

BRITISH STANDARD

Design of joints and jointing in building construction –

Guide

ICS 91.060.01



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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 July 2006. It was prepared by Technical Committee B/547, *Sealants for building and construction*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

BS 6093:2006+A1:2013 supersedes BS 6093:2006, which is withdrawn.

Information about this document

Text introduced or altered by Amendment No. 1 is indicated in the text by tags **A1** **A1**. Minor editorial changes are not tagged.

As a code of practice, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

Any user claiming compliance with this British Standard is expected to be able to justify any course of action that deviates from its recommendations.

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 provisions in this standard are presented in roman (i.e. upright) type. Its 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.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

1 Scope

This British Standard gives recommendations for the design of joints and the use of jointing products in building construction. Following an analysis of joint functions and of the performance of the parts to be joined, joints are classified in this standard on the basis of the movements and inaccuracies they have to accommodate. Mechanisms by which joints operate are identified and recommendations are made on the use of sealants and gaskets. Some emphasis is placed on weather resistance of joints in the external envelope of buildings.

The code does not present guidance in the form of a catalogue of proven joint designs, because the extent to which a design is appropriate to a particular use depends on circumstances specific to the building, e.g. its exposure, desired performance, durability and costs. The code therefore draws attention to matters that need consideration, in order that solutions may be developed that are appropriate.

The code does not cover:

- a) rigidly connected joints (except type 1 joints, see **4.6.4.1**);
- b) joints within components normally made in a factory, such as those around opening lights in windows;
- c) the load-bearing functions of structural joints;
- d) glazing (see BS 6262);
- e) joints in service pipes and ducts and their connections to appliances;
- f) methods of test for joints or for jointing products.

All figures in this standard showing detailed joint designs illustrate principles in a recognizable context and are not production drawings of proven and universally applicable joints.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the reference cited applies. For undated references, the latest edition of the referenced document (including any amendments).

BS 5606, *Guide to accuracy in building*

 Text deleted 

 BS 6100-6, *Building and civil engineering – Vocabulary Part 6 – Construction parts*

BS 6100-11, *Building and civil engineering – Vocabulary: Part 11 – Performance, characteristics measurement and joints* 

BS 6213, *Selection of construction sealants – Guide*

BS 6750, *Specification for modular coordination in building*

BS 6954-3 (ISO 3443-3), *Tolerances for building – Part 3: Recommendations for selecting target size and predicting fit*

BS 8000-16, *Workmanship on building sites – Part 16: Code of practice for sealing joints in buildings using sealants*

 Text deleted 

BS 8210, *Guide to  facilities  maintenance management*

BS 8297, *Code of practice for design and installation of non-loadbearing precast concrete cladding*

BS 8449, *Building and construction sealants with movement accommodation factors greater than 25 % – Method of test for determination of adhesion/cohesion properties at variable temperatures*

BS EN 1996-1-2, *Eurocode 6: Design of masonry structures – Part 1-2: General rules – Structural fire design*

BS EN 1996-2, *Eurocode 6: Design of masonry structures – Part 2: Design considerations, selection of materials and execution of masonry* ^(A1)

BS EN 13830, *Curtain walling – Product standard*

BS EN 15651-1, *Sealants for non structural use in joints in buildings and pedestrian walkways – Part 1 Sealants for facade elements*

BS EN 15651-2, *Sealants for non structural use in joints in buildings and pedestrian walkways – Part 2 Sealants for glazing*

BS EN 15651-3, *Sealants for non structural use in joints in buildings and pedestrian walkways – Part 3 Sealants for sanitary joints*

BS EN 15651-4, *Sealants for non structural use in joints in buildings and pedestrian walkways – Part 4 Sealants for pedestrian walkways* ^(A1)

BS EN ISO 6284, *Construction drawings – Indication of limit deviations*

BS EN ISO 11600, *Building construction – Jointing products – Classification and requirements for sealants*

BS EN ISO 9047, *Building construction – Jointing products – Determination of adhesion/cohesion properties of sealants at variable temperatures*

ISO 2445, *Joints in building – Fundamental principles for design*

PD 6697, *Recommendations for the design of masonry structures to BS EN 1996-1-2 and BS EN 1996-2* ^(A1)

3 Terms and definitions

For the purposes of this British Standard, the terms and definitions given in ^(A1) BS 6100-6 and BS 6100-11 and the following apply. ^(A1)

3.1 Joint design

3.1.1 induced deviation

dimensional deviation that occurs as a consequence of operations performed such as setting out, manufacture, assembly, erection, etc.

3.1.2 inherent deviation

dimensional deviation that occurs as a consequence of an inherent material property such as changes component dimension caused by changes in temperature, humidity, stress, bond breaker, etc.

3.1.3 interchangeability

ability of a component to be used and jointed satisfactorily with a variety of other components

3.1.4 joint (1)

construction formed by the adjacent parts of two or more products, components or assemblies when these are put together, fixed or united with or without the use of a jointing product

3.1.5 joint (2)

position in the construction works where the joint (3.1.4) is situated

3.1.6 joint clearance

distance between the joint faces of adjacent building components, i.e. the joint gap widths considered in order to achieve fit

3.1.7 joint gap

space between adjacent components, with or without a jointing product

3.1.8 joint geometry

disposition of all the parts that contribute to the functions of a joint

3.1.9 joint profile

form of that part of the cross-section of a joint derived from each of its components

3.1.10 joint reference plane

theoretical reference plane from which the relative position of the joint profiles of adjacent building components and/or associated jointing products may be determined

3.2 Materials for jointing**3.2.1 seal**

NOTE The term does not presuppose the use of any particular material or mechanism, but implies effectiveness in sealing against whatever agent is relevant, such as water, air, fire or sound.

physical barrier that is notionally impenetrable and is in contact with the components forming the joint

3.2.2 sealant

material which, applied in an unformed state to a joint, seals it by adhering to appropriate surfaces within the joint

3.2.3 movement accommodation factor (MAF)

<of a sealant> maximum movement, the difference between the maximum and minimum joint widths, which a sealant is capable of tolerating throughout its working life, expressed as a percentage of the minimum joint width

3.2.4 elastic sealant

NOTE Elastic sealants are more suitable for joints where the movement that occurs is reversible.

sealant that has been classified as type E according to BS EN ISO 11600

3.2.5 plastic sealant

NOTE Plastic sealants are more suitable for joints where the movement that occurs is irreversible.

sealant that has been classified as type P according to BS EN ISO 11600

3.2.6 back-up material/backer rod

material inserted in a joint that limits the depth of sealant applied and defines the back profile of the sealant

3.2.7 bond breaker

film or thin strip material applied to the back of a joint to prevent sealant adhesion to the back of the joint

3.2.8 sealing strip

preformed material that constitutes a seal when compressed between appropriate joint surfaces, and that can have adhesive properties

3.2.9 gasket

flexible, generally elastic, preformed material that constitutes a seal when compressed

3.2.10 baffle

strip of flexible material inserted into a multi-stage joint to prevent the passage of rain

3.2.11 joint filler

compressible non-adhesive material used to fill and define movement joints during their construction that may also act as a back up material

4 Design of joints

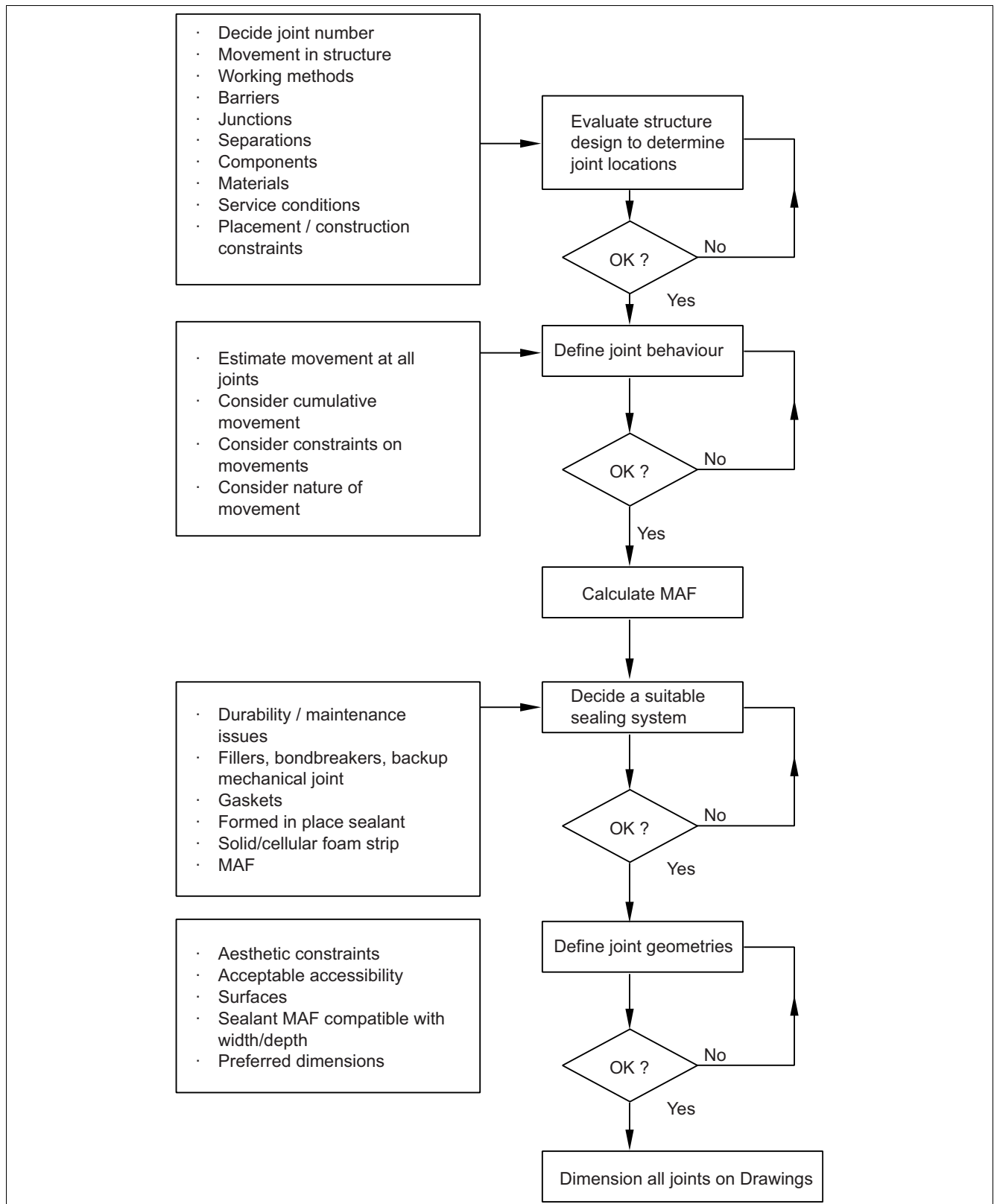
4.1 General

Since joints are breaks in the physical continuity of construction, they are potential breaks in the continuity of performance. It is therefore important that an entire assembly, including the joints, should achieve the desired performance.

4.2 The need for joints

Decisions should first be made with regard to the need for and the types of joints to be used as shown in Figure 1.

Figure 1 Joint design flow chart



From physical attributes inherent in materials and methods of work, the need for site joints arises at or on account of:

- a) junctions of different elements or components and junctions comprising different materials;
- b) change of conditions necessitating separation by a barrier;
- c) limitations imposed by methods of working, e.g. the formation of day-work joints in *in situ* concrete construction;
- d) limitations of size and/or weight of components imposed by their manufacture, handling, storage, transport and assembly;
- e) limitations imposed in service by inherent properties of materials.

4.3 Location and frequency of joints

Once the need for joints is established, their location and frequency are determined from design decisions and are influenced by:

- a) general planning decisions about storey height, relationships between solids and voids (e.g. walls and windows), room sizes, floor spans, etc.;
- b) values chosen from the range of coordinating sizes;
- c) the location of joints to take account of areas of high stress of components and elements in service;
- d) the avoidance of complex joint intersections;
- e) the facilitating of fit, e.g.:
 - 1) by increasing the number of joints;
 - 2) by avoiding components having to be fitted within preformed openings;
 - 3) by preforming internal and external corners;
- f) the minimizing of the extent of jointing for reasons of e.g. hygiene, cost or performance;
- g) the obtaining of a particular appearance of scale, proportion, pattern, symmetry or other attributes such as false joints.

4.4 Procedure for the design of a joint

NOTE See also Annex B.

The procedure for designing a joint should be as follows and is further illustrated in Figure 1.

- a) Examine the types and positions of all the joints in the building.
- b) Examine each joint at a large scale: full size or half full size.
- c) Establish the joint reference plane for each joint and relate it to a building reference plane.
- d) Check the joint functions (see **4.5**), and whether provision should be made for dimensional deviations (see **4.6**).
- e) Modify the design of the joint to meet all the requirements at the positions where it occurs.

4.5 Sealed joint functions

NOTE The recommendations in this subclause are similar to those given in ISO 3447.

4.5.1 Environmental factors

When the general needs for joints have been considered, environmental factors should be quantified.

The data for joints are the same as those needed for the components. Some values emerge from user requirements. Other values derive from the natural environment.

Designers should also consider the immediate environment that could exist during construction. This can be more severe than the service conditions referred to previously.

Joints might need to be constructed so as to obstruct the passage of any or all of the following:

- a) insects and vermin;
- b) plants, leaves, roots, seeds and pollen;
- c) dust and inorganic particles;
- d) heat, light, sound, radiation;
- e) air, gases and odours;
- f) water, snow, ice and water vapour;
- g) joints might need to avoid the generation of sound and odours.

4.5.2 Capacity to withstand movement induced stresses

4.5.2.1 Types of movement

The performance of any sealed joint will be affected not only by the magnitude of the movement but also by the mode, frequency and rate of movement.

