8 TOLERANCES

Before discussing the subject of tolerances, it is wise, in the light of common misuse of relevant terminology, to clarify the meaning of terms which will be used in this Section.

- *deviation* misalignment (used here in the context of the frame),
- *lack of fit* local misalignment (used here in the context of frame components),
- *tolerance* limiting value for a deviation.

The relationship between these terms can best be illustrated using an example. Consider a 3 m high column forming part of a frame. When the frame is aligned and bolted up, the top of the column is offset 4 mm relative to a vertical line drawn from its base. This 4 mm is a frame deviation. The tolerance for non-verticality, expressed as an offset, is 5 mm according to the NSSS[6]. The column is acceptable because the tolerance of 5 mm exceeds the deviation of 4 mm. However, the non-verticality of the column may cause lack of fit between the components in the beam to column connections.

The word tolerance should not be used, as is often the case, to describe provision for adjustment to overcome lack of fit.

8.1 Reasons for tolerances

Structural and architectural tolerances on frame and member geometry are specified in order to ensure that the 'as built' frame geometry complies with the designer's assumptions. Failure to satisfy these tolerances may result in:

- premature failure of the frame due to secondary forces
- premature failure of individual components
- inability to fit other building components around the frame
- inability to meet architectural requirements.

These reasons should not be forgotten by any of the parties involved with the design or construction of a building. They are not arbitrary, and onerous tolerances should only be specified where necessary, for example at an interface.

The aim of the structural tolerances specified in BS 5950: Part 2[85] is to ensure that 'as built' imperfections are no greater than those assumed in the structural design calculations. Compliance guarantees that frame deviations will not cause secondary forces greater than those allowed for in the design. It also guarantees that lack of fit between the frame members will not be excessive. Limited lack of fit can be accommodated using appropriate packing, without adversely affecting the performance of the connections. Compliance with BS 5950: Part 2 does *not* ensure that the frame components will fit together within an envelope which is suitable for the other building components. A lack of appreciation that BS 5950: Part 2 only covers 'structural issues' is the most common source of problems at handover.

The NSSS specifies tolerances needed to satisfy wider conditions than BS 5950: Part 2. Quality and buildability of the structure, and requirements for the

components to fit together within the specified envelope are addressed. Requirements for specialist following trades such as glazing are not included.

The NSSS tolerances reflect the process capabilities of good modern practice, so that specified tolerances are achievable. To quote from the foreword to the Third Edition, *The object of the NSSS is to achieve greater uniformity in contract specifications issued with tender and contract documents. This Specification should be invoked as part of the individual Project Specification and thus be part of the total building contract.* The NSSS adds to and draws out some of the information which is contained in BS 5950, and which the client has in the past placed in a job specific technical specification. The NSSS can be used for all types of orthodox steel buildings designed for static loading.

The European Prestandard ENV1090-1[88], available in 1997, will eventually supersede BS 5950: Part 2. In it, consideration has been given to why tolerances are needed. For example, during code development, evidence from multi-storey buildings in Sweden and Canada indicated that between one third and one half of all the steel columns failed to meet the requirements for plumb then incorporated in an early draft. These requirements were substantially based on the NSSS. Closer investigation showed that the failure of individual columns to comply was not important, provided that groups of columns could be considered to be tied together for stability purposes. The ENV was modified to allow relaxation of the requirement for an individual column, provided it was tied to a further five columns, and that the group as a whole complied. The consequences of having an individual column outside the tolerance limits was deemed not to compromise the structure.

Whereas structural tolerances are generally given to ensure that the centerline of a member is in an acceptable position, architectural tolerances may be associated with the face of an element, or indeed may apply to surface finishes.

KEY POINTS - Reasons for tolerances

Reasons for specifying tolerances must be understood by those involved in both design and construction. They are specified in order to;

- avoid premature frame failure
- avoid premature component failure
- avoid clashes
- meet architectural requirements.

8.2 Inspection and test plan

The project *inspection and test plan* should lay down procedures for ensuring and demonstrating that the 'as built' frame satisfies specified tolerances. When the plan is implemented, the designer can be assured that his assumptions with regard to deviations are valid. Full details of items to be addressed in this plan are given in Table G. 1 of ENV 1090 Part 1. Tests required at the handover stage are specified in terms of: