# Sustainable Modular Construction

## Introduction

On January 30, 2018, Red Sea Housing delivered a Technical Workshop which discussed a holistic approach of achieving sustainability through modular construction. The workshop was facilitated by Nicholas Reynolds and Rakhi Raghavan, of Red Sea Housing Services, who provided an overview of the global status of modular construction and the various benefits it offers as compared to traditional construction.

## What is Modular Construction?

Modular Construction is the method of using prefabricated modules, built off-site in a controlled manufacturing process, to construct building structures. Contrary to misconception, modular construction is not a new concept and has existed for 150 years with a patent shown in Figure 1, showing a “portable” town for Australia made from a “manufactory”. Additionally, modular structures can also be permanent standing structures; for instance, a modular church built in 1897 still exists in Australia. A key difference of modular construction, however, is that the modules are constructed with steel rather than concrete; though it can be constructed with other materials such as cross laminated timber and fibre reinforced polymers (composites).

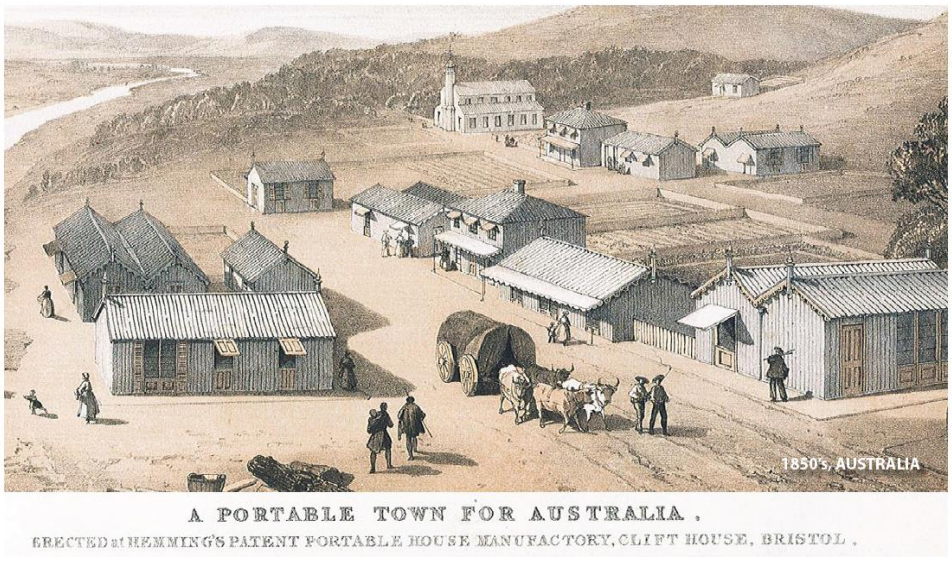



**Figure 1 Showing a patent for a portable town in Australia**

**Advantages of Modular Construction**

Smarter – Modular buildings are built with the same materials and to the same building codes and architectural specifications as traditional construction. They however, can be more economical as modular construction saves capital expenditure and delivers on time, and within budget. It also offers a safer construction environment as all the modules are built within factory conditions, thereby reducing the risks of accidents and related liabilities for workers. The MEP services within the building can be built so that they be easily connected on-site. An example of this is seen in Figure 2.


**Figure 2 Modular MEP risers**

Additionally, Building Information Modelling (BIM) compliments modular construction very well as modules can be construction ready as soon as the design process is complete. Comprehensive, fully co-ordinated digital models mean that the finished product remains true to original production drawings.

Greener – The factory-controlled process ensures less waste is generated as waste is almost eliminated by recycling materials, controlling inventory and protecting building materials. It also results in less site disturbances as on-site traffic from workers, equipment (up to 90% less vehicle movements to site) and suppliers is greatly minimized. This has an indirect benefit of reducing the carbon footprint of the construction and also results in reducing noise, dust, etc. Additionally, demolition of the building

can be incorporated right from the beginning of the design as the modules can be disassembled, and the building materials and components can be re-used again.

Faster – This is where modular construction outclasses traditional construction as shown in Figure 3. Construction of modular buildings occurs simultaneously with site and foundation work, allowing projects to be completed 30% to 50% sooner as compared to traditional construction. Furthermore, 60-90% of the construction is completed inside a factory, which mitigates the risk of weather delays. Buildings can be completed and occupied faster, resulting in a faster return on investment.