Sealed joints might need to withstand stress (either during or after assembly) in one or more directions due to compression, tension, bending, shear, torsion, vibrations or any other type of stress that can induce fatigue, impact, abrasion, shrinkage, creep, and expansion or contraction due to temperature variations.

4.5.2.2 Mode

The principal modes of movement are:

- a) *tension/compression*, typified by the common plain butt joint, where movement is at right angles to the line of the joint;
- b) *shear*, typified by the lap joint, where the movement is parallel to the adhesion faces of the joint. Shear also occurs in butt joints where the joint, for example, is designed to accommodate settlement or other types of differential movement;
- c) *combined movement*: sometimes a joint might move in tension/compression and in shear.

4.5.2.3 Movement in curved components

Usually movement at a joint is considered to be uniformly distributed along two straight components positioned parallel to each other to form the joint.

Where shaped or curved components form one or both joint boundaries, a careful study of the distribution and magnitude of movement should be made. Thermal expansion and contraction will cause changes in the length of curved surfaces which, if restrained at the edges, will result in bowing or deformation. Movement at the position of restraint will be small and will be at a maximum at the mid-point between the restraints.

Where dissimilar materials of differing coefficients of thermal expansion form the joint interface, the amount of movement occurring at the mid point can be magnified, necessitating wide joints or a reconsideration of the design to reduce the movement.

4.5.2.4 Movement frequency

This can range from a steady movement in one direction that occurs only once in the life of the structure, to more or less regular cyclical movement corresponding to diurnal and seasonal temperature and moisture changes. An example of the former is the irreversible shrinkage of concrete and an example of the latter is the daily thermal movement of lightweight cladding.

It should be noted, however, that because of friction and other constructional factors, cyclic movement can operate on a slip/stick basis. The effect of this might be more severe than a steady extension and compression, depending on the rate of joint movement and the characteristics of the sealant with respect to physical movement accommodation.

4.5.2.5 The rate of movement

Large movements occurring at high rates in joints can place severe strains on the seal. High rates of movement tend to be associated with lightweight forms of construction with efficient insulation immediately behind the external skin of the component. Such components often have a relatively high coefficient of expansion and low thermal inertia. Thus temperature changes are immediately reflected in dimensional changes in the components and, consequently, movement is rapid and under certain weather conditions continually alternating. The use of dark surfaces on such components exacerbates the situation because of the higher temperatures attained and the rapid heat gain or loss that occurs.

4.5.3 Safety

NOTE See also 8.5.

The functions of sealed joints in the context of safety are:

- a) to obstruct the passage of fire, smoke, gases, radiation and radioactive materials;
- b) to resist sudden positive or negative pressures due to explosion or atmospheric factors;
- c) to avoid the generation of toxic gases and fumes in case of fire;
- d) to avoid harbouring or proliferation of dangerous micro-organisms.

4.5.4 Appearance

Sealed joints should have an acceptable appearance. The effects of weathering of the appearance (colour) of the jointing material itself should be borne in mind during its selection.

Sealed joints should also avoid:

- a) promotion of mould and plant growth;
- b) discoloration due to UV radiation and biological, physical or chemical action;
- c) all or part of the internal structure showing;
- d) dust collection.

4.5.5 Durability

NOTE See also 8.6.

If a sealed joint is likely to be less durable than the components joined, then the maintenance and ease of repair should be considered. In considering durability and the minimum life of such a joint, designers should aim to reduce its exposure, minimize damage to the fabric and, should the joint fail, provide access for repair or replacement, and establish the expected frequency of replacement.

Sealed joints might be required to resist abrasive action and damage or unauthorized dismantling. They might also be required to resist the action of animals and insects, plants and micro-organisms, water and water vapour and aqueous solutions or suspensions, polluted air, light and radiation, freezing of water, extremes of temperatures, airborne or structure borne vibrations, shock waves and high intensity sound, and acids, alkalis, oils, fats and solvents.

4.5.6 Maintenance

NOTE See also 8.6.

The design of joints should allow for inspection, partial or complete dismantling and reassembly, and the replacement of decayed jointing products, during maintenance.

4.5.7 Ambient conditions

Joints and jointing products should be able to perform the required functions over a specified range of temperature, atmospheric humidity, air or liquid pressure differential, joint clearance variation and driving rain volume.

4.6 Variation in the sizes of joints

4.6.1 The consequences of variation in joint width

The accommodation of movement after assembly (inherent deviations) and the variability in size and placement of jointed parts (induced deviations) should be taken into account as these are crucial factors in the performance of seals. Variations in joint width should allow for performance limitations of jointing products and can be limited by tolerances of assembly.

Variations in joint width become even more critical at junctions; stresses can become more concentrated in sealant joints and gaskets might lose their effectiveness. Manufacturing tolerances impacting the

geometry and deformation of components affect joint profile which, in turn, affects joint gap sizes.

