

**THE ENGINEERING EQUIPMENT AND MATERIALS USERS ASSOCIATION**

# **Factory stairways, ladders and handrails**

## **Including access platforms and ramps**

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## **ENGINEERING EQUIPMENT AND MATERIALS USERS ASSOCIATION**

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- Promoting and presenting members' views, and encouraging the application of good sound engineering practices
- Developing user guides, specifications, training and competency schemes
- Facilitating members' participation in national and international standards making
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## Notes for Users of this Publication

This Publication refers throughout to British and European Standards and relevant United Kingdom of Great Britain and Northern Ireland legislation. Standards are prepared to ensure that only proven techniques are used and that materials employed are suitable for the purpose. Through the adoption and use of standards, the requirements for essential safety should be met. The use of standards is not a requirement in UK law, unlike in some other countries in Europe. However it is stressed that, where a contract is placed which states that manufacture is to be in accordance with specified standards, then this may be determined as a legal requirement. Manufacturers or suppliers of equipment may offer equipment not conforming to standards but in such cases they should have to be able to prove that all legislation concerning essential safety has been complied with. This could be a time consuming and expensive task.

Designers may from time to time find difficulty in designing stairways and associated landings to fit into existing buildings. Minor deviations from the standards may be unavoidable in such cases. Any such deviations should be documented and approved by the Health and Safety Inspector prior to manufacture.

With continual improvement in materials and rationalisation of product ranges, it may not always be possible to obtain a type or quality of material that was available when this Publication was revised. Occasionally, revisions to standards, particularly for steels, may amend the range of qualities available. Manufacturers or stockists should be consulted for the appropriate or acceptable alternative. This is of particular importance where steel is to be fabricated or welded.

Users of this Publication should satisfy themselves that the parts they are using are relevant to the application being considered, that they are correctly applied, and that no legislative changes have taken place affecting this Publication's content subsequent to the date of publication.

The recommendations contained in this edition do not necessarily follow exactly any particular British Standard referred to. However, none of the recommendations fall outside the values given in the British Standards, i.e. minimum values are always equal or higher and maximum values equal to or lower than those in the British Standards.

Other than in Chapter 2, the Building Regulations referred to in this Publication are "The Building Regulations 2010", and the Approved Documents are Approved Document B Volume 2 2006 Edition Incorporating 2007, 2010 & 2013 amendments and Approved Document K 2013 Edition. Users should ensure that they work to documents relevant to the location of the installation in question.

## **Eighth Edition**

This EEMUA Publication was first issued in 1954. Since that date new editions have been made to bring it into line with changing legislation, British and European Standards.

This edition has been issued to take into account a number of changes to related British Standards and legislation. Users are advised to check for any particular health and safety legislation applicable to their location.

In the preparation of this edition, the chapters and clauses of the earlier editions have been rearranged. Care should be taken when comparing clause numbers used in previous editions with those of this edition.

## 1 Scope

This Publication gives recommendations and typical details for the design and general construction of factory stairways, ladders, access platforms, ramps and handrails. It is primarily intended for use by engineers and architects responsible for the preparation of detail drawings for the construction and installation of this ancillary equipment. Its scope covers the design, construction, maintenance and inspection of such equipment.

The recommendations are specific to industrial applications. However there is nothing in these recommendations which precludes their adoption and use in the sometimes less onerous conditions applicable to low-rise office, shop and domestic situations.

All construction should be in accordance with the relevant statutory requirements and safety regulations. Reference to these should be made before a design is finally adopted. The materials used, as well as the design and workmanship, should also comply with the appropriate British and European standards.

Special attention is drawn to Clause 5.3, Clause 6.4, Figure 1 and Figure 2, which specify the stairway and ladder slopes that are preferred for different types of access and different uses of stairways. Reference is also made to those angles which should not be used in view of the hazard they present.

Because of the very specialised nature of the materials or section dimensions needed to provide ladders and ancillary equipment suitable for steeplejack use where loadings may be abnormal and possibly also under difficult atmospheric conditions, these ladders are excluded from this Publication.

Temporary access systems (e.g. scaffolding, mobile towers and platforms) are excluded from the scope of this Publication but the decision making process between the provision of permanent or temporary access is included.



## 2 Legislation, standards and codes

### 2.1 Legislation

The following UK legislation puts general and specific requirements on the installation and use of access systems. This is not an exhaustive list and users must ensure that they comply with all necessary legislative requirements.

Users of this Publication outside the UK should ensure that they comply with local legislation in force.

#### 2.1.1 The Health and Safety at Work Act 1974<sup>(1)</sup>

The following clauses put general requirements on employers:

Clause 2 (d) states: “so far as is reasonably practicable as regards any place of work under the employer’s control, the maintenance of it in a condition that is safe and without risks to health and the provision and maintenance of means of access to and egress from it that are safe and without such risks”;

Clause 4 (2) states: “It shall be the duty of each person who has, to any extent, control of premises to which this section applies or of the means of access thereto or egress therefrom or of any plant or substance in such premises to take such measures as it is reasonable for a person in his position to take to ensure, so far as is reasonably practicable, that the premises, all means of access thereto or egress therefrom available for use by persons using the premises, and any plant or substance in the premises or, as the case may be, provided for use there, is or are safe and without risks to health.”

