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Accuracy and tolerance in design and construction — Guide

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Foreword

Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 28 February 2022. It was prepared by Technical Committee B/209, *General building codes*. A list of organizations represented on this committee can be obtained on request to the committee manager.

Supersession

This British Standard supersedes [BS 5606:1990](#), which is withdrawn.

Information about this document

To aid the development of a previous edition of this standard, BSI and the Department of Environment commissioned a survey of dimensional variability on projects where tolerances had been specified. The results of the survey were analysed by the Building Research Establishment and included in that edition of the standard. This data is retained in the current edition in the tables in [Annex C](#).

This is a full revision of the standard, and introduces the following principal changes.

- The examples of issues in [Section 2](#) have been updated.
- [Section 3](#) and [Section 4](#) have been updated to include technology and process changes.
- A clear distinction has been made for the use of accuracy and tolerance as independently definable and required characteristics.
- Clarifications and caveats have been added to the BRE industry performance assessment tables from the 1970s and 1980s (in [Annex C](#)), including the importance of not relying on these for an assessment of current practice, i.e. tables of industry performance in relation to manufacturer and assembly, and construction tolerances from the 1970s and 1980s have not been updated, but are retained for historical reference for empirical site/manufacturing performance in that period. The assumptions around dimensional variability in the industry current practice (on- or off-site) need to be assessed without reliance on the legacy tables included in this document for historical example and context.

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Use of this document

As a guide, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification or a code of practice.

It has been assumed in the preparation of this British Standard that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

Presentational conventions

The guidance in this standard is presented in roman (i.e. upright) type. Any recommendations are expressed in sentences in which the principal auxiliary verb is “should”.

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Where words have alternative spellings, the preferred spelling of the Shorter Oxford English Dictionary is used (e.g. “organization” rather than “organisation”).

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Section 1: General

1 Scope

This British Standard gives guidance on and provides examples of principles that relate to accuracy and tolerance in design and construction activity for the built environment. It is intended to be a practical guide to assist designers and constructors in determining and managing the risks associated with accuracy and tolerance and taking steps to control them appropriately, which, if unmanaged, can be very significant to cost, time and quality.

The fundamental objective is to provide awareness and advice on ways to avoid problems of inaccuracy or fit arising on-site. The need for such advice on any particular project varies, depending on the character of the project and the materials and methods of construction. This British Standard is designed to be relevant to all types of construction including the most sophisticated ones. Those concerned with an individual project can judge the extent to which each section is relevant to their needs.

This British Standard takes into account the growing importance of off-site construction [e.g. MMC (modern methods of construction)] and the changes in technology (e.g. digital measuring equipment) and processes [e.g. BIM (building information modelling)] since the last edition was issued. However, it also retains previous guidance where it provides essential insight and wisdom which might still be relevant today.

While this British Standard is not a guide to productivity in the construction industry, some of the impacts of accuracy and tolerance on productivity, which can be either potential improvements or lessons to be learnt, have been illustrated in [Section 2](#) by practical examples for user understanding. These are not exhaustive but are intended to highlight how these impacts can be significant, either positive or negative, and that this standard can be used as an important part of the quality planning, management and execution of design and build activity for the built environment (buildings and infrastructure).

This British Standard is designed to support the creation and implementation of a project strategy for accuracy and tolerance and provide practical implementation guidance throughout the life cycle and is supported and supports other important standards and processes. It is intended to be applied to buildings and infrastructure works in design and construction and aims to assist in the following:

- a) avoiding or resolving problems of inaccuracy or fit by assessing the dimensional needs of a design regarding tolerances, and then designing and specifying appropriately;
- b) assessing the likely achievement of tolerances in construction specified for a particular project, and giving guidance on strategies to verify capabilities and mitigate challenges;
- c) providing for monitoring and controlling work during construction to check that it is in accordance with specified dimensional tolerance and accuracy for surveys;
- d) aiding digital design and engineering (on- and off-site) including the application of BIM for the built environment; and
- e) understanding the importance of the accuracy of surveys undertaken pre, during and post construction works to measure existing features and as-built with the ability to support and verify the achievement of design tolerances and fit.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes provisions of this document¹⁾. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

[BS 6100-11](#), *Building and civil engineering – Vocabulary – Part 11: Performance characteristics, measurement and joints*

BS 6954-3, *Tolerances for building – Part 3: Recommendations for selecting target size and predicting fit*

BS 7334 (all parts), *Measuring instruments for building construction*

3 Terms and definitions

For the purposes of this British Standard, the terms and definitions given in [BS 6100-11](#) and the following apply.

3.1 building information modelling (BIM)

processes, technologies and skill sets required for the management of information through the whole life cycle of a built asset, from initial design all the way through to construction, operations and maintenance and finally de-commissioning

NOTE BIM is achieved through the definition of information requirements for the organization, asset and project and use of digital technologies for modelling, collaboration and coordination of information and data across multiple disciplines and organizations, which in turn supports quality assurance workflows to enable informed decision making and verify client requirements achievement at each key stage in a project life cycle.

3.2 characteristic accuracy

accuracy, expressed in terms of systematic deviation or standard deviation or both, found by measurement of a representative sample and assumed to be characteristic of the whole

3.3 dimensional control

process for controlling dimensional variability

NOTE Dimensional control includes the creation of datums, survey control, as-built surveys, setting out reference lines and grids and the calibration and checking of survey equipment.

3.4 dimensional variability

range of dimensional deviations from a target or reference size, relative position or location resulting from induced or inherent spatial deviations

3.5 induced spatial deviation

dimensional variability in size, relative position or location from a reference or target size due to a manufacturing, assembly or building process

3.6 inherent spatial deviation

dimensional variability in size, relative position or location from a reference or target size due to environmental and/or operational and loading effects on materials and assemblies

¹⁾ Documents that are referred to solely in an informative manner are listed in the Bibliography.

3.7 reference size

spatial dimension, size, relative position or location of something in a design, from which deviations are measured

3.8 spatial deviation

dimensional variability in size, relative position or location from a reference or target size

NOTE Spatial deviation is typically established by a survey measurement as the difference between the desired value and the actual value at a given time when the survey was undertaken. It is to be considered alongside the spatial measurement accuracy.

3.9 spatial measurement

dimensional values established by survey or setting out process

NOTE Spatial measurement is used to quantify an actual size, dimension, relative position or location.

3.10 spatial measurement accuracy

accuracy of a survey measurement used to quantify the possible difference between an actual dimension, size, relative position or location and the measurement value

NOTE Spatial measurement accuracy is typically expressed as a standard deviation value and confidence statistic having a positive or negative affect on the measurement (i.e. $\pm N$ mm Std dev or $\pm N$ mm with 68% confidence). See [Annex A](#) for guidance on survey measurement and setting out strategy, specification and risk/challenge management.

3.11 spatial tolerance

permissible dimensional variability from a target or reference size, relative position or location

NOTE 1 Spatial tolerance is typically expressed as a lower and upper limit deviation from the reference or target position.

NOTE 2 It is assumed that the permissible dimensional variability is designed within limits which mean the performance requirements of the design can be met in construction and operation.

3.12 target size

spatial dimension, size, relative position, or location of something in a design, from which deviations would ideally be zero

Section 2: Challenges with accuracy and tolerance associated with the fit of elements and components of construction

4 Challenges and examples

4.1 General

Dimensional variability in construction, whether operations are carried out on a construction site or in an off-site environment, can generate issues of performance and fit. Recognizing and addressing this before manufacture and/or construction is critical to minimize delays and expensive remedial measures when the desired objectives in terms of functionality, durability and appearance are not achieved. These performance impacts can be looked at from three perspectives:

- a) functionality: structural integrity is likely to be dependent on achieving certain design parameters, for example, fire stopping is dependent on both continuity and fit;
- b) durability (longevity): poorly fitting components might accelerate weathering damage such as corrosion by moisture ingress or compromise fire integrity by exposing fragile materials; and
- c) appearance: for example, where panel components that are clearly intended to align fail to do so or where a deficient fit creates unsightly staining.

