Client Guide for Single Storey Buildings

This client guide presents the benefits that steel construction can provide to the owners and occupiers of single storey buildings. It offers guidance to clients on how to obtain best value from steel construction.

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1. Introduction

Single storey buildings contribute substantially to the built environment of Europe. They accommodate manufacturing, warehousing, transport, sports, retail and leisure activities.

Steel construction can offer the occupants, owners and developers for these wide ranging activities exceptional value, as evidenced by the overwhelming market shares that it achieves in some European countries.

The purpose of this document is to:

- Demonstrate the benefit that steel construction can bring to its customers
- Highlight the success of steel single storey construction in major national markets
- Illustrate the wide range of steel solutions that are available.
- Give some guidance on how to obtain best value from the market place.

2. The European market for single story steel buildings

2.1 Market size and distribution

The European market for steel for single storey industrial buildings comprises approximately 100 million square metres of covered space per annum, with a value of about 6 billion euros.

This data on industrial buildings encompasses manufacturing and warehousing applications. Reliable data is not available for the other single storey constructions in steel for sports, retail, leisure and transport, but must add substantially to this total.
As shown in Figure 2.1, market shares for steel in single storey construction vary substantially in Europe. Apart from some skewing in favour of steel in northern Europe, there are no obvious geographic or cultural explanations for this variability. The following section highlights some of the issues that create success in individual countries.

### 2.2 Factors influencing choice of material

Factors influencing market success for any supply chain are complex. However, an analysis of some of the more successful countries would suggest that the following criteria act in favour of steel.

- The presence of large developers who repeatedly procure single storey buildings and both appreciate the advantages that steel construction can provide and have the purchasing power to ensure they achieve value for money.
- The development of supply chain teams of main frame manufacturers, purlin and side rail system suppliers, cladding manufacturers and equipment (e.g. doors) suppliers who work efficiently together in long term relationships.
- The wide spread use of forms of contract that suit this form of construction (e.g. Design and Build in the UK).
- Strong industry infrastructures (e.g. BCSA and SCI in the UK, SCMF and CTICM in France) that support the supply chain, for example by ensuring that design, construction and contractual guidance is readily available and that the regulatory framework is benign for steel, especially with regard to fire safety engineering.
3. Advantages of steel for single storey buildings

All clients commissioning buildings have a business case for doing so. For instance, they may be building it for their own use, to rent out, as an investment or to sell on. Although industrial buildings are one of the least complicated building forms, there are several criteria which can affect the value that the building brings to the clients and users alike:

**Speed of Construction**

Logistics or similar businesses may need the building urgently to service a new contract and therefore speed of construction is vital. This can affect the design in many ways that are perhaps not immediately apparent. For example:

- The layout and components can be designed so that parallel rather than sequential construction can take place.
- Interfaces between trades need to be minimised.
- Collaborative discussion between trades will be needed to ensure that, whatever is decided, all aspects of construction can proceed quickly and safely.

**Flexibility in use**

Change is now a fact of life for most European businesses, with the likelihood of substantial evolution in the activities for which the building provides shelter during its design life. The wide spans and minimal use of columns that are readily offered with steel construction offer the maximum opportunity for the building to be able to accommodate different processes efficiently.

The client may at some point wish to sell the building to an investment organisation. To facilitate this option, institutional criteria such as minimum height and more onerous imposed loads can be specified to maintain the asset value and provide flexibility for unknown future uses.

**Maintenance**

Many buildings are constructed for owner occupation. Where a building is let, full-repairing twenty-five year leases, where the tenant is responsible for maintenance, are being replaced by shorter ones, where the owner carries maintenance responsibility. Any situation where the owner, who originally specified the building, has responsibility for maintenance, encourages the choice of better quality materials with a longer life expectancy in order to reduce maintenance costs. Increasingly, suppliers are providing guarantees and advice on necessary maintenance.

**Sustainability**

Energy costs and the reduction of CO₂ emissions are becoming increasingly important and sustainability is now a key issue within the planning process. In future, it is likely that planning permission will be easier to obtain with sustainable, environmentally friendly, solutions. Many clients, potential clients and occupiers have sustainability policies against which their performance is monitored by shareholders and the public.
Value for money

As illustrated in Section 2, where there has been sufficient client pull and investment by the steel construction supply chain, steel achieves high market shares. This success has been achieved in very competitive national market places and demonstrates the value for money that steel construction provides.

Examples

The examples of single storey construction in this client guide demonstrate the client value that may be achieved from steel construction for a wide range of single storey applications.