Data concerning inherent and induced deviations in components and openings should be used where needed to determine the effects of these deviations on joint dimensions and to aid selection of appropriate joint mechanism and materials.

The data needed are as follows:

- a) the predicted variability in the size and position of components and openings normally achievable in construction given in BS 5606 (or, when not given therein, the normally achievable deviations estimated by the building designer);
- b) the predicted changes in sizes of components and openings in services due to thermal, moisture, creep and load deformation;
- c) the number of joints in the assembly involved/required to accommodate the deviations predicted in a) and b).

NOTE Guidance on calculations to predict target size, clearances and fit are given in BS 5606 and BS 6954-3.

When building components are located in relation to a continuous reference system such as a modular grid so that the structure is subjected to overall dimensional control, deviations of size, shape and position have to be absorbed within the jointing system.

The consideration of tolerances for the manufacture of components and for the construction of buildings is therefore inseparable from the design of joints to provide the required dimensional flexibility (see ISO 2445). This does not mean that all joints should necessarily have this capability, but it is necessary for deviations to be accommodated at some point; this may be achieved at the joints between individual components, or by the provision of special joints at intervals.

4.6.2 Inherent deviations

4.6.2.1 *Reversible inherent deviations.* Reversible inherent deviations are due to cyclic environmental factors such as thermal and moisture variations and vibration.

The greatest range of temperature is usually experienced on the external face of buildings and especially on south facing elevations, but resulting dimensional changes might tend to be balanced by opposite movements due to changes in moisture content. Internally, both thermal and moisture movements can be less significant depending on the environment within the building.

Whereas the annual air temperature range in the United Kingdom is about 35 K (–5 °C to 30 °C), the actual temperature range to which materials are subjected due to radiant heat is greater and depends on the orientation of, and the incidence of radiation on, the surface, as well as on the colour and degree of protection (insulation or shading). Surface temperatures can, in extreme circumstances, be as high as 80 °C and as low as –20 °C.

Movement per unit length can be influenced by:

- a) temperature range;
- b) degree of exposure;
- c) response of materials to thermal change;

- d) colour of surfaces;
- e) restraint of movement.

NOTE Information concerning the calculation of thermal movement per unit length is given in BRE Digests 227, 228 and 229 [1].

The capability of joints to accommodate movement determines the maximum interval between them, taking account of the way in which fixings may permit or distribute movement.

While it may be sufficient for a designer to make allowance for movement for in-service conditions on the basis of thermal movement only (see Annex A for list of coefficients), the validity of this assumption should always be confirmed. Examples of exceptions are sandstone and timber (across grain), where movement due to moisture might exceed that due to thermal change (see Annex A). Movement due to moisture along the grain of timber is not significant.

Some materials respond to changes in moisture content following changes in weather conditions, and appropriate allowance has to be made taking into account the environment at the time of construction. Examples of such materials are concrete blockwork and timber.

Care should be taken about the moisture content of absorbent materials in storage and during the course of construction, in order to minimize subsequent movement.

In such environments as are found in swimming pools and certain industrial processes where high humidity occurs, the behaviour of moisture-sensitive materials should be given special consideration.

4.6.2.2 Irreversible inherent deviations

Irreversible inherent deviations are due to non-cyclic factors. They occur over predictable short or long-term periods depending on the nature of the material.

In addition to reversible movement, concrete is subject to irreversible drying shrinkage and thermal contraction.

Plastic shrinkage can occur during the first few hours after placing through the loss of water from the plastic concrete by evaporation or, sometimes, by absorption into adjacent materials. Plastic shrinkage is common in hot weather and in drying winds and can result in cracking. It can largely be avoided by slowing down the drying of the concrete. Early thermal contraction can be significant in concrete over about 0.5 m thickness. It is due to the natural cooling that takes place when the heat of hydration passes its peak. The temperature rise can typically be about 20 K, two days after placing. The designer should be aware of the effect of early thermal contraction and, where appropriate, should provide joints or planes of weakness to confine cracking to predetermined positions.

Drying shrinkage is a long-term process and can continue over many months. Any movement is influenced by the size of section, the concrete mix, the amount of reinforcement and the environment. Allowance should be made for the effects of drying shrinkage when detailing concrete blockwork. Calcium silicate bricks need to be protected against excessive moisture up to and during construction. Provision should be made for the free circulation of air within the stack so that the bricks may dry out before they are built in.

Fired clay units exhibit reversible movements due to changes in moisture content. These are usually small but there is a permanent

moisture expansion, the rate of which decreases with time and is dependent upon the type of clay and firing process.

