

**COMPARATIVE STUDY OF STRUCTURAL STEEL AND REINFORCED CONCRETE
METHOD: A PROJECT MANAGEMENT CASE STUDY**

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To my beloved parents.

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ABSTRACT

Structural steel construction has been quite common construction method in the world. In other developed countries such as Japan, structural steel is considered as a norm and is frequently opted for in construction. However, in Malaysia, steel construction is one of the construction methods, which is yet to be as popular. Many of our traditional construction methods such as reinforced concrete construction are still greatly favoured by our construction industry. One of the common comment of the usage of structural steel in construction is it is a more expensive option if compared to R.C construction. It is the aim of this research study to carry out a comparative study between structural steel construction method with one type of traditional construction method (R.C construction is chosen here). Comparison will be made with 3 principle project management criteria for a successful project, i.e. time, cost and quality. Through this case study on these two type of construction methods, the advantages and weaknesses of steel construction can be reviewed. It was found that material cost for the structural steel construction method is indeed more expensive than the R.C construction method and this is because focus is on the material cost only and other perspectives such as quality; time savings and cost savings, which may result; are generally ignored. From this study, it is hope that structural steel usage can be strengthened and other aspects such as time savings and quality can be taken into more serious consideration by all parties in the industry when choosing construction method to adopt. And hopefully, structural steel can be as good as option if not a better one compared to R.C construction.

ABSTRAK

Pembinaan struktur keluli merupakan jenis pembinaan yang umum di seluruh dunia. Di negara maju seperti Japan, struktur keluli selalu digunakan dalam pembinaan. Di Malaysia, pembinaan struktur keluli merupakan salah satu cara pembinaan yang sedang menjadi semakin popular. Cara pembinaan tradisional seperti konkrit bertulang masih banyak digunakan dalam industri pembinaan kita. Komen umum bagi pembinaan struktur keluli ialah harganya lebih tinggi berbanding dengan pembinaan konkrit bertulang. Kajian ini adalah bertujuan untuk membanding antara cara pembinaan struktur keluli dengan cara pembinaan tradisional (pembinaan konkrit bertulang telah dipilih). 3 aspek projek pengurusan, i.e. masa, kos dan kualiti telah dibandingkan. Melalui kajian kes bagi 2 jenis cara pembinaan ini, kebaikan dan kelemahan bagi pembinaan struktur keluli dapat diketahui. Didapati kos bahan untuk cara pembinaan struktur besi adalah lebih tinggi berbanding dengan cara pembinaan konkrit bertulang kerana tumpuan diberi kepada harga bahan sahaja dan tidak mengambil kira aspek lain seperti kualiti, menjimatkan masa dan kos. Melalui kajian ini, harap penggunaan struktur keluli dapat dipertingkatkan dan aspek lain seperti penjimatan masa dan kualiti boleh diberi tumpuan secara serius semasa memilih cara dan bahan pembinaan. Harap struktur keluli dapat setanding dengan pembinaan konkrit bertulang kalau tidak lebih baik daripadanya.

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CHAPTER 1

INTRODUCTION

STEEL, as we know of it today is a modern human creation. Steel as a basic ingredient in construction has come a long way in the evolution chain.

As early as the fourth century B.C, the cast iron has been invented in China. From the mid-eighteenth century to the mid-nineteenth century, wrought iron was used in building and bridge construction. Steel was first manufactured in United State in 1856. The first important construction project using steel was in the still-existing Eads Bridge at St. Louis, Missouri, which was completed in 1874. In 1884, the first high-rise steel-framed building, the 10-storey (later 12-storey) house of the Insurance Company Building was built in Chicago.

In the nineteenth century, within Europe, a new construction system identified as the "Architecture of Iron" was developed. With only rare exceptions, much of that construction erected in Europe no longer exists because of its replacement with more modern structures. But a large portion of this type of system was exported to the European colonies for rapid, quality construction that bypassed the need for first developing a construction materials infrastructure. Production was exported to the

Americas, Asia and Africa: mainly from United Kingdom which at that time had sovereignty over metallurgical products in general, even within Europe. Brazil was a major recipient of prefabricated cast iron buildings and residences. They were practical, relatively inexpensive and could be assembled with local labor after a training period.