Examples a) to c) are all important and can be cumulative and interdependent but expectations and relative importance can vary, with emphasis shifting depending on the assembly or building operation, the construction elements affected and the type of project. Accuracy and tolerance should be taken into account to balance this relative importance, including implications on adjacent elements, operations, or other matters such as unintended consequences.

Spatial design parameters and tolerance should be specified such that functionality, durability and appearance are achieved and achievable. For construction, dimensional control is required to verify that the specified parameters and tolerances have been met. In cases where tolerances are small on a particular project or in a particular element of construction, for example:

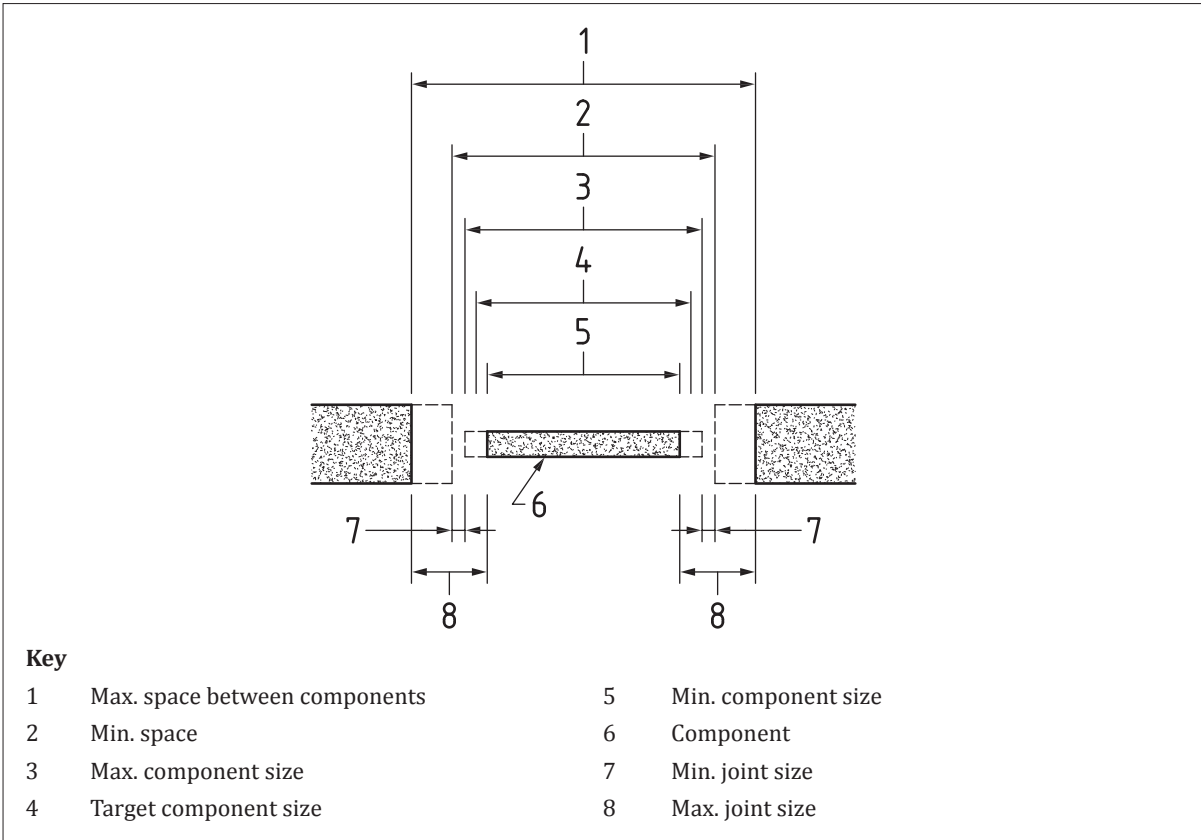
- the casting-in of critical fixings into concrete (functionality); or
- the flatness of a floor finish (longevity and appearance); or
- the gaps between wall tiles (appearance); or
- the misalignment of structural connections for sub-assemblies manufactured off-site, such as roof, floor or wall cassettes (appearance and functionality);

this should be made clear, documented and communicated.

Strategies for managing and mitigating these challenges are critical during the construction stage. For example, one strategy might be to remove as many constraints on fit as possible, perhaps by providing for adjustability of fixing so that fine adjustment of position can be made. Whatever the desired outcome, there should be a planned methodology from factory to site and consideration given to the costs and implications of trying to achieve the design parameters related to spatial fit and performance.

[Figure 1](#) illustrates the principles involved in considering the interaction of components in relation to tolerances and fit. The principle applies in all planes and in relation to location and is often expressed in terms of horizontal or vertical dimensions, shapes, sizes and spaces. Further examples of common issues are given in [Clause 6](#).

Figure 1 — *Example of dimensional variability aspects in construction of components, spaces and joints*



Accuracy reflects the certainty of dimensional control including surveying and setting out. The principle applies in all planes and in all axes in relation to location and spatial dimensions.

[Annex A](#) includes some examples of issues associated with these elements of a survey strategy and an example industry table of specifying survey accuracies for spatial measurements for surveying, setting out or verification of as-built tolerances independently of equipment or method used.

[Table C.3](#), which was provided to support the original BRE studies of construction accuracy in 1975–76 and 1985–88, is included in [Annex C](#) for information purposes only and should not be used as a specification or for current industry norms.

4.2 Strategies for the management of critical issues

The most straightforward way to reduce tolerance risks is to coordinate from a very early stage of a project to ensure that tolerances between related elements are compatible.

Tolerance information (e.g. tolerance values, dimensional and geometric properties of components, tolerance risks etc.) should be communicated between stakeholders with the aim of ensuring that components fit and function properly.

Tolerance risks can be mitigated with effective identification, planning, communication, collaboration, coordination and control.

4.3 Identification

Tolerance requirements should be captured at early project stages.

The class of tolerances applied to tolerance requirements should be selected with the aim of ensuring stability and serviceability.

Connections with a high risk of tolerance problems should be identified in the early project stages.

Tolerance risks with potentially negative effects on dimensional and geometric accuracy of components and assemblies and their functions should be proactively identified.

The severity of tolerance risk should be estimated using qualitative, quantitative or semi-quantitative approaches.

4.4 Planning

Solutions to mitigate tolerance risks, especially tolerance risks with high severity, should be generated based on factors such as site conditions, labour availability/skills, schedule constraints, incurred costs, manufacturability, etc.

Tolerance values should be collected from appropriate reference documents, manufacturers, designers and contractors.

Realistic tolerance values should be specified based on the capability and competence of manufacturing and construction teams to obtain a certain level of accuracy, consequences of tolerance risks, cost of manufacturing and construction.

Tolerance analysis should be performed, including scenarios with maximum and minimum ranges.

The impact of combined deviations on components and sub-assemblies should be evaluated (serviceability analysis).

The sequence of assembly process and its impact on the geometric accuracy of components and sub-assemblies should be determined.

The compatibility of the specified tolerances of adjoining components in sub-assemblies should be checked (tolerance coordination).

The measurement plan which includes information such as the accuracy of the survey process, the responsibility to verify deviations of components with the specified tolerances, and the list of specified tolerances should be prepared and communicated with parties.

4.5 Communication

Tolerance information (e.g. permitted deviations, used reference documents, prepared measurement plan) should be communicated clearly between designers and construction teams via specifications, drawings and other means, as appropriate, including digital data exchange.

4.6 Control

Deviations achieved on-site should be measured and their impact on the performance requirements should be assessed.

5 Digital technology considerations

5.1 General

With the application of BIM (building information modelling) processes, the importance of accurate survey information using an agreed project grid to coordinate design and construction, and the dimensional control for setting out and verification of as-built positions should be recognized and defined from the earliest stage of the project and throughout the life cycle to hand over and operation. This requirement should be included in the employer's information requirements or exchange information requirements (EIR) and the supplier's BIM execution plan (BEP), as well as in specifications and scope for surveying and setting out works and monitoring/assurance checks. Where BIM processes are not being formally applied, this information should be included in relevant appointment documentation, including the information standards, the information production methods and procedures as well as scopes of work.