#### 2.1.2 The Management of Health and Safety at Work Regulations 1999<sup>(2)</sup> and The Management of Health and Safety at Work Regulations<sup>(3)</sup> (Northern Ireland) 2000

Clause 3-(1) in both sets of regulations states:

“Every employer shall make a suitable and sufficient assessment of—

- (a) the risks to the health and safety of his employees to which they are exposed whilst they are at work; and
- (b) the risks to the health and safety of persons not in his employment arising out of or in connection with the conduct by him of his undertaking,”

#### 2.1.3 The Work at Height Regulations 2005<sup>(4)</sup> and The Work at Height Regulations (Northern Ireland) 2005<sup>(5)</sup>

These regulations impose many requirements on working at height, which include work at ground level or below ground level. Anyone involved with the design, installation, maintenance or use of access systems should be fully conversant with these requirements. Some of the schedules included in this legislation are particularly relevant to users of this Publication. However, they should not be used in isolation of the main body of regulations. The schedules concerned are:

- Schedule 1: Requirements for Existing Places of Work and Means of Access or Egress at Height

- Schedule 2: Requirements for Guard-rails, Toe-boards, Barriers and Similar Collective Means of Protection
- Schedule 3: Requirements for Working Platforms
- Schedule 6: Requirements for Ladders

It should be noted that reference to “construction work” in these regulations refers to the meaning assigned to it by regulation 2(1) of the Construction (Health, Safety and Welfare) Regulations 1996.

Clause 2(1) (e) states “construction work” means “the installation, commissioning, maintenance, repair or removal of mechanical, electrical, gas, compressed air, hydraulic, telecommunications, computer or similar services, which are normally fixed within or to a structure.”

#### **2.1.4 The Building Regulations 2010<sup>(6)</sup>**

Where the Building Regulations apply, meeting the applicable requirements of the Approved Documents should normally ensure compliance with the regulations. The Approved Documents relevant to this publication are:

- Approved Document B Volume 2 2006 Edition Incorporating 2007, 2010 & 2013 amendments, ISBN: 978 1 85946 489 2<sup>(7)</sup>

This covers fire safety for buildings other than dwelling houses and reference should be made to Section 4 “Design for vertical escape – buildings other than flats”.

- Approved Document K 2013 Edition, ISBN: 978 1 85946 484 7<sup>(8)</sup>

This covers protection from falling, collision and impact. Reference should be made to:

- Section 1: Stairs and ladders
- Section 2: Ramps
- Section 3: Protection from falling
- Section 4: Vehicle barriers and loading bays

These Approved Documents only apply in England and excepted energy buildings in Wales.

#### **2.1.5 The Building &c.(Amendment) (Wales) Regulations 2013<sup>(9)</sup>**

These regulations amend the Building Regulations 2010 (see Section 2.1.4) where the Building Regulations apply in Wales, meeting the applicable requirements of the Approved Documents should normally ensure compliance with the regulations. The Approved Documents relevant to this publication are:

- Approved Document B Volume 2 2006 edition, incorporating 2007 and 2010 amendments, ISBN: 978 1 85946 262 1<sup>(10)</sup>
- Approved Document K 1998 edition, incorporating 2000 and 2010 amendments, ISBN: 978 1 85946 210 2<sup>(11)</sup>

### **2.1.6 The Building (Scotland) Regulations 2004<sup>(12)</sup>**

Where the Building Regulations apply in Scotland, meeting the applicable requirements of the Technical Handbooks should normally ensure compliance with the regulations. The Technical Handbooks relevant to this publication are:

- Technical Handbooks 2013 Non-Domestic<sup>(13)</sup>
  - o Section 2: Fire
  - o Section 4: Safety

### **2.1.7 The Building Regulations (Northern Ireland) 2012<sup>(14)</sup>**

Where the Building Regulations apply in Northern Ireland, meeting the applicable requirements of the Technical Booklets should normally ensure compliance with the regulations. The Technical Booklets relevant to this publication are:

- Technical Booklet E October 2012 Fire Safety<sup>(15)</sup>
  - o Section 2: Means of escape
- Technical Booklet H October 2012 Stairs, ramps, guarding and protection from impact<sup>(16)</sup>
  - o Section 2: Access routes to buildings
  - o Section 3: Stairs
  - o Section 4: Ramps in buildings
  - o Section 5: Guarding
  - o Section 6: Vehicle loading bays
- Technical Booklet R October 2012 Access to and use of buildings<sup>(17)</sup>
  - o Section 4: Access within buildings other than dwellings

### **2.1.8 The Regulatory Reform (Fire Safety) Order 2005<sup>(18)</sup>**

Regulation 14 clauses (1) and (2) stipulate requirements with regard to “Emergency routes and exits”.

### **2.1.9 The Fire Safety (Scotland) Regulations 2006<sup>(19)</sup>**

Regulation 13 clauses (1) and (2) stipulate requirements with regard to “Means of escape”.

### **2.1.10 The Fire Safety Regulations (Northern Ireland) 2010<sup>(20)</sup>**

Regulation 13 clauses (1) and (2) stipulate requirements with regard to “Means of escape”.

## **2.2 Standards and codes**

Eurocodes in many parts cover load actions and design data for structures including access structures:

- BS EN 1090-2:2008+A1:2011: Execution of steel structures and aluminium structures. Technical requirements for steel structures<sup>(21)</sup>.
- BS EN 10255:2004: Non-alloy steel tubes suitable for welding or threading<sup>(22)</sup>.

- BS 4211:2005+A1:2008: Specification for permanently fixed ladders<sup>(23)</sup> (Applies to fixed ladders outside the scope of BS EN ISO 14122+A1:2010).