For various masonry materials, information on moisture movement and thermal properties is given in **Annex A1** BS EN 1996-1-2. Guidance on the determination of spacing and design width of movement joints is given in PD 6997 and BS EN 1996-2. **Annex A1**

The effect of creep might need to be taken into account in joint sizes. Continuous loading of concrete structural frames will cause beams and slabs to continue to deflect beyond their initial elastic deflection and columns and concrete walls to shorten over a long period of time. After the first year, movements due to creep are very small but recognition should be given and allowance made in the joints between the frame and components fitted to it.

4.6.3 Induced deviations

An individual component normally deviates both from its intended size and from its intended position in the building. Both kinds of deviation occur three-dimensionally. When two components are placed with a joint clearance between them, these deviations affect the size and shape of the joint three-dimensionally. Designers have to design for the generality of such deviations, but a particular assembly when constructed contains deviations with particular values. If systematic account is taken of deviations, the majority of joints can be expected to lie within the desired joint clearance limits.

If the size of a joint is likely to exceed the specified limits, consideration should first be given to the possibility of adjusting the position of the components in the assembly so as to distribute excess deviation among the joints in the assembly and optimize the joint clearances. Particular types of deviation in joint size might still need special action, e.g. the tapering of joint clearances, bow and twist of components and inaccuracy in component alignment.

When it is not practical to rectify joints that have sizes outside the specified limits, an alternative joint design should be adopted.

4.6.4 Provision for dimensional deviations

4.6.4.1 General

The initial generation of solutions may be based upon four assumptions that can be made about the distribution of induced and inherent deviations (see Clause 3). These are as follows.

- a) *Type 1 joint.* No allowance made for any deviations.
- b) *Type 2 joint.* Allowance made for inherent and induced deviations.
- c) *Type 3 joint.* Allowance made for inherent deviations only.
- d) *Type 4 joint.* Allowance made for induced deviations only.

Examples of joints for which each assumption is usually made are given in Figure 2 to Figure 5. Having made a provisional assumption about the design of the joint, the designer should then consider:

- 1) the significance and values of dimensional deviations to be accommodated;
- 2) the consequences of this assumption for joints elsewhere in that assembly.