The level of graphical and non-graphical detail required during different design development stages, from concept to detailed design, can impact spatial accuracy and tolerance management in design. Accordingly, a building designed within a 3D environment should allow for maturing of spatial tolerances as a design maturity grows.

Although the terminology is evolving, digital information creation for design and construction introduces requirements to specify the level of graphical information needed for a design at different stages of development. At the detailed design and construction handover stage this information can be at its highest and can start to include information for future operations and maintenance.

Where BIM processes are utilized on projects, the BEP should address how identification, planning, communication and control of tolerance risks can be achieved. BIM approaches can also be used to design out potential accuracy and fit issues prior to manufacture and test the tolerance management plans and setting out strategies within the context of the planned build sequence.

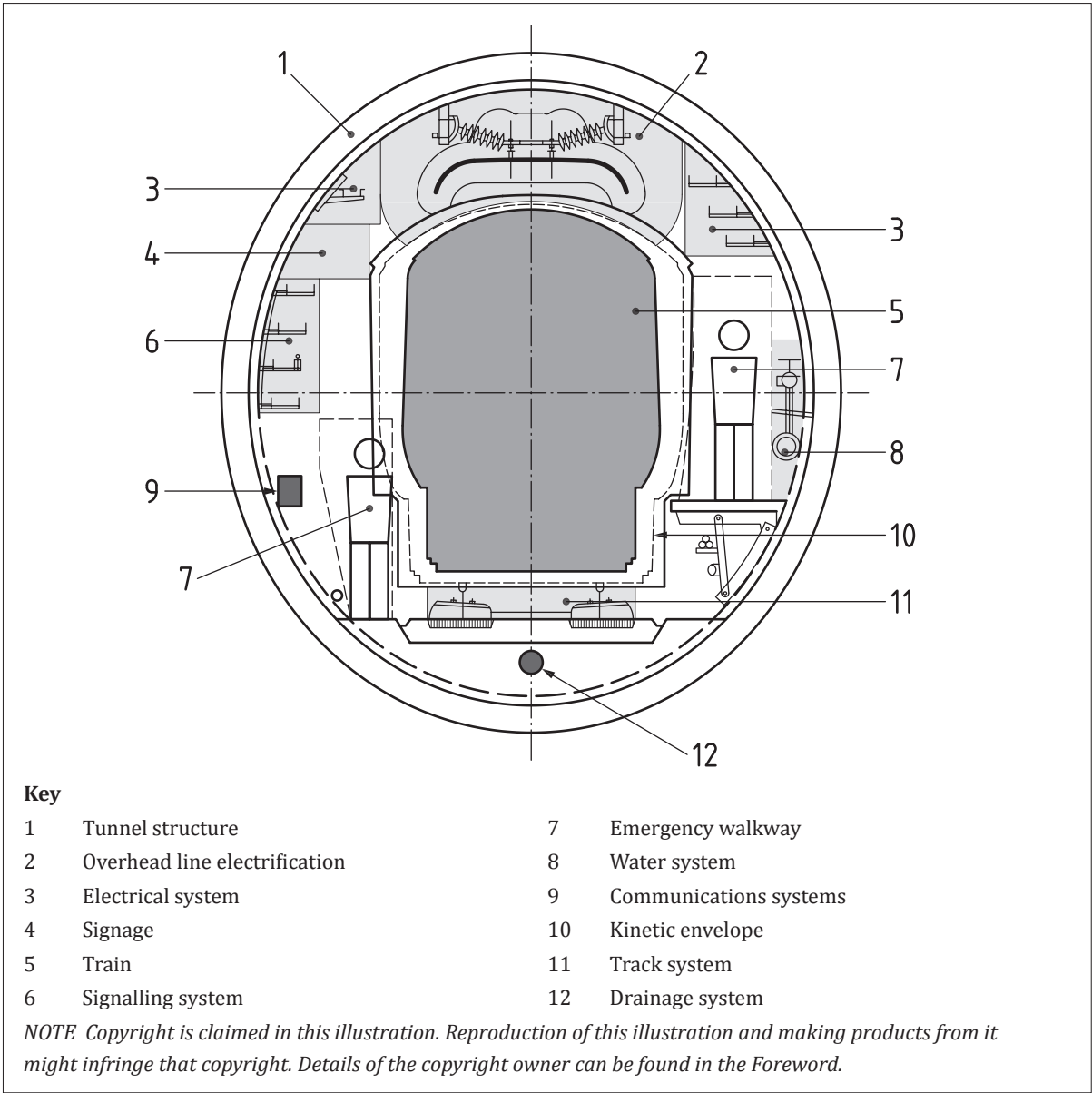
5.2 Examples

It is possible using BIM processes to combine the structural frame with the curtain wall design models to establish any spatial coordination issues during the design supported by software applications. In this example, maximum “out of tolerance” of the structure can be established to assist in the façade design, especially where the façade and structure are complex shapes where 3D modelling can, for instance, accurately position support brackets on the primary structure and eliminate design issues before fabrication commences.

Although the use of advanced measurement techniques in manufacture and on-site, e.g. laser scanning, and using precise methods of production, such as robotic assembly, can bring about improvements, dimensional and geometric variations can still be problematic due to the underlying issue of discrepancies between precise factory-made components and large site tolerances, as well as geometric effects due to building movement.

Design processes, methodologies, specialist software and relevant standards can enable project stakeholders to define exacting and precise design and construction tolerances. These can then be validated through clash avoidance/detection and co-ordination processes within software applications, as well as the application of a volume strategy which allocates spaces and buffer areas around disciplines or key elements of designs (i.e. structural frame, service zones). [Figure 2](#) shows an example of a volume strategy used in rail tunnel design.

Figure 2 — Volumes within a tunnel design for spatial co-ordination



6 Surveying and setting out

6.1 Site survey information

6.1.1 General

Given the complex and sometimes fragmented nature of construction supply chains and the number of disciplines, people’s competence measurement processes, tools and systems involved in the design and build process, it is not surprising that issues arising from dimensional control in surveying and setting out accuracy are common. Risks and issues need to be managed effectively, otherwise they can easily manifest into quality, performance and programme issues with adverse consequences.

One of the first criteria of any building or construction project is to assess the existing site information, spaces, features and potential constraints where the works are to be constructed. These constraints can include existing boundaries, buildings and other visible features, as well as less visible features such as underground services and geology, and invisible features such legal boundaries and planning constraints (e.g. land ownership, rights of way, wayleaves, right to light,

regulated distances, spaces or heights). Environmental constraints such as flood risk can be an important input to tolerance requirements for design and construction. Finally, the need to assimilate design into existing facilities or buildings for refurbishment, renovation or renewal creates an early demand for precise information to enable new design and construction spatial requirements to be integrated accurately.

Once the information is collated and combined spatially on a common project grid and coordinate system, the design and construction (including manufacturing) process can commence. The setting out and dimensional control for assembling components on- and off-site needs to be managed throughout the construction process to ensure the project runs as seamlessly as possible.

6.1.2 Examples

Previous editions of this British Standard included details of survey planning and specification, along with survey accuracies for certain types of equipment. Due to changes in technology and digital processing of surveys, it is now preferable to refer to professional body industry guidance on surveying techniques, grids and accuracies and generate a project survey strategy. The following list provides an outline of the principle types of challenges a survey strategy seeks to address.

- a) Lack of consistency in survey and setting out coordinates, grids and linear referencing (e.g. chainage).
- b) Inadequate accuracy in dimensional control for surveying and setting out (on- and off-site assembly).
- c) Poor specification of 3D survey requirements and digital representation of features (over and underground).
- d) Poor survey supplier or operative performance and assurance (on- and off-site assembly).
- e) Difficulties with undertaking surveys safely or accessing sites and facilities (site hazards and difficult environments).
- f) Lack of access or awareness to survey information available (including technology barriers, communication, distribution and notification issues).
- g) Lack of understanding or appreciation of survey information usefulness and risk (including lack of understanding of the accuracy, currency and completeness of information).