Note that Figure 1 and clause 5.7.1 of this standard allow a single ladder up to ten metres in height. This could potentially contravene The Work at Height Regulations 2005, which state in Schedule 6 item 9: "Where a ladder or run of ladders rises a vertical distance of 9m or more above its base, there shall, where reasonably practicable, be provided at suitable intervals sufficient safe landing areas or rest platforms".

- BS EN 10210:2006: Hot finished structural hollow sections of non-alloy and fine grain steels (two parts)<sup>(24)</sup>.
- BS 4592-0:2006+A1:2012: Flooring, stair treads and handrails for industrial use. Common design requirements and recommendations for installation<sup>(25)</sup>.
- BS 4592-1:2006: Industrial type flooring and stair treads-Part1: Metal open bar gratings-Specification<sup>(26)</sup>.
- BS 4592-2:2006: Industrial type flooring and stair treads-Part2: Expanded metal grating-Specification<sup>(27)</sup>.
- BS 4592-3:2006: Industrial type flooring and stair treads-Part3: Cold formed metal planks-Specification<sup>(28)</sup>.
- BS 4592-4:2006: Industrial type flooring and stair treads-Part4: Glass reinforced plastic (GRP) open bar gratings-Specification<sup>(29)</sup>.
- BS 4592-5:2006: Industrial type flooring and stair treads-Part5: Solid plates in metal and glass reinforced plastic (GRP)-Specification<sup>(30)</sup>.
- BS 4592-6:2006: Industrial type flooring and stair treads-Part6: Glass reinforced plastics (GRP) moulded open mesh gratings and protective barriers-Specification<sup>(31)</sup>.
- BS EN ISO 14122-1:2001+A1:2010: Safety of machinery-Permanent means of access to machinery-Part 1: Choice of a fixed means of access between two levels<sup>(32)</sup>.
- BS EN ISO 14122-2:2001+A1:2010: Safety of machinery-Permanent means of access to machinery-Part 2: Working platforms and walkways<sup>(33)</sup>.
- BS EN ISO 14122-3:2001+A1:2010: Safety of machinery-Permanent means of access to machinery-Part 3: Stairways, stepladders and guard rails<sup>(34)</sup>.
- BS EN ISO 14122-4:2001+A1:2010: Safety of machinery-Permanent means of access to machinery-Part 4: Fixed ladders<sup>(35)</sup>.
- BS 5578-2:1978, ISO 3881:1977: Building construction - stairs. Modular co-ordination: specification for co-ordinating dimensions for stairs and stair openings<sup>(36)</sup>.
- BS 9999:2008: Code of practice for fire safety in the design, management and use of buildings<sup>(37)</sup>.

- BS 6150:2006: Painting of buildings. Code of Practice<sup>(38)</sup>.
- BS 6180:2011: Barriers in and about buildings. Code of Practice<sup>(39)</sup>.
- BS EN 10296-2:2005: Welded circular steel tubes for mechanical and general engineering purposes. Technical delivery conditions. Stainless steel<sup>(40)</sup>.
- BS 5395-1:2010: Stairs, ladders and walkways. Code of practice for the design of stairs with straight flights and winders<sup>(41)</sup>.
- BS 5395-2:1984: Stairs, ladders and walkways. Code of practice for the design of helical and spiral stairs<sup>(42)</sup>.
- BS 5395-3:1985: Stairs, ladders and walkways. Code of practice for the design of industrial type stairs, permanent ladders and walkways (Partially replaced by BS EN ISO 14122 parts 1 to 4:2001+A1:2010 and BS 4592-0:2006+A1:2012)<sup>(43)</sup>.
- BS EN 353:2002: Personal protective equipment against falls from a height (two parts)<sup>(44)</sup>.

Building Regulations control the construction of buildings including access stairways. Items of process plant or equipment may be erected within or external to a building. They do not constitute a building and therefore are not subject to the Building Regulations. The British Standards listed have been developed, in order to ensure that the means provided to gain access to such equipment are safe.

Wherever possible, the standards transpose the requirements of the Building Regulations to factory stairways, ladders and handrails, but there are instances where this cannot be achieved. In particular, the three categories given in the Building Regulations of 'Private', 'Other' and 'Institutional/Assembly' have no equivalence to the usual factory requirements. There are factory requirements for a stair equating to the steeper part of the 'Private' category for relatively infrequent use. Therefore, for some applications, both BSI and EEMUA acknowledge and approve the use of stairs, at a pitch greater than 38°, but not exceeding 42°.



### 3 Hazards associated with access installations

A suitable and sufficient risk assessment of access installations should be made and any hazards eliminated if reasonably practicable; or the risk reduced to as low as reasonably practicable (ALARP). Before any measures are considered to reduce the risk, the possibility of eliminating the hazard by removing the need for access should be explored. Possibilities include: repositioning plant, provision of remote actuation, and fitting remote indications. Some of these measures could be implemented on existing installations, if reasonably practicable.

The risk assessment should take into account all foreseeable hazards including:

- Falling;
- Tripping/slipping;
- Entrapment in case of fire;
- Hazards arising from proximity to plant;
- Exhaustion;
- Objects falling onto personnel below.

#### 3.1 Falling

Factors to be considered include:

- Access and egress from a ladder/stairway to working platforms;
- Ladders providing access to a higher level from an elevated platform;
- Potential distance to fall, e.g. long uninterrupted flights of stairs or long runs of ladders;
- Structural integrity;
- Degradation over time;
- Profile of personnel expected to use access;
- Requirement for tools/equipment to be carried;
- Safety gate operation.

