- special environmental conditions
- details of underground services, overhead cables and site obstructions
- provision of hard standing for cranes and access equipment, as this may influence the plant that can be used for erection.

2.2.2 Site production requirements

The layout of a building or buildings on site should wherever possible recognise the requirements of site access, material handling and construction sequences. Access to and around the site may impose limitations on the size of members that can be used. These limitations may, in some cases, dictate the whole philosophy of the frame design. For example, a design which utilises a truss to give a large, clear span, is inappropriate if the truss is too large to be assembled on site and then erected.

In addition to physical constraints, the design philosophy may be dictated by time constraints on site. A 'construction led' approach means that the construction programme has a major influence on design decisions. For example, a restrictive construction programme may necessitate the incorporation of pre-fabricated components in the design. Pre-fabrication may also be appropriate for export work when labour costs on site are high, or there is a shortage of skilled labour.

2.2.3 Practical sequence

The designer will need to determine a possible construction sequence that would satisfy the requirements of a main contractor, whilst maintaining stability of the structure at all stages of construction. Computer modelling may be useful in developing the erection sequence, using a 'virtual prototype' (see Figure 2.1). The sequence should optimise plant use when practical; plant should not be idle for long periods of time, and principal member weights should not vary widely, so that cranage can be used efficiently.

The form of construction should be one that encourages the most effective, and safe, sequence of building operations. The designer should outline the assumptions made when developing the design in a 'design basis method of erection' (DBME), to use terminology from ENV 1090-1. The DBME should be included in the Health and Safety Plan (see Section 5). It is worth emphasizing that the DBME outlines the possible method of erection which the designer assumed, but it does not prohibit the adoption of an alternative method by the contractor.

Although additional method statements must normally be produced for each significant site operation, this is not the responsibility of the designer. They will be produced by the contractor, and should be compatible with the Health and Safety Plan. In this way, potential problems and safety issues, such as working near overhead cables or over water, are thought through in advance. The contractor will send these method statements to the client's representative for approval.

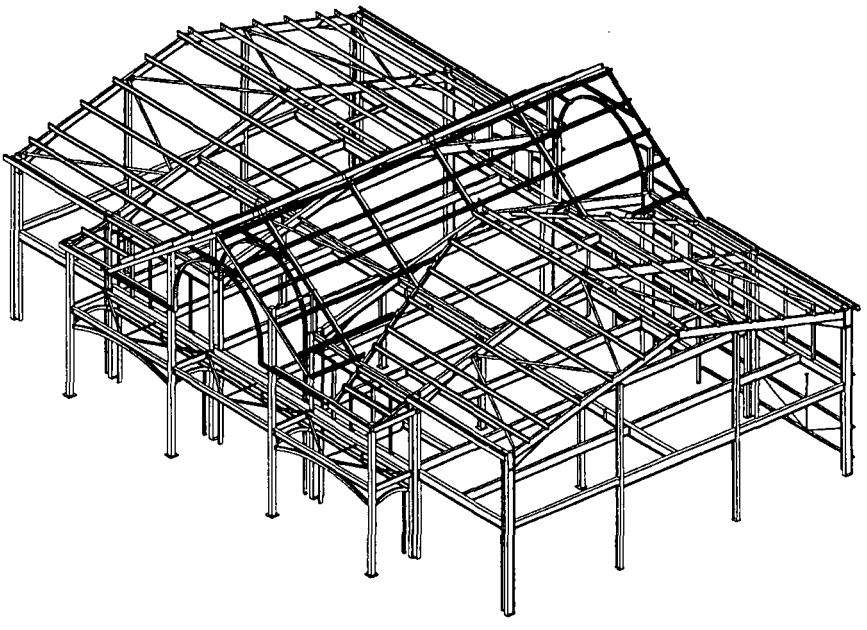

Figure 2.1 *Computer model, produced using CSC Xsteel software, of a steel frame (courtesy of Barrett Steel Buildings Ltd)*

2.2.4 Simplicity of assembly

The designer should design and detail a building to encourage simplicity of assembly. Standard, simplified connections should be used wherever possible. Time and cost penalties are often associated with less familiar forms of construction (see Section 3.3), because of the 'learning curve' effect. Repetitious, automated procedures, and the use of trial assemblies for complex parts of a structure can all help to speed construction and reduce costs.

2.2.5 Logical trade sequences

The main contractor will establish a master contract programme based on logical trade sequences and availability of information. This programme will be arranged to minimise the need for return visits, and optimise the time spent on site. The designer's choices can have a substantial influence on the potential 'efficiency' of this programme. For example, the use of steel decking in a multi-storey frame enables following trades to work at lower levels as steelwork erection continues up the building (see Section 6.4). The programme for steelwork erection will be more detailed than the master programme, but clearly must be compatible with it.

2.3 Management of the design process

A publication produced by the Institution of Structural Engineers, *Communication of structural design*[4] , lists several stages in the development of a project. The schedules given in that publication form a suggested framework containing the sequence of operations in which designers may be involved on any project, from inception to completion of the work. A consulting engineer would typically be involved in the design process from the feasibility study, and carry on through subsequent stages of design development to the preparation of production information such as drawings and schedules. However, a steelwork fabricator will not normally be involved in the process before the detailed design stage. It is worth noting that interpretation of the word 'design' therefore varies significantly.