[Annex A](#) provides further information and guidance on the surveying issues and specifications.

6.2 Structural elements

6.2.1 General

Tolerance risks associated with dimensional and geometric tolerance variability (tolerance problems) in structural elements are often addressed on-site during the construction phase of projects using ad hoc strategies and trial-and-error methods. Failure to consider how the combination of geometric changes and tolerances in structural elements which manifest themselves during construction can considerably increase the cost of construction and maintenance, cause delays and increase material wastage if this is not taken into account during the design phase.

No geometrically sized or positioned components absolutely meet their specified size or position. The difference between the actual and nominal dimension is termed a geometric deviation.

Geometric deviations are a manufacturing and assembly issue and are determined by the accuracy with which individual elements in the overall structure are manufactured and how accurately they are brought together on- or off-site.

Geometric deviations include deviations relating to specific geometric size or position (e.g. floor thickness, length of beam, etc.) and deviations relating to specific geometric properties (e.g. flatness of concrete slabs).

Geometric changes in structural elements occur over time as a result of deflection, drying shrinkage, temperature effects, foundation movement, or other factors.

To design a structure that is fit for the use for which it is intended, and is compatible with the associated building fabric, the designer should take into account:

- a) the geometric changes associated with the structure, and individual structural elements, due to actions (e.g. forces applied to the structure), material properties and geometry; and
- b) the permitted geometric deviations for the structure, and individual structural elements, related to the manufacturing and construction of those elements.

Geometric changes should determine the difference between the initial and final position of any relevant points on structural elements, such as node points, and should take into account any free movements allowed by the structure, such as bolt slip in oversize holes of steel connections.

The designer should define limits for both the geometric changes (e.g. deflection limits) and the geometric deviations (e.g. geometric tolerances) in response to the intended function of the structure. Geometric deviations are different, and additive to, geometric changes.

Different limits for geometric changes (e.g. deflection limits) might be required to suit different building uses, or at interfaces between the structure and non-structural components (e.g. cladding, panelling units, pipework, lift well, stairwell).

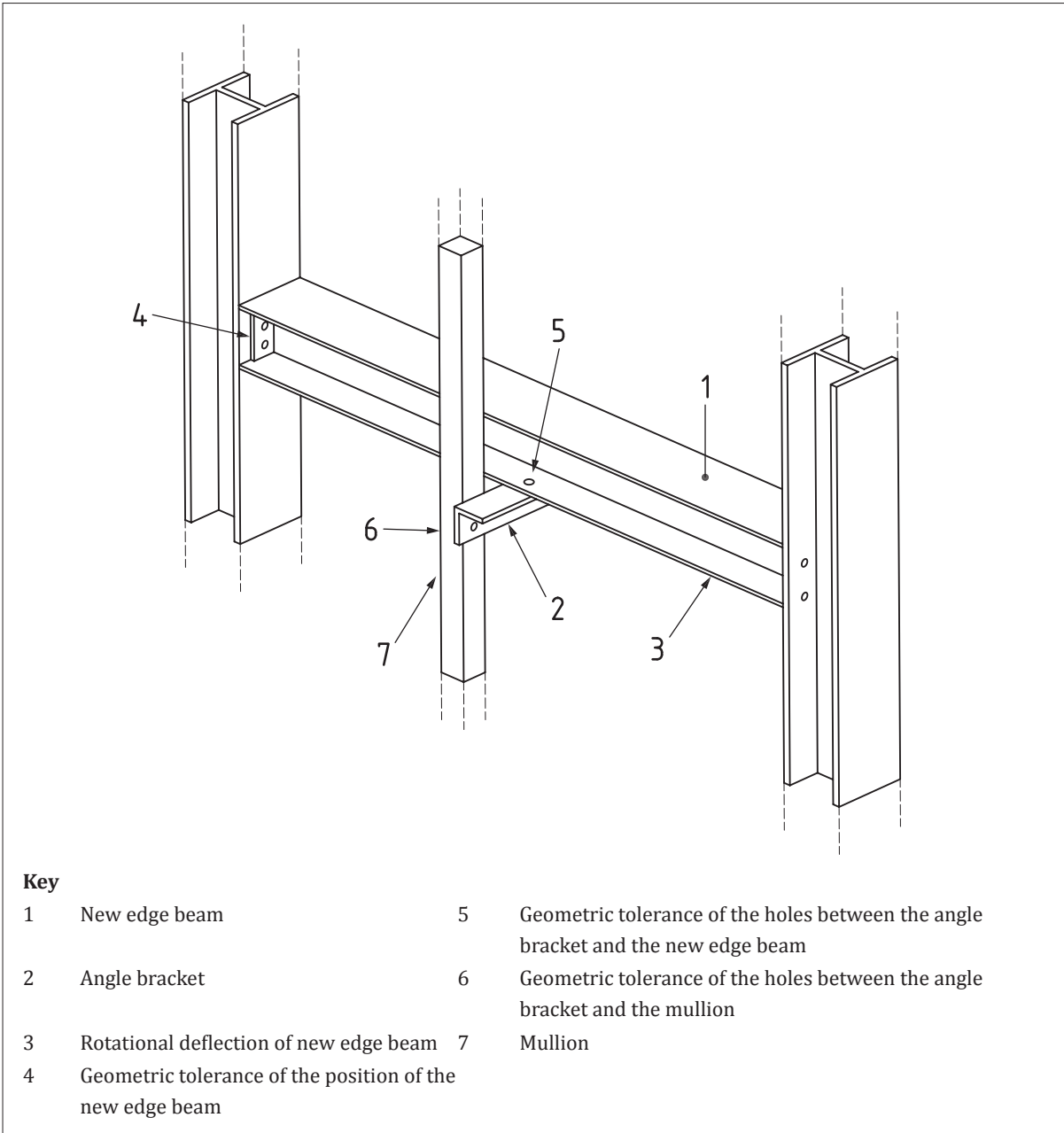
6.2.2 Examples and typical issues

[Figure 3](#) illustrates how the combination of geometric changes and geometric deviations should be taken into account by the designer to define appropriate limits compatible with the associated building fabric. The example in the figure relates to the design of a structural edge beam supporting a cladding mullion on a cantilevered angle bracket.

The final position of the mullion support(s) compared to its nominal position would need to take into account:

- a) the vertical deflection of the new edge beams from the applied loads (geometric change);
- b) the vertical deflection of the angle brackets due to applied load (geometric change);
- c) the rotational deflection of the new edge beams due to the eccentric nature of the loading on the edge beam (geometric change);
- d) the geometric tolerance of the position of the new edge beam (which might require consideration of the geometric tolerance of the supporting columns) (geometric deviation);
- e) the geometric tolerance of the holes between the angle brackets and the new edge beam (geometric deviation); and
- f) the geometric tolerance of the holes between the angle brackets and the mullions (geometric deviation).

Figure 3 — Example of interface tolerances between edge beam and cladding



6.3 Cladding and façades to external walls

6.3.1 General

The failure to take into account the tolerances and the potential out of vertical alignment of the primary structure, such as a steel frame, concrete frame and brick or blockwork backing wall, can result in either the unitized or stick system curtain walling system clashing and causing installation issues. The dead load and live load deflections should be taken into account in the design as this can cause issues such as buckling, slippage, misalignment and excessive movement of the façade causing joints to open or close and ultimately not allow the system to drain properly and keep the curtain wall water and airtight.

Non-load-bearing external walls should be isolated from movement of the supporting primary structure to eliminate the risk of inducing/transferring loads into them which they have not been designed to accommodate. Loads such as wind and thermal in the external wall should be able to

accommodate expansion and contraction against the structure, which can impact on accuracy and fit issues between joints and junction areas.

Cladding which presents unbroken planes needs special care. Brackets, fixings, supporting nibs and ties should allow not only for deviations in floor edges, beams and columns at one level but also deviations of adjacent slabs and columns and those across the whole façade as these affect local and overall accuracy of the wall.