The risk of falls from height can be minimised by good design and adequate through life maintenance. Proposed installations should be thoroughly examined, at the design stage, for weaknesses in the safety envelope. Some critical areas are discussed below.

Access systems must have adequate structural integrity to safely support all loads imposed during the life of the plant. Loadings should be calculated using the relevant clauses of National Annexe to BS EN 1991-1-1:2002 UK<sup>(45)</sup> and National Annexe to BS EN 1991-1-4:2005 +A1:2010<sup>(46)</sup> and any known specific loads to be supported, e.g. spare or removed equipment.

Where corrosive environments are anticipated in service it is usual to allow for metal loss by either reducing the allowable stresses or increasing the loading by a suitable factor. It is also common to specify a minimum section thickness. This is particularly necessary where the corrosion protection is provided by a non-durable finish, such as paint, which may not be well maintained. Where a hot dip galvanised finish is used, these allowances should not be necessary.

Any corrosion protection/corrosion allowance should be adequate for the projected life of the plant plus 50%, in order to allow for extended operation.

Access and egress from a stairway to a working platform should preferably turn through 90 degrees and be by a level platform. This reduces the risk of personnel walking straight off the platform and tumbling down the stairway. Access and egress from a ladder to a working platform should preferably be by side stepping onto the working platform. This enables much easier access and egress while operating the safety gate.

Ladders providing access to a higher level, from an elevated platform can give rise to an increased risk of falling outside the guard rail envelope, to a lower level. Where this hazard exists, the guard rails should be increased in number and height, or the safety cage should be extended to platform level on the side that the hazard exists.

Long uninterrupted flights of stairs or long runs of ladders should be avoided. Stairways should be made up of short flights, preferably not more than 16 risers, with 180° landings. Long runs of ladders should be made up of equal runs, not exceeding 6 m between rest platforms. The runs should be staggered to reduce the potential fall distance.

The profile of personnel, any requirement for bulky clothing to be worn, and tools/equipment to be carried should be considered when deciding on dimensions and slope angles.

Safety gates should be easily operated and reliably self-closing, by use of rising hinges or springs.

### **3.2 Tripping /slipping**

The working surface of access platforms should be level and non-slip. Any change in level necessary should either be at least two steps; or in the case of a small change in level, a shallow ramp can be used. If it is necessary to use a single step, then handrails and a safety gate should be used to allow transit from one level to another. The change in level should be highlighted using a coloured nosing bar, or similar, and suitable warning signs should be installed at the access point.

In non-fire hazardous areas, open mesh flooring should be used in preference to raised pattern solid flooring because it prevents pooling of liquids such as oil or water, provides a superior non-slip surface, and is less prone to corrosion.

In fire hazardous areas, use of raised pattern solid flooring may need to be considered, in conjunction with solid side protection, because it can provide short term fire and flame protection, allowing people to escape.

### **3.3 Entrapment in case of fire**

Factors to be considered should include:

- Frequency of use of the installation;
- Duration of use of the installation;
- Type of activity to be carried out, e.g. hot work;
- Provision of alternative means of egress;
- Likelihood of a fire during the use of the installation;
- Potential for rescue in the event of entrapment.

Access and working platforms should be designed so that they can be readily evacuated in the event of a fire. Particular features to avoid are long vertical travels, with no other means of egress than retracing the access path, and long horizontal travels to dead ends.

### **3.4 Hazards arising from proximity to plant**

Factors to be considered include:

- Hot surfaces;
- Steam, hot liquids or gases, e.g. relief valve vents;
- Moving parts, e.g. cranes, hoists, actuators;
- Exposed electrical conductors;
- Noise.

Hazards presented by the proximity of personnel to plant need to be identified and adequately addressed. This could include design features of the access or the adjacent plant, e.g. maintaining adequate safety distances, lagging of hot surfaces.

The option of restricting use to prevent access at times when it would not be safe should be avoided, unless there is no alternative. If this is necessary, the system to restrict access should be robust, e.g. the use of interlock keys to isolate a crane's power supply, before a physical barrier to the crane rail access ladder can be opened. If permanent access is not required, the preferred solution would be to provide temporary access once the plant is safe.

### **3.5 Exhaustion**

Factors to be considered include:

- Length and angle of inclination of ladder runs and stairways;
- Provision of rest platforms;
- Profile of the personnel expected to use access;
- Requirement for tools/equipment to be carried;
- Requirement to wear PPE, e.g. respirator, heat resistant suit;
- Anticipated environmental conditions.

The length and angle of inclination of ladder runs and stairways together with the provision of rest platforms should be chosen to ensure that they will not give rise to undue exhaustion of personnel using them. Recommended risers and goings should be adhered to wherever practicable.

### **3.6 Objects falling onto personnel below**

Adequate safeguards should be provided to ensure that objects cannot slide off the working surface onto personnel below. Any equipment being used in a way where it could slip over or through the handrails, or through openings in the platform, should be adequately restrained.

Adequate edge protection should be provided to ensure that objects cannot slide off the working surface onto personnel below. All permanent openings, e.g. where piping, or other plant, passes through, should have as small a gap as is practicable to allow for any differential movement and a toe board fitted around the opening. Where there is a significant risk of tools or other objects slipping

between the handrails, consideration should be given to in-filling the rails with a suitable mesh or similar material.

