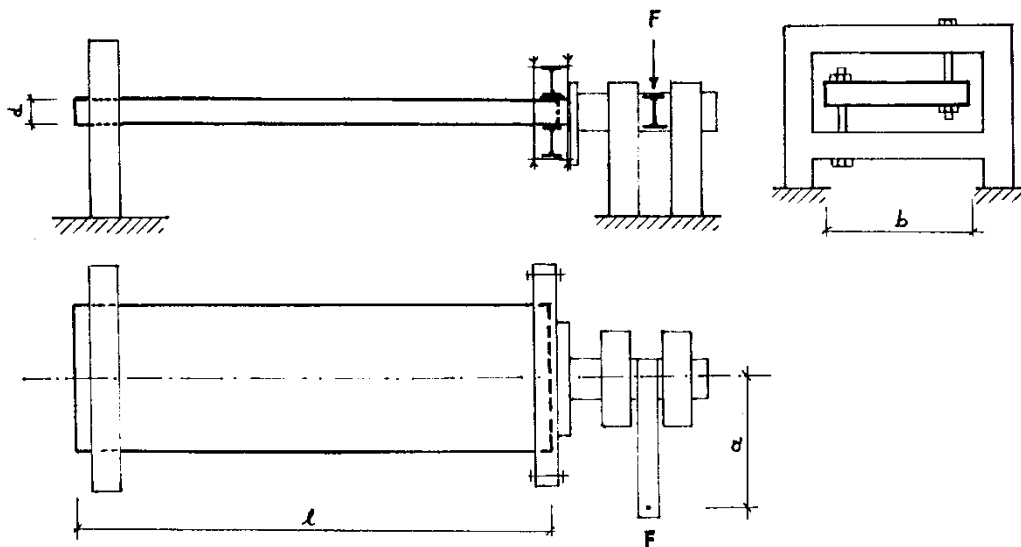


Figure A4.1. Example of test equipment for torsion tests

Bending test

The elastic bending modulus, the bending stress at failure as well as the residual load resistance shall be determined by short-term tests carried out on single rectangular steps (for spiral stairs on single trapezoidal steps) and for stairs with an effective load-bearing handrail, also on single pieces of handrail. The steps or the pieces of handrail shall be subjected to the three-point bending test. Load is applied via a loading element in the form of a rail with linear load acting parallel to the supports. An example of test equipment is shown in Figure A4.2. The elastic bending modulus shall be determined at about 50 % of service load. The residual load resistance shall achieve at least 1.1 times the value of service load.

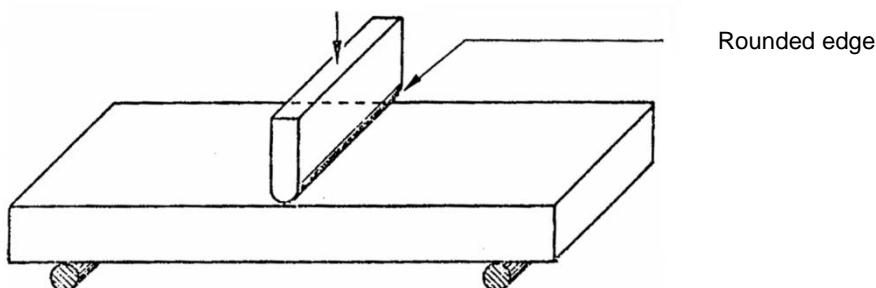


Figure A4.2. Example of test equipment for bending tests

For spiral stairs the bending stress at failure of the steps shall be determined directly at the point of fixing (section of spindle) by a test carried out on structural members. An example of test equipment is shown in Figure A4.3.

