- the method of testing
- location and frequency of tests
- acceptance criteria
- actions to be taken if compliance is not achieved.

A dimensional survey is the usual method of testing, but its accuracy is limited by the accuracy of the surveying equipment. Dimensions are only measured to at best 2 mm, and often 5 mm, using optical instruments. This limited accuracy means that it may not be possible to achieve, or demonstrate, compliance of the frame.

A sequential, non-iterative process of plumbing-up is normally followed to bring the position of components within tolerance. This is not a final acceptance test as such. A simultaneous survey by engineers representing both the steelwork contractor and the main contractor is the most trouble-free way to achieve final acceptance. The process relies on an understanding of what is possible, and why tolerances are specified. Tolerance limits need not always be taken as go/no-go acceptance limits; the consequences of exceeding a limit should be considered before judging acceptability (see previous comments referring to how ENV1090-1([88]) treats a group of columns).

Demonstration of compliance using a full three-dimensional survey of the complete structure as a final acceptance test is not practical, because of difficulty, time and expense. Neither is it necessary if the purpose is to ensure the stability of the frame. When tolerances are satisfied over a representative part of the frame, deviations in the rest of the frame can be assumed to be acceptable based on a visual inspection alone. Often the frame may be represented by no more than one quarter of the frame nodes. As well as considering representative parts of the frame, testing should also cover those parts where deviations are critical. Ideally, plumbing-up should begin with braced regions, and end where onerous tolerances are specified at interfaces with, for example;

- cladding
- lift shafts
- crane rails
- architectural features.

Tolerances specified in the NSSS for erected steelwork assume that the frame position is checked under the self weight of the steel members alone.(10) Due consideration must also be given to the fact that the frame position will vary according to wind loading, so checks should be made in calm weather conditions. The influence of differential temperatures must also be considered; the NSSS specifies a reference temperature of 20°C.

8.3 Further reading

(For further information, see Section 9, References)

Tolerances in steel construction([80]). A three page article which gives good background to what tolerances are, why they are required and what different specifications contain.

The National Structural Steelwork Specification for Building Construction, 3rd Edition [6]. Presents tolerances for fabrication and erection operations. See also *Further Reading* in Section 2.4.

A suggested design procedure for accuracy in building [81]. Suggests a systematic design procedure. Covers design and site aspects.