## 4 Access design

Where new installations are being designed or modifications to existing installations carried out, permanently installed access should be designed in accordance with relevant current standards wherever possible. Some relevant British Standards are included in Section 2.2. In all cases suitable lighting systems should be provided, where necessary, as part of the installation.

The requirements of the Construction (Design and Management) Regulations 2007 must be complied with where applicable.

Plant layouts resulting in the need for the removal of floor panels or handrails, for foreseeable maintenance activities, should be avoided wherever possible. Where this is not practicable, the following points should be taken into consideration to make the activity easier and safer:

- The removable panels should be sized to provide the minimum opening necessary for the safe execution of the maintenance activity;
- Handling and temporary storage of the panels should be considered;
- The fixings should allow easy removal and re-instatement of the panels, e.g. by using captive nuts, or drilling and tapping support flanges where they are thick enough;
- Any hinged hatches should be lockable and kept locked, when not in use.

### 4.1 Decision making between permanent and temporary access

Deciding whether a plant item should have permanent access installed depends on several factors, including:

- The required frequency of access;
- The suitability of installing permanent access to the plant;
- An evaluation of permanent versus temporary access.

These issues are discussed in more detail below.

#### 4.1.1 The required frequency of access

The required frequency of access is a major factor in determining whether permanent access is required and what type of installation is acceptable. Very frequent access for operational reasons requires easy-to-use permanent access, using stairways sloping a maximum angle of 38°, wherever possible. Less frequent access could be served by a stairway up to the maximum angle of 42°, or a sloping or vertical ladder, where installing a stairway is not practicable. Where it is envisaged that plant items will only need very infrequent access, this may be achieved using temporary access methods, e.g. temporary scaffolding, other temporary structures, or Mobile Elevating Working Platforms (MEWPs). There will be cases between these extremes where the decision on whether or not to fit permanent access should be based on a careful analysis.

#### 4.1.2 Suitability for permanent access installation

Some areas of the plant may not be suitable for permanently installed access.

These include:

- Areas where the access to an item of plant would impede access to other plant or walkways;
- Access needing modification at different stages of the task;
- Access which is unsafe to use during some phases of operation.

Temporary scaffolding (or other temporary structures) is often employed in these cases; and for light work a Mobile Elevating Working Platform (MEWP) can be used.

#### **4.1.3 Evaluation of permanent versus temporary access**

Where it is not clear from the above whether permanent or temporary access should be used, the factors below should be considered, provided that the use of permanent or temporary access offers similar, acceptable, levels of safety:

- Estimated cost for installation, and through life maintenance of a permanent installation;
- Estimated cost for provision of scaffolding, multiplied by the anticipated number of occasions it will be required;
- A factor, if necessary, to compensate for the capital and revenue aspects of the two costs.

## **4.2 Basic design**

Basic factors for design purposes are given in each chapter of this Publication but the general proportions and pitch (slope) for each type of access are shown in Figure 1 and Figure 2.

An ideal staircase for general factory use has the following dimensions

- Rise: 165 mm
- Going: 275 mm
- Pitch: 31°

An easier stair, when this is considered necessary for the use of the general public:

- Rise: 150 mm
- Going: 300 mm
- Pitch: 27°

Stairs to either of these dimensions will satisfy the Building Regulations and are the optimum dimensions given in BS 5395 for semi-public and public stairs, respectively. They will also meet BS EN ISO 14122:2001, which deals with access to machinery. They will be satisfactory for fire escapes and general factory use.

A pitch of 38° is recommended as the maximum for general use. Where space is at a premium and the stairs will only be used occasionally, such as access stairs used for maintenance purposes by persons knowing the building layout, these will be comparable to the Building Regulations 'Private' category. In such cases, steeper stairs are possible, having a pitch of up to 42°. Above this, pitch stairs are considered too steep for the average person to descend safely, while facing forwards.

A minimum pitch for straight stairs in factories should be 30°.

An important consideration when designing staircases and ladders for factory use is that safety of descent is more important than ease of ascent. Any stair which is safe for a person to descend will be sufficiently easy for the same person to ascend.

Where there is insufficient room for a staircase, a companion-way ladder with handrail can be provided (to be descended backwards) with a pitch from 65° to 75°. From 75° upwards it becomes a ladder and a separate raised handrail is not required. Single rungs are acceptable in place of treads. A sloping ladder will be easier to use than a vertical ladder. The latter should be provided only when very occasional access is required and it is necessary due to space constraints.

When assessing the type of access or means of escape to be provided the designer should take into account all the factors listed in Table 1. The design characteristics should be uniform in any given installation.

Materials should be selected in accordance with Table 2 and the appropriate British or European Standard or Code of Practice. Where dissimilar materials are used in contact, they should be selected to minimise galvanic action (which may lead to corrosion), or differential movement. For further guidance on protection against corrosion see relevant standards on corrosion protection, e.g. BS 6150:2006, BS EN ISO 14713:2009<sup>(47)</sup>.