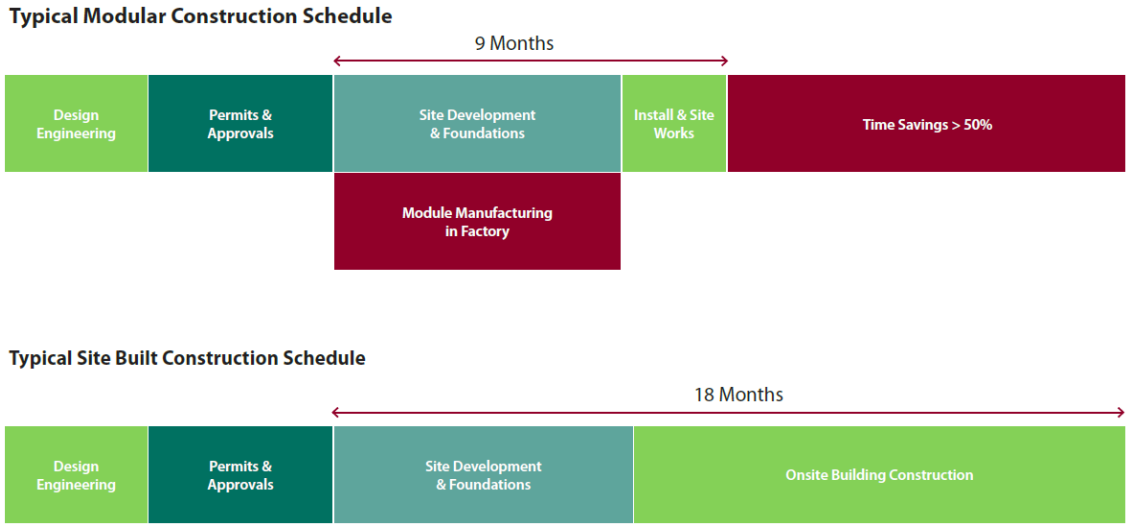
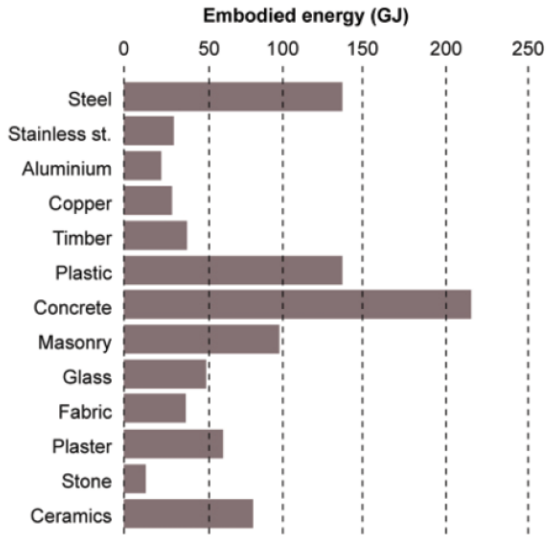



**Figure 3 Construction time for typical modular construction vs. a typical site-built construction**

**Steel vs concrete**

Steel, and not concrete, is primarily used as the structural element in the construction of the modules. The use of the steel framing provides environmental benefits as it results in less scrap and job site waste than wood or concrete. Additionally, structural steel can be continually recycled and has very low embodied carbon (see Figure 4) and does not lose any of its inherent properties. It also complies with sustainable building standards such as the International Green Construction Code (IgCC), ASHRAE Standard 189.1 (Standard for the Design of High Performance Green Buildings Except Low-Rise Residential Buildings), and the Green Building Standard (ICC-700).




Source: CSIRO

**Figure 4 Embodied energy of different materials used in the average Australian household**

Steel offers higher tensile strength as compared to concrete and offers higher versatility as it can be fabricated into a wide array of designs due to its elasticity. However, its strength can be significantly compromised at elevated temperatures and therefore fire-resistant materials needs to be incorporated to improve safety. Furthermore, it does not have the same chemical/corrosion resistance that concrete offers.

**Global overview**

Australia and UK are leading the way in terms of using modular construction with hotels and apartments being constructed using this technique; the US is also following suit. The buildings are not limited in terms of the height with the some of the highest modular constructed building standing at 44 floors (see Figure 5).


**Figure 5 Modules being transported on-site and being craned into position for final assembly. Final constructed building stands at 44 floors.**

Hotels and apartments are ideal for modular construction as the hotel rooms are traditionally standardized and there is not much variation. Furthermore, the modules can be fitted out with out with furniture, lighting and electrical wiring, ductwork, etc. which result in even faster construction to occupation time, resulting in higher return on investments. All Citizen M Hotels, for example, are constructed using modular construction, which results in the same standard of quality across all their built properties across the globe.

In space-limited cities such as San Francisco, London and Toronto, there are trends of moving towards build to rent development models that enable repetition, scale and volume in production; making modular construction ideal for use. Build to rent models result in a higher quality standard of construction and operation of the building as the company (contractor) retains possession of the property for an extended period and therefore operate it efficiently. Other trends in these space-limited cities are transitions to micro-apartments and moveable walls and furniture, which make modular construction more attractive.

Findings from direct cost to cost comparison for just the on-site construction of modular construction shows that production of the modules is more cost effective; but there are other costs associated with modular construction such as soft costs (foundational work, factory set-up, etc). In the context of UAE,

overall traditional construction costs are still quite cheap. However, if you compare the compare the other economic factors such as the return on investment, then modular construction within UAE can be cost-competitive. Bathroom modules are commonly used in the UAE and some projects in Abu Dhabi are already being constructed entirely using modular construction. Affordable housing projects using modular construction are also in development in Saudi Arabia.

**Future of modular construction**

Modular construction can benefit from the innovations made from the manufacturing industry and therefore be largely automated entirely; requiring very little manpower. Additionally, augmented reality using devices such as HOLOLENS and GOOGLE GLASS 2 and Artificial Intelligence can allow factory work to be combined with the digital realm, opening up possibilities of training, supervising, instructing and collaborating with immediate feedback and information coordination. 3D printed components can significantly reduce the material usage within the modules and can even further enhance the structural integrity of the modules. Components and parts can also be made as and when necessary so that there is also a possibility of shifting towards a build to use model of construction as opposed to a build to stock model. As fit-out of the modules can take place entirely within the factory, smart controls and sensors can also be incorporated, which can potential contribute to the Internet of Things (IoT).

## Conclusion

There are numerous benefits of using modular construction over traditional construction, among which includes improved sustainability and shorter construction times. These benefits, however, are only realized for cases where there is repetition within the buildings, as is the case for hotels and apartment blocks. Furthermore, the production of these modules requires the input of various stakeholders within the building industry chain such as the consultants and MEP engineers who need to verify that the modules being produced built according to requirement. Globally, Australia, UK and US have made significant progress in this field and therefore the UAE should utilize their knowledge and expertise to accelerate the use of modular construction in the MENA region.