Deviations to be taken into account should include those arising from transfer of reference marks vertically and horizontally, setting out the façade from the reference marks and alignment of floor edges and columns. The total effect should be assessed statistically.

With systemized wall construction, the components should be positioned to achieve the required overall length and required elevation relative to each floor. Deviations of elevation are greater where the wall is standing on the ground floor slab rather than hung from the primary structure at each storey. Penetrations through the wall arising from external features such as balconies, external structural members, external lift wells and ventilation openings have deviations (and tolerances) associated with them that should also be taken into account.

Support bracketry fixed into either cast insert in masonry or concrete or hole and plate provisions in primary steel should be designed to accommodate the potential “out of tolerance” structure. Holes in steelwork can be designed to be slotted, façade brackets can be designed to be adjustable in different orientations. It is critical to design to worst case “out of tolerance” of the primary structure and this normally can be established by fully understanding the movement and tolerances report of the primary structure including erection tolerances of steel and concrete frames. The *National structural steelwork specification* [1] and *National structural concrete specification* [2] are often referenced and used as a basis to develop a project-specific movement and tolerances report. On some projects there is the opportunity to survey the as-built structural or supporting frame before manufacture of the external wall; however, it is likely that modern curtain walls on new build projects have very long design and fabrication lead times and therefore have to be designed and procured well before the structure is built. This can lead to larger adjustable connection details which should be carefully designed such that the façade is installed in the design intent position. On more complex structures and façade interfaces, the primary structural tolerances might have to be tighter than the allowances normally permitted in the *National structural specifications* [1, 2] but this can sometimes incur additional costs to meet the desired architectural intent if not captured and addressed early in the design.

6.3.2 Two cladding scenarios to a primary steel structure

6.3.2.1 Scenario 1: Walls mounted outboard of the primary structure

For out-of-plane fit, fixings and brackets should be provided with a range of adjustability at least equal to the total range of expected deviation. If ultimately fixings and brackets have to be modified to enable construction to be executed, it is normally easier to design an extended bracket than to resolve a clash. It is good practice to design walls with a clearance between the wall and the primary structure to reduce the risk of the primary structure elements intruding into the cladding zone.

For in-plane fit, joints should be designed to allow adjustment in plane to achieve the required overall length to fit across adjacent floors and be tailored around penetrations. It should be anticipated that these joints might be required to permit movement and also accommodate deviations with the adjoining primary structure as constructed which, when merged, can allow any specified movement to take place without failure of the system.

6.3.2.2 Scenario 2: Walls mounted within the primary structure

It is common practice to construct a wall as a stud or SFS (structural framing system) back wall positioned between floor slabs and clad with a sheathing board and supporting an external surface of panels, brickwork or render.

The ability to adjust the plane of the surface relative to the back wall depends on the exact form of façade construction and might be severely limited, particularly in the case of a render finish direct to insulation.

The allowable deviation of the stud or SFS from the slab edge should be taken into account. These are normally designed with a nominal projection over the slab edge; this can be reduced or extended to accommodate deviations in the positions of the floor edges, but this adjustment is often insufficient to fully accommodate the deviations. Ultimately, an SFS back wall can be supported off the floor edge on additional brackets.

The floor slab should not project so far forward that it prevents the correct installation of sheathing boards. It should be taken into account that cavities are required to hold the specified thickness of insulation, and a drained and ventilated cavity of the specified depth is required behind a rainscreen. Similar considerations apply to walls constructed of blockwork, brickwork or stone supported on the slab edge or on a shelf bracket mounted on the slab edge.

6.4 Concrete floors

In deriving the levels for a structural floor, the specified minimum thickness of in-situ flooring is applied over the highest point of the structural floor (see [Figure 4](#)).

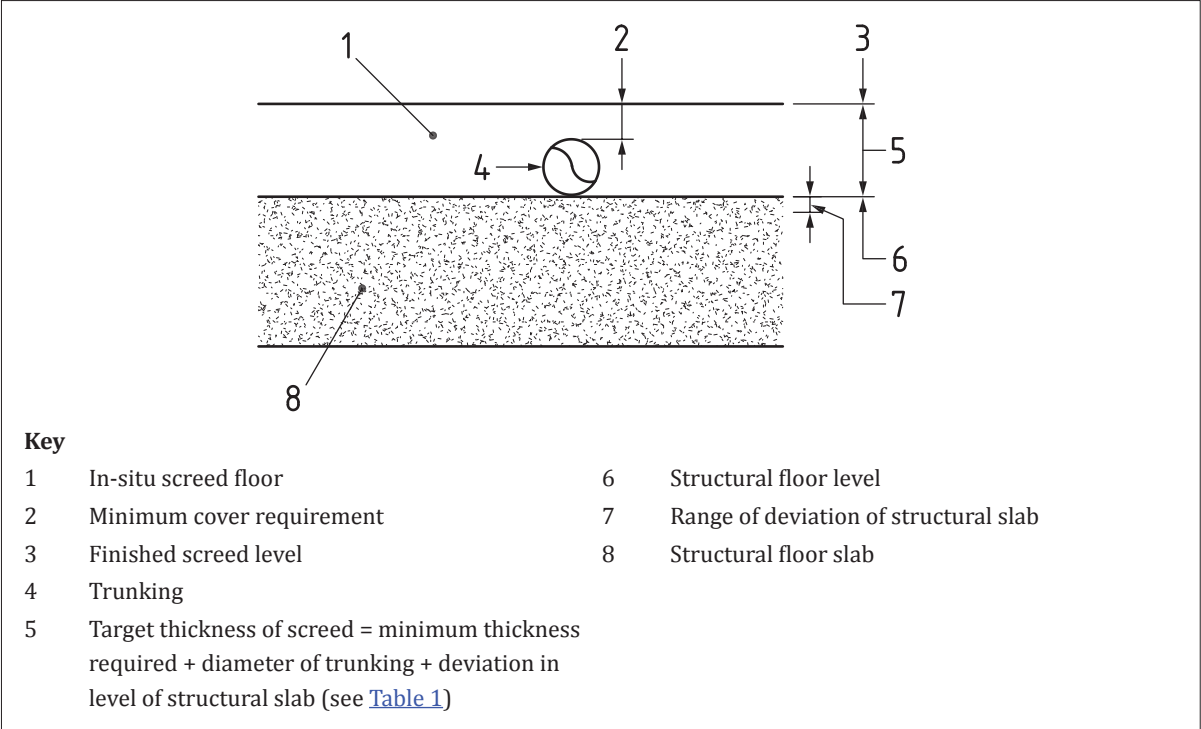
As types of flooring of differing thicknesses can occur in adjacent areas of the same floor, the finished floor level is normally taken as the datum.

The thickness specified should allow for deviations from the designed structural level, for deflection and for the effect of dead load on camber as well as for conduits, ducts, crossovers and junction boxes.

The tolerance for flatness needs to include both the construction methodology and the structural creep over the design life of the building to enable the performance to be maintained (e.g. the appearance of sensitive floor coverings, or the verticality of equipment positioned directly on the floor).

Recommended tolerances in the surface finish of in-situ floorings are given in [BS 8204-1](#) for surfaces to receive a covering and in [BS 8204-2](#) for concrete wearing surfaces.