**Table 1 Factors affecting choice of means of access or escape**

| Factors to be Considered            | Remarks                                                                                                                                                                       |
|-------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Height of building or storey height | Height governs the number of flights, rise, clearance and headroom.                                                                                                           |
| Plan area                           | Plan area governs going and clear width. Helical and spiral stairs are not recommended for industrial use.                                                                    |
| Convenience of use and safety       | Straight stairs give maximum convenience of use. Where loads are being carried regularly, stairs should be used rather than ladders.                                          |
| Number of people                    | The number of people using the stairs governs their size and loading.                                                                                                         |
| Frequency of use                    | Ladders should only be installed where occasional or infrequent access is required. A companion-way ladder should be used in place of a fixed ladder on rises of 3 m or less. |
| Extent of supervision and control   | Consider congestion at work break times.                                                                                                                                      |
| Disabled access                     | See BS 8300: 2009 + A1:2010 <sup>(48)</sup>                                                                                                                                   |
| Fire                                | See BS 9999:2008                                                                                                                                                              |

**Table 2 Structural materials**

| <b>Material</b>                         | <b>British Standards</b><br>Codes of practice Specifications             |                                                                                                         | <b>Other recommendations / Notes</b>                                                                                                                                |
|-----------------------------------------|--------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| In situ & precast concrete              | NA to BS EN 1992-1-1:2004 <sup>(49)</sup>                                |                                                                                                         |                                                                                                                                                                     |
| Aluminium                               | NA to BS EN 1999-1-Parts 1 to 4 <sup>(50)</sup> & CP 118 <sup>(51)</sup> |                                                                                                         | See fire safety recommendations in BS EN ISO 14122 Part 2: 2001+A1:2010.<br>Note CP 118 replaced by BS 8118:2006 Parts 1 & 2 but remains current, superseded status |
| Cast iron                               |                                                                          | BS EN 1561:2011 <sup>(52)</sup>                                                                         |                                                                                                                                                                     |
| Copper alloys                           |                                                                          | BS EN 1172:2011 <sup>(53)</sup><br>BS EN 12165:2011 <sup>(54)</sup><br>BS EN 12163:2011 <sup>(55)</sup> | Aluminium bronze (grades CA101 to 106 inclusive) or phosphor bronze (grades PB101 to 104 inclusive) should be used.                                                 |
| Steel including stainless steel         | Eurocode 3. BS EN 1993 - relevant parts + UK NA <sup>(56)</sup>          | BS 7668:2004 <sup>(57)</sup><br>BS 4-1:2005 <sup>(58)</sup>                                             | See fire safety recommendations in BS EN ISO 14122 Part 1: 2001+A1:2010.<br>For stainless steel external stairs, only austenitic grades should be used.             |
| GRP (FRP)                               | BS 4592:2006 Parts 4 & 5 and BS 4592:2008 Part 6                         |                                                                                                         | GRP material should be chosen to provide adequate strength and resistance to ageing (e.g. UV embrittlement) for any particular application                          |
| Plastics materials and laminated sheets |                                                                          |                                                                                                         | Plastic material should be chosen to provide adequate strength and resistance to ageing (e.g. UV embrittlement) for any particular application                      |
| Timber                                  | Eurocode 5. BS EN 1995-1-relevant parts + UK NA <sup>(59)</sup>          |                                                                                                         |                                                                                                                                                                     |

### 4.3 Design method for factory stairs

Practical experience suggests that a good stairway correlates the rise (R) and going (G) with the stride of a typical user, which lies between 550 mm and 700 mm. Thus if shallower steps are used a greater going is required, and the converse is true. A typical figure for rise multiplied by going is 50000.

The Building Regulations 2010 (England and Wales) Approved Documents K use the formula:  $(2R + G)$  to be between 550 and 700.

If the floor to floor height in metres is H, then for a typical rise of 200 mm (with five steps per metre):

The number of rises, 'N', will be the next whole number above  $5 \times H$

The actual rise, 'R' in mm, will be floor height in mm (1000 H) divided by 'N'

The total going, 'G', in mm, is  $\frac{50000}{R}$  (with a minimum of 250 mm)

The total going of the stairs is (N-1) G

The tangent of the angle of pitch (slope) 'S' is  $\frac{R}{G}$

The design should be checked; one more rise for easier stairs and one less for steeper stairs.

Example:

$$H = 1.7 \text{ m}$$

$$N = 9$$

$$R = 189 \text{ mm}$$

$$G = 265 \text{ mm}$$

$$S = 35^\circ 30'$$

Note: The foot placement should not be less than 260 mm in order to meet the needs of heavier boots/shoes worn in industry. This should exclude any radius on the front edge of a tread.

Checking for one less rise,

$$N = 8$$

$$R = 212 \text{ mm}$$

$$G = \frac{50000}{R} = 236 \text{ mm}$$

236 mm is less than the minimum specified.

Using the minimum specified going of 250 mm will give an angle of  $40^\circ 30'$ . This would be suitable for occasional access stairs but is too steep for general purpose stairs where the maximum angle is  $38^\circ$ . This stairway would also fail to meet the Building Regulations 2010 for stairs, where the rise R should not exceed 190 mm.

#### 4.4 Steel stairs

While it is usual and in many cases convenient to design staircases associated with factory plant and installations in steelwork, the general considerations of design given in this Publication are equally relevant to other materials and these can have advantages in certain circumstances.

Definitions of some common terms are given in Appendix B.