From a social and architectural viewpoint, construction in iron also fitted the mood of a developing industrial revolution. Iron adapted well to these constructions; its characteristics lifted discussions about industrial aesthetics to a new level. The battle of styles, present throughout the whole of Europe in the nineteenth century, varied from New Gothic to Eclecticism by facilitating the repetition of any former style with more elegance and lightness than the materials used until then.

Nowadays, the steel industry has always been a vibrant one in the developed world. While the Eiffel Tower made in steel stands tall as the landmark for Paris, the Howrah bridge and Vidyasagar Setu across River Hooghly in Calcutta sing laurels to the amazing capabilities of this ingenious building material. There are lots of other great steel structures have been built all over world such as Burj Al-Arab Tower Hotel (tallest tower hotel in the world) and Skywalk tower bridge, which link the two Marriot Executive apartments in Dubai, Melbourne's Colonial Stadium in Australia, Kingdom Centre Riyadh in Saudi Arabia and the Sky Restaurant (one of the most complex buildings).

Over the last few years, the use of steel in Asia has developed considerable interest, especially for the high-rise buildings. A future Olympic host city, Beijing,

has also adopted a steel solution for one of its major pre-Games infrastructure projects, the new International Airport.



Figure 1.1: Beijing International Airport, China

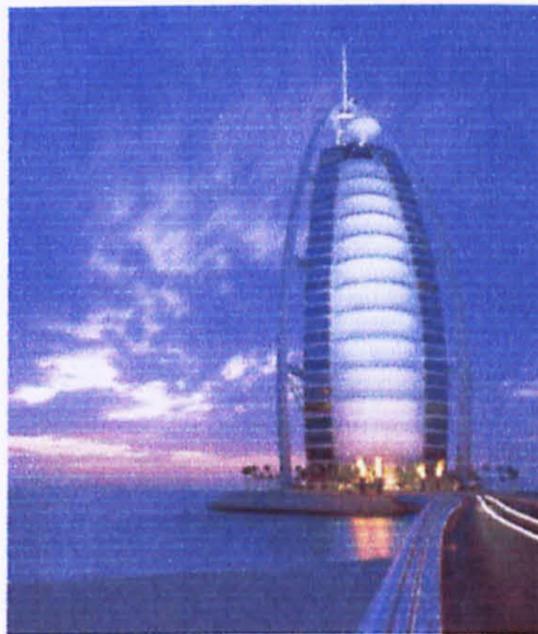


Figure 1.2: Burj Al-Arab Tower Hotel

The usage of steel in construction has been quite common in the world. Lots of structures are built by using steel, such as high-rise buildings, ware houses, houses, bridges, stadiums and other else. Many architects and engineers prefer to design the structures with steel as the main material. It is because there are lots of advantages. Steel is not only used to provide a stable framework for a structure, in many cases, it is also chosen for its aesthetic appearance.

Steel framing for single family homes is already popular in some parts of the country. In areas of Florida, where concrete block is the predominant exterior wall material, steel has about half of the interior stud market. Steel homes are also common on the West Coast (because of concerns about earthquakes) and in Hawaii. Another common use is in markets where basements are built and finished by the builder. According to the American Iron and Steel Institute, approximately 25% of all Homes in the next five years will be built with steel framing. This is due to the tremendous success of the already existing thousands of steel frame Homes around the U.S.A. and other countries.

Besides that, steel construction is also frequently used in high-rise building. It is because the weight of steel is very much lighter than concrete. Structurally, steel provides large, clean span bays and fewer columns, making for economical and efficient layout, merchandising and occupant traffic flow. By this reason, steel construction is common method to use in building the bridge.

In Malaysia, steel construction is still at the beginning stage. Usually steel truss is the most common element that is used in construction. Besides that, steel construction is also used in ware house, factory, bridge and stadium. Only in these few recent years, some of the superstructures such as Petronas Twin Towers, tallest building in the world, built by using steel construction represents one of the best examples of high rise building. However, the usage of steel in construction is still very low compare with other developing countries.



Figure 1.3: Petronas Twin Towers

Steel construction has a great potential in the growth and development of the construction industry. Recognizing its pivotal role in the building and construction industry, MSSA proactively promotes structural steel as a material of choice. The aim of the Association is to develop and promote the use of structural steel in Malaysia, comprises a group of dynamic individuals and corporations who share the vision of establishing structural steel as a material of choice for the construction and building industry in Malaysia. Inevitably, structural steel, will become an important construction material and continue to grow in its applications and uses in the future.