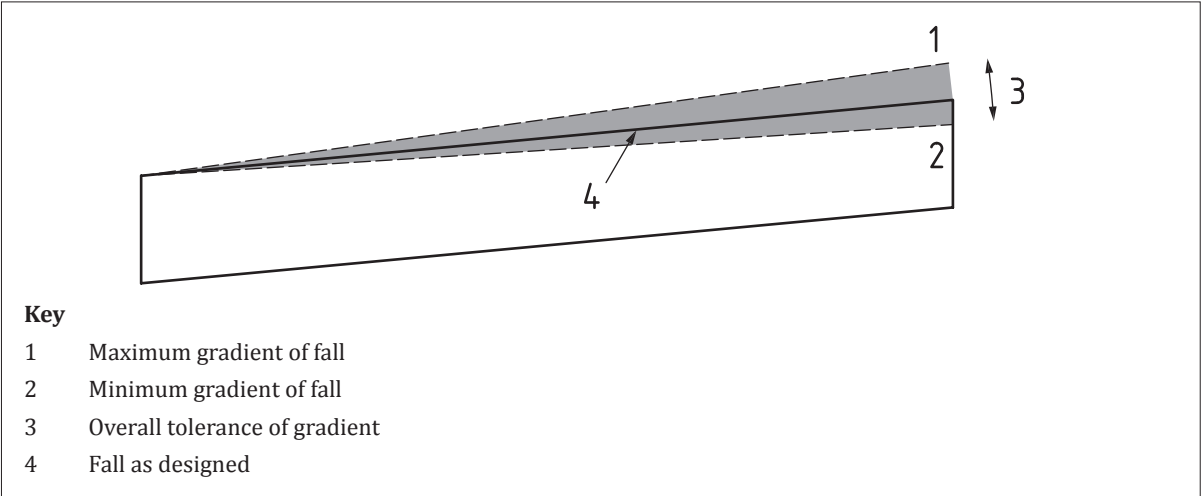
Figure 4 — Diagrammatic section showing screed accommodating trunking and range of deviations involved



6.5 Flat roofs

Flat roofs should be designed to allow water to drain while avoiding the risk of ponding. Required designed falls should be calculated to allow tolerance for the compounded effects of deviations in the level caused by any element of the supporting construction, deflection of the deck and potential structural movement over the design life of the building. [Figure 5](#) shows the type of tolerance specification for a fall or slope of roof that still retains its required performance requirements (e.g. gradient tolerance to distribute rainfall from surface at a required rate, or minimize risk of ponding due to deflection).

Figure 5 — Sloped floor with tolerance expressed in gradient variation



6.6 Lift wells

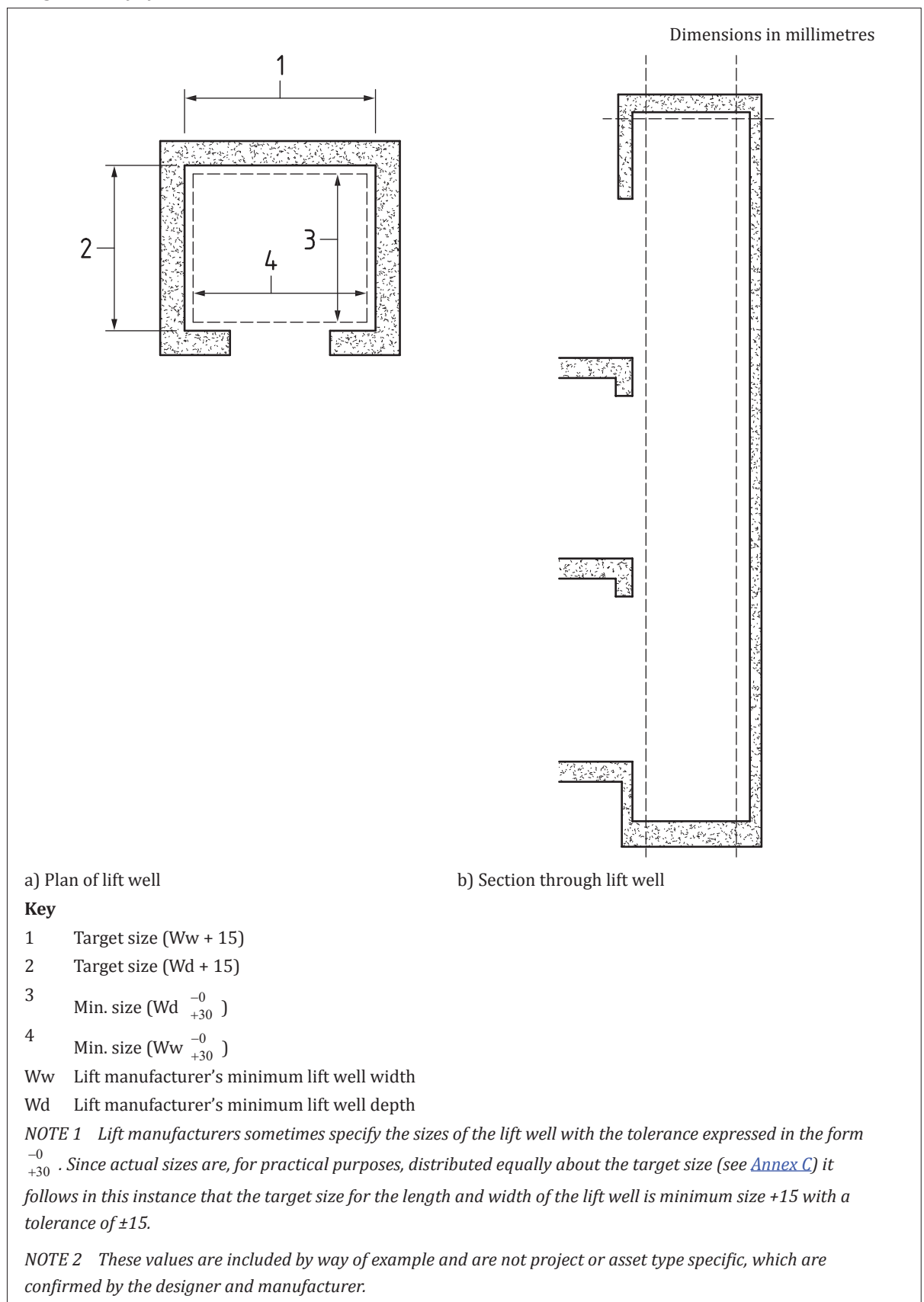
NOTE Lift wells are also known as lift shafts.

6.6.1 General

Lifts need to move vertically through a building, and the car and landing door equipment are a critical interface. Therefore, the plumbness of the well and the alignment of the landing openings are of paramount importance. It is also important to build the well to a high degree of verticality, i.e. plumb. Decreased dimensions are likely to result in the lift not being able to be installed.

Lift well dimensions are specified in standards such as [BS 5655-6](#) and [BS ISO 8100-30](#) with a zero negative tolerance and a positive tolerance to reflect this need. See [Figure 6](#) for guidance regarding the specification of sizes for lift wells.

Lift well dimensional tolerances used for initial planning should be no greater than those in [BS ISO 8100-30](#). Once the requirements of the lift installer are known, lift well dimensional tolerances should reflect the requirements of the lift installer.

Figure 6 — Target sizes of lift well

6.6.2 Examples and typical issues

In forming the structural openings in concrete walls to lift wells, allowance for masking or packing should be provided to enable doors to be aligned vertically with each other in elevation, by increasing the width and height of the openings, and by reducing the size by means of packings after the doors have been located correctly.

Since door openings might not line up one above another in section through the well, adjustments should be allowed for in the width of linings to jambs to mask inaccuracies. As the height of the lift well increases, the difficulty in getting door openings to line up one above the other increases also; therefore, in lift wells higher than 60 m, the width of structural openings to receive lift doors should be increased by an appropriate amount (see [Table C.1](#)).

It is important to facilitate the alignment of landing sills; one way of doing this is by providing, at each landing, an independent threshold, the position of which can be adjusted.

To achieve integrated fire protection of the lift landing door entrances (including any architraves) and the structural opening of the lift well front wall (brick, blockwork, concrete, etc.), it is very important that clearances between the lift entrance and the structural opening, above, below and to the sides of the lift entrance, are maintained within the limits supplied by the lift installer.

6.7 MEP services

6.7.1 General

6.7.1.1 Pipework

Deviations occur in the manufacture of pipework and conduit assemblies and in the location of inlets and outlets connected to the structure. The in-situ connection should be designed to accommodate the predicted total of deviations from all sources and this can include off-site manufactured assemblies.

6.7.1.2 Ductwork

The sizes of apertures for ducting, including allowance for insulation, joints, flanges, junctions, crossovers, firestops, valves and fixing lugs, should be detailed by the designer.