#### 4.5 Concrete stairs

Concrete has a much higher fire resistance than steel, which can collapse at relatively low fire temperatures. Concrete stairs, as detailed in Figure 3, are more permanent, require less maintenance, afford more grip and (with higher fire resistance and a tendency to use closed risers) can be generally safer than steel stairs. Steel stairs, which tend to be pre-fabricated and easier to install, are more appropriate for access to plant in industrial complexes, e.g. petrochemical

and power station installations. For installations within buildings, concrete stairs are to be preferred. Reinforced concrete can be cast *in situ* or pre-cast, or be a combination of the two. Cast *in situ* stairs normally span lengthwise from floor to floor, or from floor to landing. For practical and economic reasons, *in situ* stairs are always constructed in two operations; the basic structure is cast on rough form work and finished off later by a screeding process to final, more exact, contours. A better finish is then obtained to more uniform dimensions, with pre-cast treads having any desired finish. The easiest way to form a concrete stair is to build pre-cast treads into supporting walls at both sides, but if this is not convenient or if an open effect is desired, pre-cast treads can be laid on a cast *in situ* carriage of rough steps spanning up the stairs.

Plain concrete finishes are not particularly attractive and though various worked surfaces leading to a full marble or terrazzo finish are possible, they are expensive and not practical for stairs. A much cheaper solution for office or works stairs is to form a simple concrete stair, fit an aluminium nosing with a non-slip insert, and surface the treads and risers with thermoplastic or vinyl tiles. The resulting staircase is practical, clean and attractive.

Appendix A gives data on a number of common surface finishes that may be applied to stairs and landings. The low slip resistance of clay tiles and terrazzo when wet is particularly important.

#### 4.6 Timber stairs

Timber stairs are not normally recommended for use in factories. However, where timber stairs are permitted, a stair with hardwood treads could have advantages over steel stairs in some circumstances.

The Building Regulations 2010 require that stairways (including landings) should be constructed of materials of limited combustibility if they are:

- Within a storey which comprises elements of structure for which the fire resistance should be one hour or more. This rule does not apply for any stairway in a building or compartment occupied as a shop, if the stairway is not within a protected shaft, or;
- External and connecting the ground floor with a floor or a flat roof at a height of not more than 6m above the surrounding ground.

It is permissible to apply combustible surface coverings to the upper surface of timber stairways and landings.

#### 4.7 Stairways subject to differential movement

Some stairways are a special case because they experience significant changes in level, e.g. access to large water tube boiler fronts and access between adjacent vessels subject to thermal expansion. These stairways usually have a pivot at the top with a sliding foot. The pivot should be designed to give a large factor of safety and the sliding foot should be fitted with a secondary support, usually in the form of chains. The chains should be arranged such that they are not loaded under normal conditions, but would prevent undue rotation in the event of failure of the primary support.

## 4.8 Loading

### 4.8.1 Loading for stairs, platforms and walkways

Dead and imposed loadings for stairs, platforms and walkways should be derived from the UK National Annex to BS EN 1991-1-1:2002 – “General actions, densities, self-weight, imposed loads for buildings” using Table NA2 to determine the category and Table NA3 for the loading. If the structure is exposed to wind action, loadings should be derived using the UK National Annex to BS EN 1991-1-4:2005 +A1:2010 – “General actions – Wind actions”.

In addition, any known, or foreseeable, loading in excess of the derived loading must be catered for, e.g. heavy tools or machinery being transported or used.

It should be noted that the current Building Regulations 2010 Approved Document A<sup>(60)</sup> references superseded standards but carries the note:

“The British Standards Institution will shortly be publishing a series of Structural Eurocodes together with their National Annexes. These Eurocodes are CEN Standards comprising many parts, which when used in conjunction with their National Annexes and when approved by the Secretary of State, are intended to be referenced in this Approved Document as practical guidance on meeting the Part A Requirements.”

BS 5395 has been partially replaced by BS EN ISO 14122:2001+A1:2010, which refers specifically to platforms and walkways for access to machinery. In such cases the minimum operating loads should be:

- 2 kN/m<sup>2</sup> under distributed load;
- 1.5 kN concentrated load applied in the most unfavourable position over a concentrated area of 200 x 200 mm;
- The deflection of the flooring shall not exceed 1/200 of the span and the difference between the loaded and a neighbouring unloaded flooring shall not exceed 4 mm in height.

### 4.8.2 Horizontal loads on parapets and handrails

Horizontal loading should be derived from the UK National Annex to BS EN 1991-1-1:2002 – “General actions, Densities, self-weight, imposed loads for buildings”, using Table NA.8.



## 5 Factory stairways

### 5.1 General

The design of a stairway should be governed by such factors as ease of access, frequency of use, as well as by a suitable proportion between rise and going. Space should be made available to meet these requirements during the layout of plant and buildings. All the rises in a stairway should be equal and all the treads should be horizontal. When possible, intermediate landing levels should be arranged so that all rises and goings in successive flights are equal. It is desirable that design characteristics should be uniform in any one building or structure. Typical steel stairway arrangements are shown in Figure 4 and Figure 5.

### 5.2 Clear width

The clear width of a stairway is the clear distance measured between the handrails. It should not be less than:

- 1000 mm for a main stairway used for regular two-way traffic;
- 600 mm but preferably 800 mm for stairways for occasional access to plant platforms. (See BS EN ISO 14122:2001+A1:2010 Part 3 Clause 6.7).

### 5.3 Pitch

In the interests of safety, the pitch (measured from the horizontal) should be kept to a minimum, but not less than 30°. The recommended stairway pitches are:

- 30° to 38° for main stairways used for regular two-way traffic;
- 30° to 42° for stairways used for occasional access to plant platforms.

The lower pitch is always preferable.

Pitches between 42° and 50° are not recommended.

Pitches between 50° and 65° should not be used under any circumstances, since they can prove dangerous to a user who may be uncertain whether to descend forwards or backwards. Neither should this critical range of pitch be used for companion-way ladders (see Clause 7.4).