4. Achieving value from the whole: Form of contract and choice of suppliers

In a single storey building, the contributions to the overall value of the superstructure are typically:

- Primary frames 35%
- Secondary structure, purlins and side rails 15%
- Cladding 50%

All three components are clearly important individually. As discussed in more detail below, there are also very significant structural and performance interactions between these three components. All components are supplied by specialists.

Whatever form of contract is adopted, it is therefore essential that all significant suppliers have an opportunity to contribute to the development of the design and construction specification, if client value is to be maximised.

A key feature of any successful supply chain team is that it collectively understands how the whole building works and recognises the interdependencies between the various elements. The criteria for the selection of the various companies in the supply chain should take into account the potential supplier’s and individual’s understanding of how they can ensure the outcome that best meets the client’s business aspirations.

The success of any construction project depends not only on the quality of the companies and individuals involved, but also on the procurement route. Sheds differ from other forms of building in terms of their architectural design approach, since they involve the integration of a few well-developed systems. The details within each system are in the control of that system’s supplier rather than the overall architect. (By comparison, other buildings are constructed from many individual components and often assembled in a form that is unique to that particular building, with the architect having more control over all aspects of the design).

It is essential that clients recognise this important difference between sheds and traditional building construction, by selecting a contractor who has a history of bringing the system suppliers together early in the procurement process. This will enable their interdependence to be recognised and exploited to provide the overall best solution for the client. Successful clients recognise this and ensure that they select the procurement route and suppliers to suit their needs.
5. Overall design issues

Clients should have some understanding of the design process in order to be able to interact effectively with the design team. This section highlights the most important issues.

5.1 General

Steel construction is one of the most efficient sectors in the construction industry. Leading suppliers manufacture the components offsite, using computer controlled equipment driven directly by information contained in 3D computer models used for detailing. In addition to driving the manufacturing process, the information in the model is also used for ordering, scheduling, dispatch and erection. Single storey construction at its best, with its highly integrated design and manufacture, represents levels of efficiency to which other sectors aspire. The key to realising the highest level of efficiency is to work in a way that enables the optimum use of this infrastructure.

5.2 Choice of primary frame

The most popular choice of structural form for single storey buildings with spans of 20 to 60 m is the portal frame because of its excellent structural efficiency and ease of fabrication and erection. Portal frames may be designed using elastic or plastic analyses and design. Elastically designed portal frames are likely to be heavier, as they do not fully utilise the capacity of the sections, but are simpler to design and detail using non-specialist design software.

For longer spans, lattice trusses may be used to advantage instead of portal frames. Trusses are likely to be more efficient for spans over 60 m and in buildings of shorter spans where there is a significant amount of mechanical plant.

5.3 Interdependence of frames and envelopes

The structural efficiency of portal frames is partly due to the provision of restraint to the rafters and columns by the purlins and side rails respectively. Similarly, the efficiency of the purlins is dependent on restraint provided by the cladding. The cladding sheets are profiled to provide the necessary strength to span between the purlins and provide the required restraint. The profile has also to accommodate storm water run off. Designers and contractors should note that good interaction between the components is essential for structural efficiency and, for this reason, the cladding must be fixed to all purlins and rails in accordance with the manufacturer’s recommendations.

The design methods for the steel structure are now well understood and accepted by all parties and the focus of attention has shifted to the envelope and how this is to be supported. There are three major reasons for this:

- The use of sheds is no longer restricted to industrial buildings and they are now used in a wide range of commercial applications. Examples include multi-functional headquarters, call centres, retail and leisure premises.
- The need to promote client image and public access has meant more attention has been given to planning and aesthetics.
The focus on the energy saving qualities of the envelope and the increased significance of the EU Energy Performance of Buildings Directive (EPBD) with its requirement for energy labelling. The cladding has become the most significant element in the building and the emphasis and culture have to reflect this by designing the building from the outside in, rather than the earlier approach of the structure first with basic cladding systems fixed to it. The choice of building envelope contractor has also become more significant, if economic compliance with regulations is to be reliably achieved.

5.4 Energy performance

Reductions in U values over recent years have led to a considerable increase in insulation thickness, with implications for stability (of built-up systems), cladding weight and consequential handling requirements. There is a common perception that this trend will continue indefinitely as future regulatory changes increase the demands on the building envelope. However, in reality the relationship between insulation thickness and energy efficiency is subject to a law of diminishing returns and the point has now been reached where further increases in insulation thickness are unlikely to yield significant improvements in energy performance.