The order of installation and the space needed for access to install, operate and maintain equipment should be taken into account. When insulation is to be applied to the duct after installation, sleeves should be inserted at the point where the ducting passes through the structure. Tolerances specified for the sizes of the openings to be left should allow ventilating grilles or diffusers to be fitted and for flanges to mask the joints and/or packings.

6.7.2 Example

6.7.2.1 Piped supply functions

The pipework for piped supply systems can have manufacturer's fabrication variances that should be taken into account.

It is usual practice to run pipework together in banks; therefore, as well as the manufacturing tolerances, the bracketry and wall/floor transits (for making good or fire stopping) should be accounted for. Bends, valves, automatic air vents (AAVs), pipe/fire collars and insulation with their associated tolerances should also be taken into account.

6.7.2.2 Electrical power and lighting functions

Electrical power distribution is usually carried out by cabling individually run or in multiple runs on/in containment (i.e. cable basket/cable tray or ladder/conduits/trunkings).

These various types of cable and containment types come in several sizes and profiles, each with respective manufacturer's tolerances, and the proposed installation method(s) and their associated accessories (e.g. clips, saddles, bracketry, flanges, bends, tees, crossovers etc.) and how they fit within the building structure should be taken into account.

Installations through walls/floors might need transits for making good or fire stopping.

Outlets and accessories in the majority of instances require recessing (or semi-recessing) and by the nature of their relative size the tolerances required are small. However, careful consideration of the mounting box depth is required and its impact on the integrity of the structure strength once the recess is formed.

Lighting installations might require recessing (or semi-recessing) into the structure. In these instances, tolerances are required for the body of the luminaire with the flange or bezel of the fitting masking the opening.

6.8 Windows, doors and panelling units

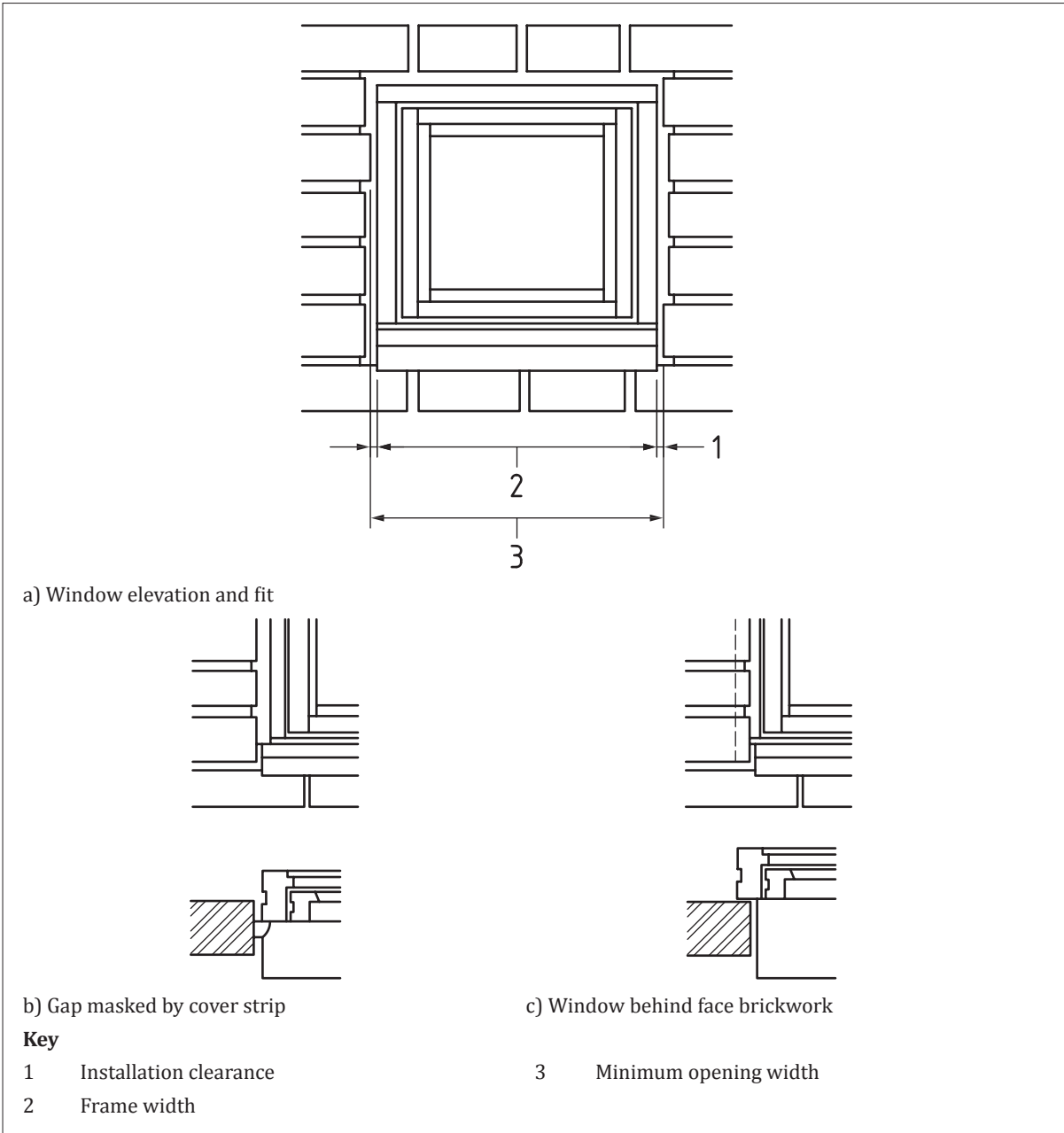
6.8.1 General

Windows, doorsets and panels are generally installed into pre-formed openings that can be formed with greater precision by using jigs or templates. Any inaccuracies in the openings should be allowed for in the sizing of the component taking into account the width of joints between the component and the surrounding structure. There should be sufficient clearance to allow the window, doorset or panel to be positioned without distortion, to allow for any in-service thermal movement where required, and to enable the joint to be sealed against the ingress of air and water. Additional considerations might be needed for fire doors. Where the widths of the joints become too wide, they should be masked by cover strips. Overlapping joints, e.g. where a window is installed behind the face brickwork, can accommodate inaccuracies but variations in the visible margins around the component, e.g. window jamb, might be more apparent and therefore less acceptable than wide joints. See [Figure 7](#) and [Figure B.1](#) to [Figure B.3](#) in [Annex B](#) for tolerance interfaces in window openings.

6.8.2 Examples and typical issues

It is also challenging to control structural tolerances where these are not formed before window and door manufacture needs to commence due to long lead times and the programme does not allow for site surveys and measurements to be taken. The design should be coordinated such that the jointing around the perimeter can be detailed to accommodate the as-built structural openings, the window manufacturer's tolerance and the aesthetic and functional requirements of the installation. [Figure 7](#) shows interface options which might allow the aesthetic impacts of tolerances to be resolved.

Figure 7 — Window opening and frame to wall interface variations



6.9 Prefabricated partitions

6.9.1 General

When partitions are to be fitted between previously constructed items, problems of fit can arise. It should be determined that the particular system specified can accommodate any tolerance in the floor and ceiling level and is capable of maintaining the performance requirements specified for a particular project. Small openings such as gaps, cracks or holes can compromise fire integrity and conduct airborne sounds, significantly reducing sound insulation.

6.9.2 Example

Deflection heads (see [Figure 8](#)) in partition systems might be required when there is a need to allow for movement (up, down or both) within the structure at the head of a partition.

Where appropriate, tested and robust detailing should be implemented. All detailing should accommodate the predicted total of deviations in the structure, adjacent components and in the partition.