### 5.4 Steps

The rise should not generally exceed 220 mm, or more than 190 mm when subject to the Building Regulations 2010.

The going, as measured on plan between the nosings of the treads, should not be less than 250 mm (see Figure 6 and Figure 7). In terms of maximum going: Approved Document K: 2013 states 400 mm for utility and general access stairs and 300 mm for private stairs. BS 5395-1:2010 states 450 mm for normal use stairs and 400 mm for private stairs.

Where the going is less than 260 mm, the tread should be extended beneath the nosing of the tread above by a distance not exceeding 30 mm. 260 mm is the

minimum recommended size of tread for foot placement when descending stairs (measured from the back of the heel to edge of nosing) and 30 mm is the maximum effective overhang (see Figure 6). Where an open riser design is employed, a minimum overhang of 16 mm is necessary for all treads.

Over many years, experience with industrial stairways has led to optimum values for 'R' and 'G' being developed. These are shown in the shaded area in Figure 2. It will be noted that these create a narrower band than in both the Building Regulations 2010 and BS EN ISO 14122:2001+A1:2010. However, it does not extend beyond the boundaries accepted as suitable by the foregoing.

The optimum combinations of rise (R) and going (G) will conform to the expression:  $R \times G = 48,000$  to  $55,000$ , where R and G are measured in mm.

The stairs will be dangerous to descend when this value is less than 48,000. They will also be tiring to ascend when it exceeds 55,000, although this is less important in small flights of three or four steps, which can well be larger than normal.

Where the optimum dimensions of rise and going given in Table 7 exceed a 42° pitch, and where they extend beyond the shaded area in Figure 2, their selection is not recommended.

Figure 2 shows the proportions of rise and going for the various ranges of slope. The formula quoted in the Building Regulations 2010 Approved Document K, ( $2R + G = 550$  mm minimum to 700 mm maximum) includes the proportions included in this Publication. It should be noted that where this combination of  $2R + G$  is less than about 620 mm the steps are too small for factory use. The simplified formula ( $R + G = 460$  mm to 470 mm) is more suited to factory stairways of between 30° and 40° pitch.

## 5.5 Treads

The selection of materials for treads depends on the quality of non-slip surface required and retention of the non-slip property during use. Treads for steel stairs may be of raised pattern plate (often referred to as chequer plate) or, preferably, of the open grid type to BS 4592 Part 1:2006 (see Figure 7 and Figure 8). Open type treads are unsuitable for persons wearing narrow heels, or for fire escapes. The recommended minimum thickness (as measured over plain) of raised pattern plate is 6 mm for internal stairways and 8 mm for external stairways. The bullnose type of chequer plate tread is not advised, as there is a tendency for the foot to slip off the nose.

Treads on open riser stairs should overlap by not less than 16 mm and have a nosing depth in the range 25 to 50 mm. This is to aid visibility.

Concrete stairs may become very slippery if there is oil or grease in the vicinity, or if there are waxed polished floors adjacent. A non-slip surface should be built in at the design stage. The minimum requirement is a liberal sprinkling of carborundum or similar powder in the surface. Various proprietary types of non-slip insert or nosing are the preferred choice for design. Appendix A gives details of surface finishes.

## 5.6 Risers

It is not a requirement to provide vertical risers to steel stairs or to some pre-cast concrete ones. Where there is no riser, it is necessary to extend the lower tread by a minimum of 16 mm at the back under the tread above to prevent the foot slipping "through the stairs" when ascending or turning. A solid riser is preferable as it stiffens the stairs and in the same manner as a toe-plate prevents small objects falling through.

## 5.7 Stringers

The stringers normally used are 180 x 75 mm parallel flanged channels (PFC), except in special cases when the size should be determined by structural requirements. Strings should be sufficiently robust to minimise lateral flexing of the structure and should not project more than 50 mm beyond the nosing of the bottom tread.

The 180 mm dimension has been found most convenient to suit nearly all combinations of treads and rises within the pitch recommended in Clause 5.3.

A common error to be avoided is the extension of the complete stringer to a landing used to change the direction of a flight of stairs or to the foot of a stairway. As indicated in Figure 9, this can cause a trip that may prove dangerous. Where stringers are cranked, the cranks may be either welded or fishplated.

All bolt heads or fastenings on the inside of stringers which can come into contact with the foot should have a countersunk finish.

It is good practice, in situations where corrosive liquids may be present, to support the bottom of the stringer on a concrete plinth. This safeguards the stringer fixing cleats from corrosion (see Figure 10). It is important that the bottom rise is similar to the others.

## 5.8 Landings

Landings should be used between flights and for change of direction; on no account should winders be used for industrial stairways (see Figure 4 and Figure 5). They should be designed in accordance with the recommendations for platforms and walkways given in Chapter 9. There should be a change of line or direction of not less than 30° after 32 risers.

No stairway should exceed 16 rises in any one flight. If more are necessary, a landing should be provided (see Clause 5.1). The length of such landings should not be less than the clear width of the stair, or 850 mm, whichever is the greater.

Landings at the head of a stair should be designed so that it is not possible to step from a platform or walkway on to the stair without a change of direction.

The material used for landings should be the same as for the treads (see Clause 5.5).

Landing and floor plates should be fastened to steel supports by means of M 12 (or ½ in) diameter countersunk bolts at 300 mm to 400 mm centres, or by other equivalent means.