For many applications, the inclusion of roof lights is important because they reduce the amount of artificial lighting that is needed and, consequently, the energy demands of the building. However, they also increase solar gain, which can lead to overheating in summer and increase cooling demand. Heat loss through thermal bridging also becomes more significant as the insulation thickness increases, requiring the use of enhanced details and specialised components in order to satisfy regulatory requirements.

A balance of all the factors is necessary to optimise the reduction of emissions in the operation of any building.

5.5 Air-tightness

The introduction of air-tightness testing has highlighted the importance of designing and delivering a building that is not ‘draughty’. Recent studies have demonstrated that controlling air-tightness is a very effective way of improving energy conservation. As an example, while the current minimum standard for air-tightness of buildings is 10 m$^3$/m$^2$/hr at 50 Pascals, levels of air-tightness down to a tested value of 2 m$^3$/m$^2$/hr are possible with standard construction. However, achieving this level depends on an assured quality of construction and detailing. For buildings with floor areas less than 5 000 m$^2$ achieving good levels of air-tightness becomes difficult to achieve due to the higher proportion of openings relative to the clad area. While a common view is that air-tightness is the responsibility of the cladding contractor, in reality the necessary quality of construction can only be achieved if all contributors to the supply chain understand the requirements and the building design is well coordinated.

5.6 Design Coordination

Buildings are larger, higher and more highly serviced than they used to be. The contractor is responsible for the design, and it is important to select one who knows what constitutes a good design for the intended use, what they expect to see from the suppliers and how it can be achieved.
A significant part of the design process of the actual building is the coordination of the interfaces between the various specialist systems. This task, traditionally undertaken by the architect, is not easy because “how do you tell people what they do not know, if they do not know that they don’t know”. Better coordination will be achieved if the main frame contractor is responsible for the design. To assist with the coordination, it is beneficial for the contractor to prepare a list of drawings that the architect is expected to produce, with the help of appropriate participants.

5.7 **Mainly architecture**

The focus for the design should be to provide clients and users with solutions that improve their business performance. In the pre-contract phase, the architect has a significant role in dealing with site-specific issues such as obtaining planning permission and dealing with abnormal situations such as wayleaves and flood risk. A prime task for the architect is the sizing of the building and the determination of how the elements are set out relative to grid lines. There are institutional standards for measuring lettable area, minimum height to underside of structure, floor loadings, durability of cladding etc. The advent of the EU Energy Performance of Buildings Directive in 2006, where buildings will have to have their energy rating declared on change of ownership or usage etc, will encourage standards to be set for this attribute too.

Developers and funders are clearly anxious that any investment is future proofed in terms of its asset value. This generally means that flexibility for potential future tenants or owners is a significant criterion. Nobody wants to pay more than they need, but it is important to set appropriate quality and technical criteria (and see that these are maintained throughout the design and construction process), before going out to competitive tender. Attributes that should be considered, in addition to those required by regulations include:

- Overall geometry
- Minimum height (clearance for crane beams, depth of haunch etc)
- Achieving maximum lettable area according to the conventions for measurement
- Column layouts to give appropriate future flexibility of use
- Loading
  - Service loads on purlins
  - Service loads on frame
  - Imposed floor loads
- Cladding system and available guarantees
- Adequate access for possible future vehicle needs
- Tolerances of floor slab
- Potential for re-use / recycling of materials
- End of useful life liability
- Energy consumption and reduction of CO₂ emissions
5.8 Mainly engineering

The effects of the site conditions on the structural solution, together with the engineering design of external works, will normally require the appointment of a consulting engineer to work alongside the architect prior to letting the Design and Build contract. The duties will include the selection and design of a suitable foundation system. In the majority of buildings, the structural frame will be pin-based. Economies in the frame design in terms of weight of steel can be made where nominally fixed bases are used, but this approach will have implications for the cost of the foundations. It is, therefore, important that this decision is made by the consulting engineer rather than the steelwork contractor, as the former will be in a better position to assess the overall effect on the cost of the building and suitability with regard to the ground conditions.

5.9 Influences on structural design and costs

When obtaining prices, it is important to ensure that there is clarity as to what is expected in each work package and that submissions are reviewed for any ambiguities or omissions. Particular attention should be given to ensuring that:

- The cladding system and frame design are based on the same wind loading criteria. A set of calculations should be requested from the envelope contractor showing the fixings that are required. It is recommended that the steelwork contractor also issues the relevant sections of his design information to the envelope contractor.

- The tolerances of the frame and chosen cladding system are compatible. This issue has become more important as aesthetics have assumed greater importance, leading to the selection of cladding systems with tighter tolerance requirements.