Figure 8 — Example section of deflection head, standard head and sole detail

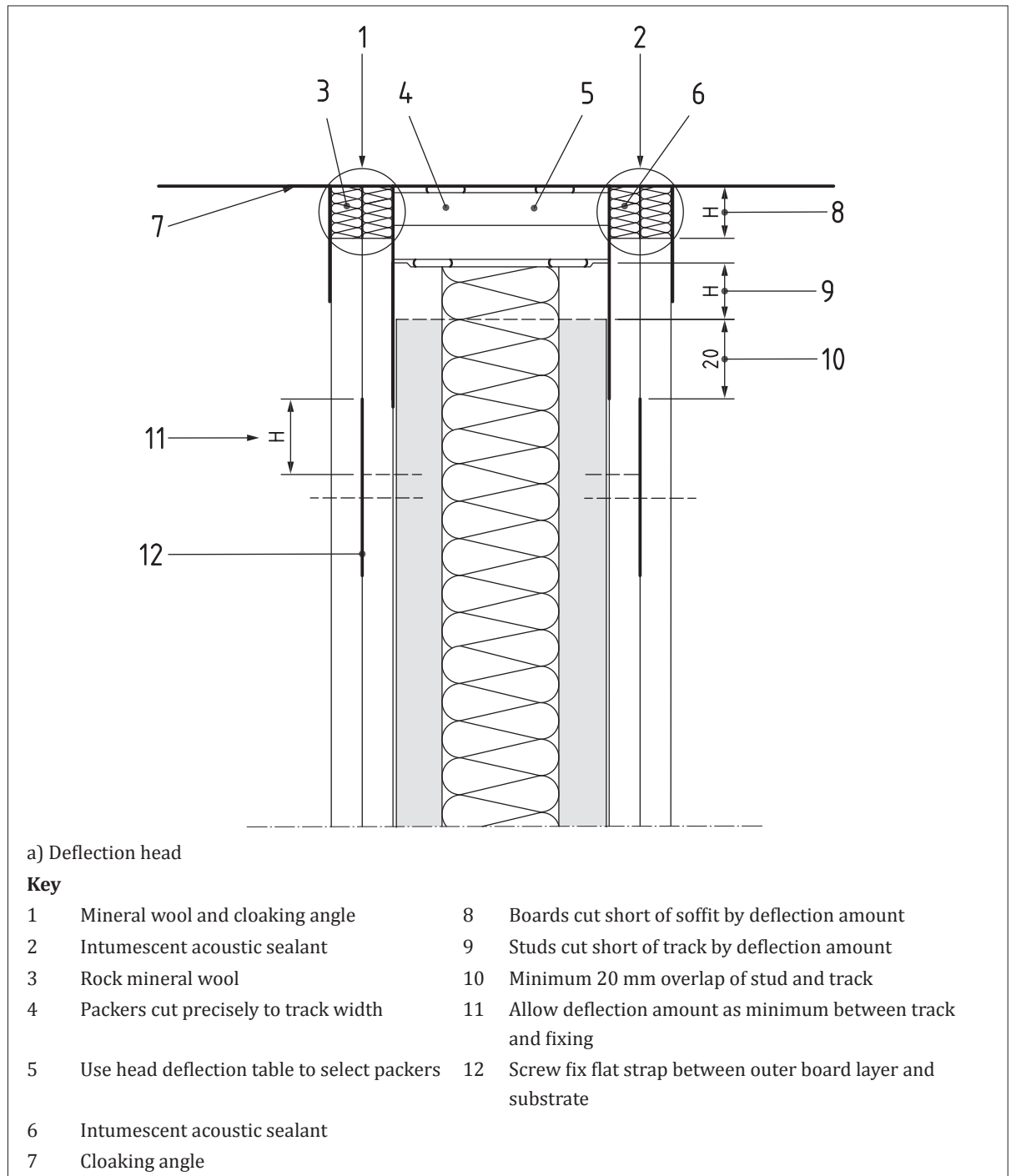
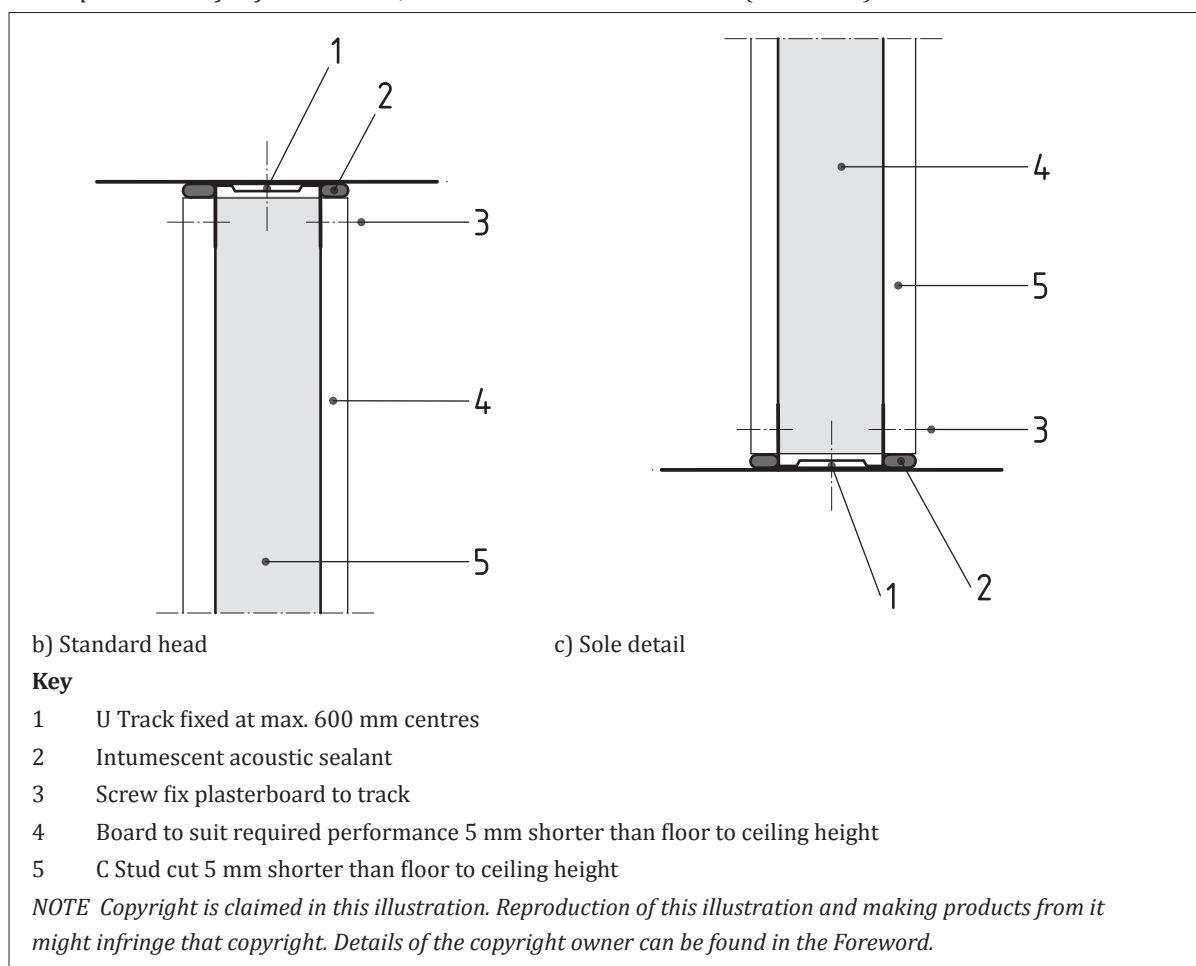


Figure 8 — Example section of deflection head, standard head and sole detail (continued)

6.10 Stairs

6.10.1 General

Staircases typically contain off-site fabricated elements. The overall achieved tolerances of the installed staircase are affected by the tolerances of the in-situ work and the manufacture tolerances of the stair. The structural and architectural design should take into account problems of fit in particular in relation to floor openings and storey heights, as well as the vertical tolerances of any adjacent walls. In some cases, floor deflection might be a consideration.

6.10.2 Examples

Stairs made of in-situ concrete typically require screed to achieve an acceptably even rise and going (depth of step).

To achieve key design dimensions, the compounded effect of a range of tolerances should be taken into account. In relation to headroom, lateral tolerances of stair placement (in the direction of the stair) are amplified by the tangent of the angle of the stair as shown in [Figure 9](#).