Figure 2 Examples of type 1 joints

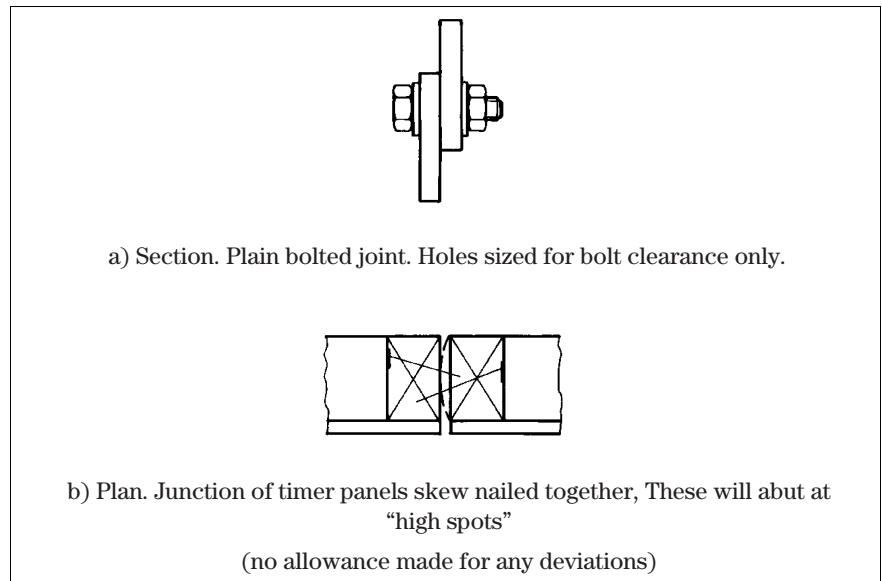


Figure 3 Examples of type 2 joints

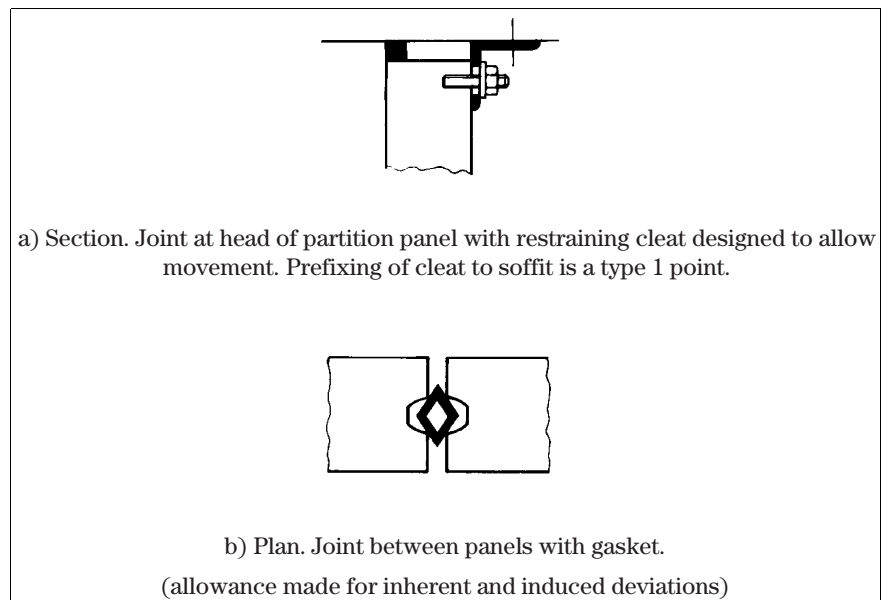
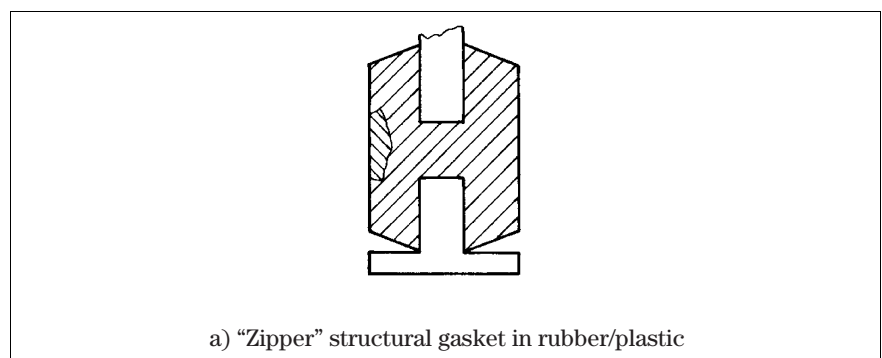


Figure 4 Examples of type 3 joints



(continued)

Figure 4 **Examples of type 3 joints** (*continued*)

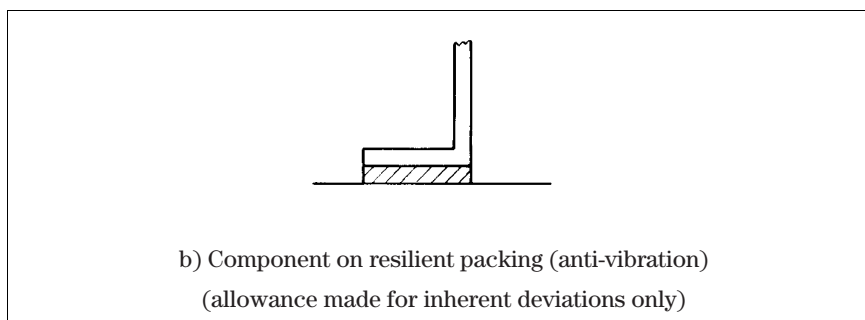
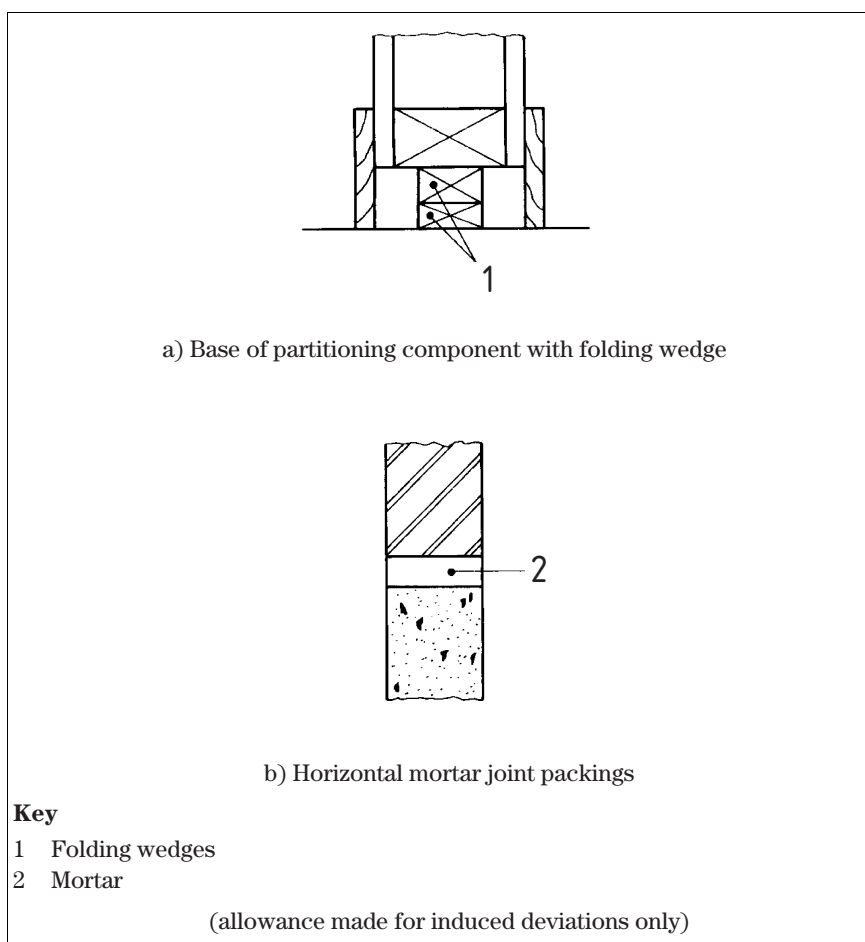


Figure 5 **Examples of type 4 joints**



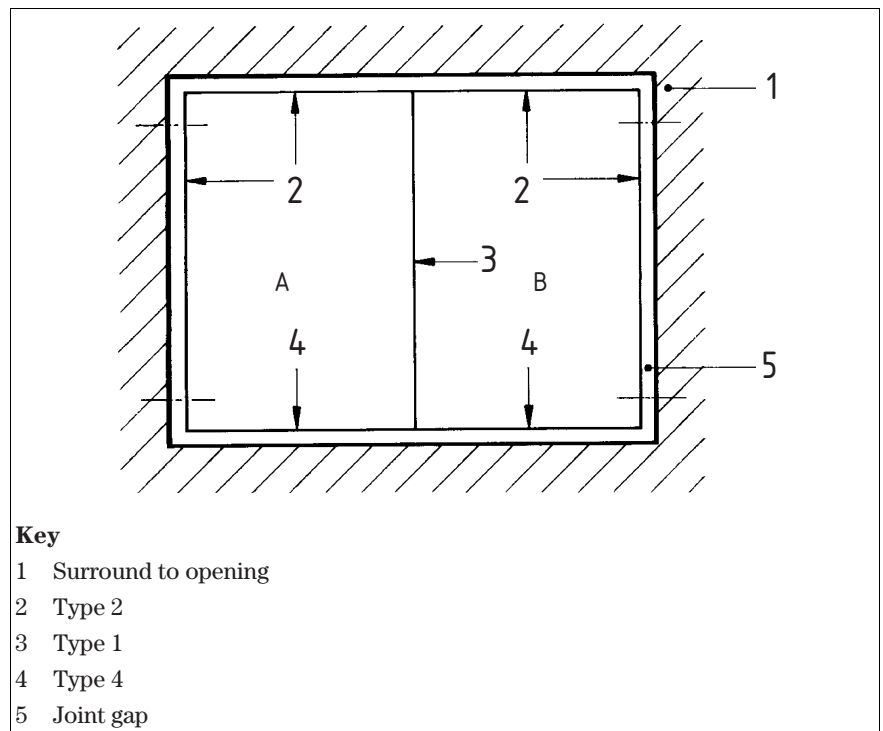
4.6.4.2 Interaction of the four joint types

An assembly usually contains more than one of the four joint types. The designer should assess the distribution of induced and inherent deviations throughout the assembly in order to choose the appropriate combination of joint types.

Figure 6 illustrates the interrelationship and effects of an assembly of two panels of walling erected in an existing opening.

Fixings can modify the distribution of inherent deviations in the assembly and this needs separate consideration. For example, central fixings cause inherent deviations to be shared between the end joints: fixings at one end concentrate all inherent deviations at the other end.

Figure 6 Elevation showing assembly of panels and joint types in an opening



4.7 Dimensioning joints on drawings

It is not unusual for joint clearances to be shown on drawings as finite dimensions. This is a matter of convenience that enables component sizes and joint clearances to be added up to give a correct overall size. However, joint clearances shown in this way can lead to the expectation that they are of fixed size when, in reality, they are of variable size and have to be so in order to fulfill their function of accommodating dimensional deviations. Limit deviations should be presented in accordance with BS EN ISO 6284.

This is illustrated in Figure B.1 as “ 8 ± 2 mm”. If this is felt to be unduly laborious, the permitted deviations may be shown in the drawing notes. Indicating joint clearances in this way makes readily available the criteria for checking compliance on site and confirming that the joint can be expected to be able to accommodate future dimensional deviations in the way intended by the designer.

5 Jointing materials

5.1 Joint sealing materials

Sealing to prevent air and water penetration is achieved using sealants, sealing strips, gaskets and baffles.

Guidance on the selection, applications and use of sealants is given in BS 6213. More information is available on sealants than on gaskets which are normally purpose-made (for which only general guidance can be given). In all cases, the details of the properties and performance of seals should be obtained from the manufacturers.