1.1 What is Steel?

Steel is a variety of iron intermediate in composition and properties between wrought iron and cast iron, and consisting of an alloy of iron with an iron carbide. Steel, unlike wrought iron, can be tempered, and retains magnetism. Its malleability decreases, and fusibility increases, with an increase in carbon.

There are five main types of steel:

- (i) Carbon Steel – containing varying amounts of carbon, manganese, silica and copper
- (ii) Alloy Steel – as in (i) and in addition containing varying amounts of vanadium, molybdenum or other elements
- (iii) High-Strength Low-Alloy Steel – as in (i) and in addition containing small amount of expensive alloying elements
- (iv) Stainless Steel – as in (i) and in addition containing chromium, nickel and other alloying elements
- (v) Tool Steel – as in (i) and in addition containing tungsten, molybdenum and other alloying elements

Each types of steel exhibits different characteristics such as strength, ductility, hardness, and corrosion resistance. The most widely used type of structural steelwork is carbon steel. Stainless steel is frequently used for architectural reasons.

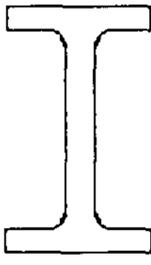
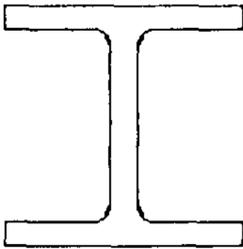
Steel is in many respects an ideal structural material, which exhibits a number of useful structural characteristics such as:

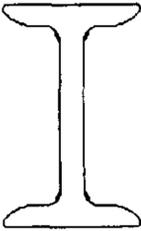
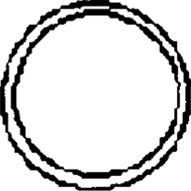
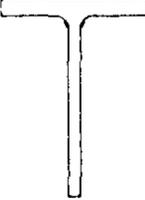
- Structural behavior up to initial yield which is linearly elastic
- Deformation which are directly proportional to applied loads, and are fully recovered on removal of the loading
- The yield strength in tension is approximately equal to the crushing strength in compression
- Isotropic behaviour
- Long term deformation (creep) at normal temperatures is not a problem

Steel construction contributes significantly to sustainable construction because of the inherent advantages of steel namely strength, durability and flexibility. Design and flexibility are the main advantages as the use of steel allows for aesthetically attractive long, slim and waveform construction. Steel is also termite-proof, fire resistant and cost effective investment when considering safety and peace on mind. Besides that, steel construction also shortened the construction period, allow longer span and headroom, good in quality control, recyclable and require minimal labour.

1.2 Types of Steel Product in The Market for Construction

Besides the rebar steel, there are many types of steel products for construction. There are universal beams, universal columns, flange channels, angles, joists, plates, circular hollow sections, square hollow sections, rectangular hollow sections and rails. All these structural steel products have its own usage in steel construction.

Type	Picture	Usage
1. Universal Beams		Beam & Column
2. Universal Columns		Beam & Column

3. Channels		Truss Member & Beam
4. Angles		Truss Member
5. Joist		Small Beam
6. Circular Hollow Sections		Truss Member & Column
7. Square Hollow Sections		Truss Member & Column
8. Tees		Truss Member
9. Tubes		Truss Member & Column

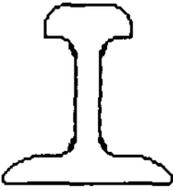
10. Rails		Railway Material
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Table 1.1: Types of Steel Products and Usage

The main supplier of structural steel products in Malaysia is Perwaja. The design standards that have been used are British Standard.

1.3 Aim and Objectives

In Malaysia, steel construction even though has been around for quite some time, the usage of steel is still very limit if compared with other construction material such as reinforced concrete. Steel construction in Malaysia is still new if compared to other countries around the world. Malaysia does not have many superstructures built by using steel. The use of steel in construction is limited to certain level. Most of the designers are still conservative and reinforced concrete construction is still the most common method that been used in past years.

The Malaysian Structural Steel Association (MSSA) contends that the usage of steel in construction is still very low. The local design engineers and architects have limited exposure to the use of steel in construction. Certain regulations are also not conducive to steel usage in construction. These cause the development of steel construction become slower.

Reinforcement concrete construction is one of the most common traditional construction methods in Malaysia. Most of the designers are familiar with R.C construction method and material and are generally not keen to use steel as main construction structure unless requested by clients or absolute necessary. As a new method, steel construction has less standards and considered as “unknown” material. The price of steel is also always considered more expensive than reinforced concrete. These have become the obstacles to the designers and clients when considering to use steel construction method.