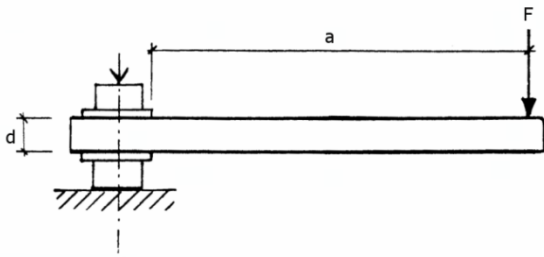


Figure A4.3. Example of bending test equipment for spiral stairs

Shear test

The shear resistance of the steps for three- and four-bolt stairs as well as for stairs with prestressed bending resistant load-bearing bolts shall be determined by a test carried out on the structural member. For this purpose, step sections of half length of the step shall be fixed to an upper or lower double bolt or to a prestressed bending resistant load-bearing bolt and loaded until failure. An example of test equipment is shown in Figure A4.4.

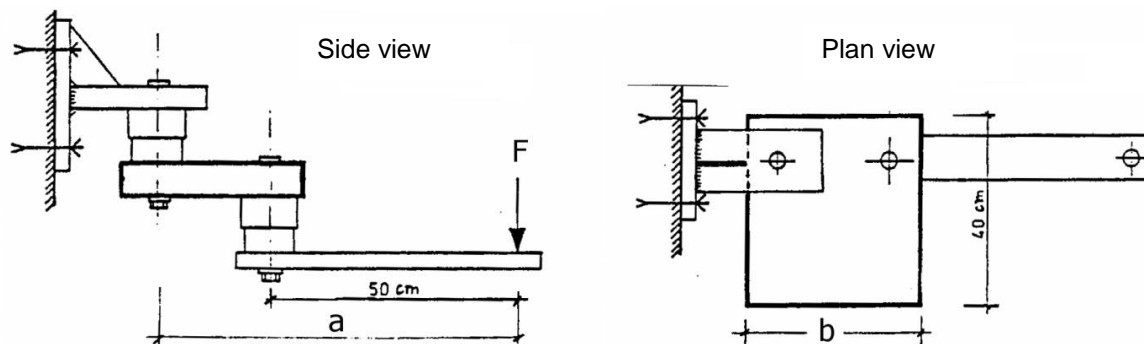


Figure A4.4. Examples of cross-bending test equipment

Drop test

This type of test is only necessary for materials tending to sudden failure in case of pulsating loading or overloading (e.g. natural stone).

The test involves dropping a mass of 50 kg from a height of 20 cm, followed by a torsion test. Any decrease in the torsion capacity is evaluated.

Load resistance of wall fasteners embedded in the step

The load-bearing capacity of circular bars embedded in the step and fixed to the staircase wall shall be assessed on the basis of tests carried out on structural members. By measurements of deformation in structural member tests, the characteristic values to be used for static design (e.g. torsion rigidity and rigidity at elongation) shall be determined. An example of test equipment is shown in Figure A4.5. The steps shall be loaded once at their centre (F1) and once at the edge just above the wall fastener (F2). As an alternative, this test may also be carried out on a step cut in half longitudinally.

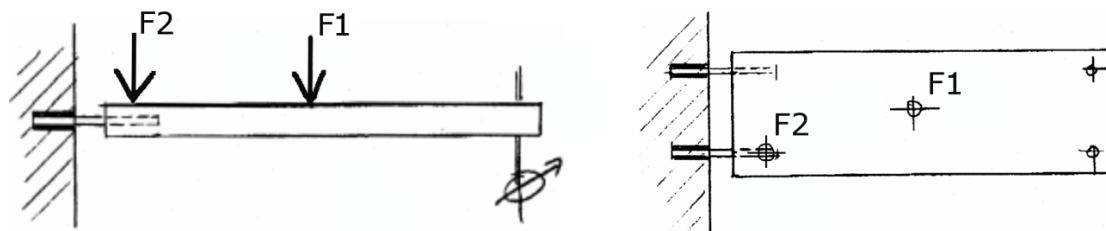


Figure A4.5. Examples of wall fastener test equipment

Testing of load-bearing bolts and their anchorage

If in the static calculation bending strength of the load-bearing bolts is taken into account, the stability of the load-bearing bolts shall be determined, from tension, compression and bending tests. For concealed sleeves embedded in the steps it is necessary to deliver proof of their stability by carrying out a test on structural members.