- Provisions have been set out for sprinkler systems and that these can be sustained in terms of both load capacity and space required, with pipes of up to 150 – 200 mm diameter. The sprinkler system is generally carried by the purlin system and the layout can affect bracing locations and arrangements. Larger pipes may need special provision.

- Loads on secondary members are adequate. Cladding systems and services have increased in weight over the years and assumptions may be lagging behind current practice.

- An adequate allowance has been made for the weight of the gutters. Insulated gutters weigh around 140 kg for a 3 m length and require specific design of the supporting steelwork. Gutters are often designed on the assumption that they will fill with snow, but it should not be forgotten that they can also fill with water, which is considerably heavier than snow. The supporting steelwork design should recognise these loads, but experience suggests that many designers have not updated their assumptions in line with changes in the construction. The location of overflow pipes affects the layout of the steel framing and the advent of syphonic drainage systems means that the tolerances and deflections of the support system can be critical for effective operation. The weight of the gutters is such that cranage is necessary for erection and this may need to be provided by the steelwork contractor.
5.10 Sustainable construction

The need to consider sustainability is now recognised in all walks of life and the importance of the role played by construction is widely acknowledged. The requirement for sustainable construction is being encouraged in many ways, ranging from EU Directives on emerging efficiency to the increasing adoption of Corporate Social Responsibility policies by companies. The ability to demonstrate a sustainable approach is becoming an essential part of obtaining planning permission. The concept of sustainability is underpinned by the need to balance the triple bottom line of economic, social and environmental viability. Good construction should meet all three criteria and good steel construction certainly does.

Economic considerations

As has been described earlier, steel construction systems have been refined over the past three decades and the various elements of the building are brought together in a highly integrated design, which is then manufactured and constructed using efficient production processes. The use of material is highly optimised and waste virtually eliminated. The buildings themselves are used for most aspects of modern life including logistics, retail, leisure, commercial and manufacturing and so provide economically the efficient infrastructure on which we all depend.

Social aspects

Sustainable construction should also help to improve the quality of life of all involved in its production. The high proportion of offsite fabrication in steel buildings means that working conditions are safer, better controlled and protected from the weather. Additionally, by providing a fixed location for employees, it is easier to develop communities and family life than with an itinerant labour force associated with site-based construction. A stable workforce is also beneficial for the development of skills, since employers will be more likely to invest in their employees by facilitating training and encouraging career development activities.

Environmental considerations

The environmental aspects of sustainability are well developed and there are powerful arguments in favour of the use of steel sheds over alternative forms of construction. Steel is among the most recovered and recycled materials available. Research has shown that 84% of steel frames and cladding from demolition sites is recycled and a further 10% reused. Although the materials are recovered after demolition, extending the building’s life is generally more beneficial. This is often possible with steel construction, since the large open spaces designed to appropriate standards give flexibility for potential changes in use. The concept of extending a building’s life also applies to the building envelope by specifying the latest organically coated steel cladding, which is designed to give a guaranteed design life of up to 30 years.

In service, energy consumption and carbon emissions are regulated by the EU “Energy Performance of Buildings” Directive of April 2006. This aspect of sustainability has possibly the greatest impact on the environment, since the CO₂ emissions associated with the operation of any building far exceed those resulting from its construction. In this respect, modern steel buildings perform well, easily meeting if not exceeding the requirements of the latest regulations.
6. Conclusions

For single storey buildings, steel offers:

- Cost efficiency in construction
- Low maintenance throughout a building’s life
- Long spans that can accommodate changes in building occupancy and activity, thus extending a building’s economic life.
- Highly sustainable contributions to Europe’s Built Environment.
- Single storey steel buildings are one of the most efficient sectors in the construction industry, with optimised approaches to the primary frames, secondary structure and cladding from specialist suppliers.
- Single storey steel buildings should be provided in a way that ensures that all the specialist suppliers can make maximum contributions to overall client value.
- Clients should interact with both the design and supply teams to ensure best value for their projects.

Gazeley G-Park, Bedford
Courtesy of Corus
Astral Court, Baglan
Courtesy of Corus

Distribution warehouse for Argos Direct, Bedford
Courtesy of Barrett Steel Buildings Ltd.
Kingswood Lakeside Business park, Cannock
Courtesy of Barrett Steel Buildings Ltd.

Logistikzentrum, Stuttgart
Courtesy of Jörg Wolf, Architekt
Campushalle, Flensburg
Courtesy of Prof. Bernhard Winking Architekten
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