The aim of this study is to do a comparative study between the structural steel construction technology with traditional construction method, reinforced concrete (R.C) construction has been chosen for this research study. It is our objective to study the advantages and disadvantages that structural steel construction has to offer in construction as compared with reinforced concrete construction. Through the study of two local case studies on two high level water tank towers structure and other relevant projects, the advantages and disadvantages of steel construction compared to reinforced concrete construction will be explored. This case study will be carried on two real projects from the project management perspective. Based on 3 criteria of Project Management of a successful project, cost, time and quality aspects of construction will be used as a guideline to do the comparison and decide on whether steel may be better, lesser or equivalent method to the R.C construction.

By making the comparison between the steel construction and traditional construction method – R.C construction, we will be exposing ourselves to another construction method. The steel construction may be another option to consider. We

could possibly have another alternative. By knowing the benefits of steel construction, the usage of structural steel in construction can be strengthened. Steel will hopefully not only use as rebar and truss, but also in other structural elements such as beam and column.

CHAPTER 2

LITERATURE REVIEW

2.1 Advantages of Steel Construction

Steel construction has a great deal to offer in terms of sustainable development. It is therefore important that the sector flourishes in a way that allows for the implicit qualities of steel and steel construction to be fully realized. This will in turn contribute to the development of the broader construction industry.

Sustainable construction encompasses a wide range of issues, such as reusing existing built assets, designing for minimum waste and maximum building flexibility, minimizing resources and energy use, reducing pollution and their environments.

The challenge is for the industry to move towards socially and environmentally responsible policies, whilst at the same time maintaining economic viability. Hence, it is important that policy and decision makers in the industry appreciate the benefits offered by structural steel.

One of the advantages from the project management perspective, the use of steel construction is reducing construction time (high speed). According to Malaysian Structural Steel Association, MSSA (2003), by using steel in construction, the amount of time in which a project may be completed is considerably less than in a project using traditional construction method such as reinforcement concrete. According to Ibrahim (2003), it is possible to achieve time saving of up to 30 percent. Steel is also very suitable for phased construction, which is necessary for complex projects. This will often lead to a shorter construction period and earlier completion period. Steel construction is very fast because there is no 'wet' work to be done. For bridge construction, there will be less disruption to public. The high speed of construction will lead to quick erection to full height of self-supporting skeleton.

According to Lobo and Wildt (2003), taking full advantage of the reduced construction time inherent with steel will required a change in Brazilian construction culture. Currently, the relatively extended period of conventional construction is compatible with the time required for the commercialization of buildings units. Therefore, the longer construction period inherent with concrete is not seen as either a cost or detriment to a project's success.

To make reduced construction time a marketing factor, a number of actions will have to occur: First, if buildings are commercialized at a faster rate, the "cost" of uncollected rent can be shown as a non-recoverable cost against construction cost. Second, during times of economic growth, the "rapid availability" of a structure can have an impact on constructional material decisions.

According to Pal and Mediratta (2000), in India, heavy dependence on borrowed capital, and necessity for permitting private/foreign participation in infrastructure projects will require speedy implementation without time and cost overrun. To achieve this goal, like most of the developed countries, which have solid infrastructure base, the steel intensive or steel-concrete composite construction route needs to be adopted. The per capita consumption of steel in India is only 27 kg, whereas the same is about 15 times higher in USA and about 45 times higher in Singapore.

Besides that, steel construction has lighter construction weight. Steel is light but very strong. The transportation of the material and site handling are easier. The steel weight is typically 50% weight reduction over concrete. As a result, there will be fewer piles and reduction of the foundations size. The foundations and site costs are cheaper than concrete construction. As a result, it reduces the foundation costs.

According to Lobo and Wildt (2003), the relatively lighter weight of steel construction, as compared to concrete, can be a positive feature due to the effect of weight on the cost of foundations in cities where underground water is close to the surface and where there are unstable geological formations. This condition may reverse for super-high structures where the overturning effects of wind demand weight for stability – a criterion not likely to impact Brazilian construction for many years to come.

Steel structures are always in high quality condition. The properties are standardized and the sizes are very accurate. Unlike concrete, the qualities are varied and it will affect the accuracy of construction. Components are produced under