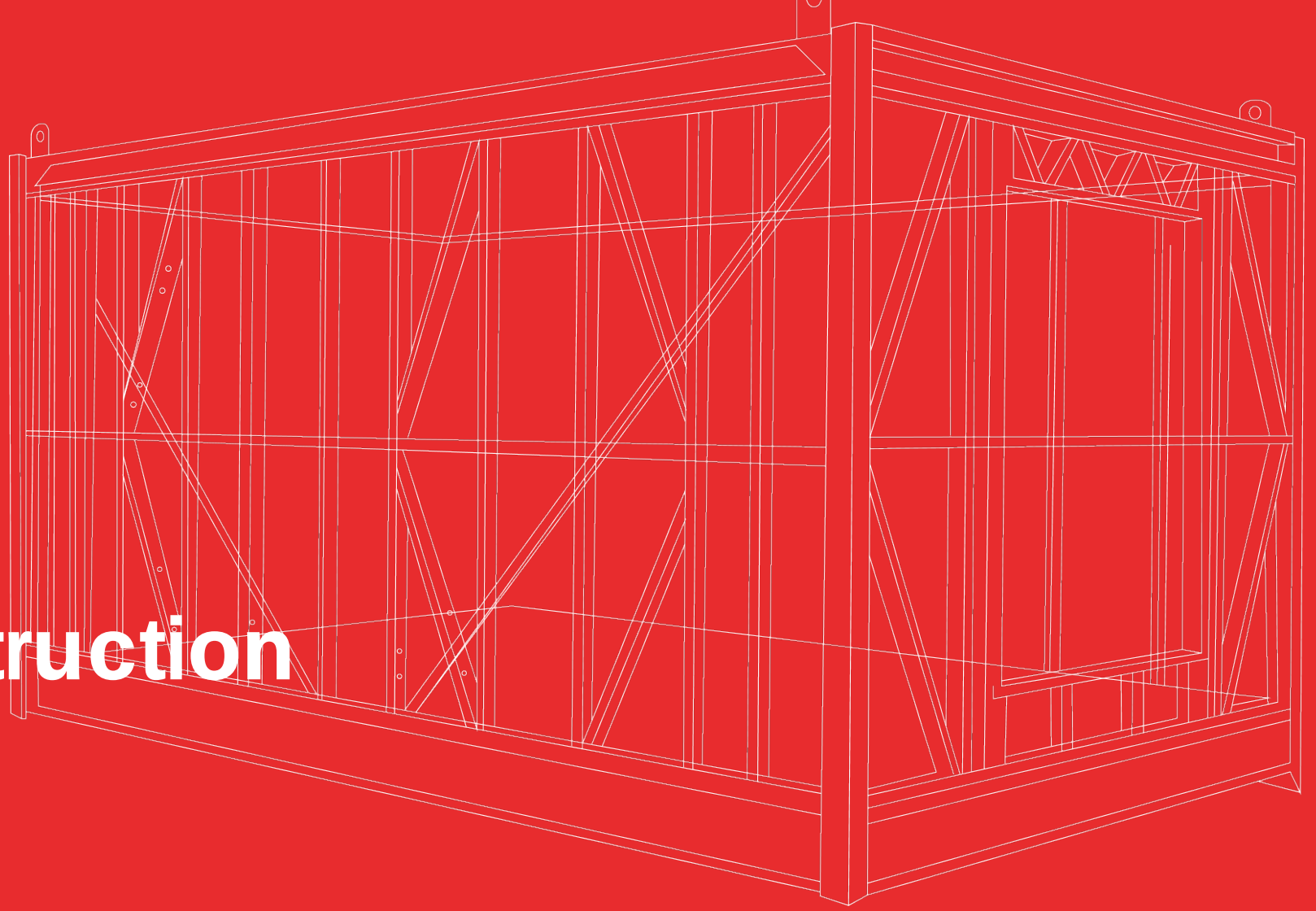
Modular Construction

hi MONTE case study



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Offsite Modular, Unitised Façade and Floor System Features

- Economy of scale through repetitive manufacture
- Rapid installation onsite
- High level of quality control in factory production
- Low selfweight leading to foundation savings
- Limited disruption in the vicinity of the construction site
- Adaptable for future extensions, and easily dismantled and moved if required
- Robustness achieved by attaching the units together
- Stability of tall buildings can be provided by a braced steel core

- Suitable for buildings with multiple repeated units
- Size of units is limited by transport – can be larger than a sea container
- Open sided units can be created
- Modules are usually stacked with no independent structure
- Self weight of 1.5 to 2 kN/m2
- 4 to 10 storeys current design, hi-rise design possible & in process
- Fire resistance of 30 to 60 to 120 minutes
- Acoustic insulation is provided through double layer walls and floors.

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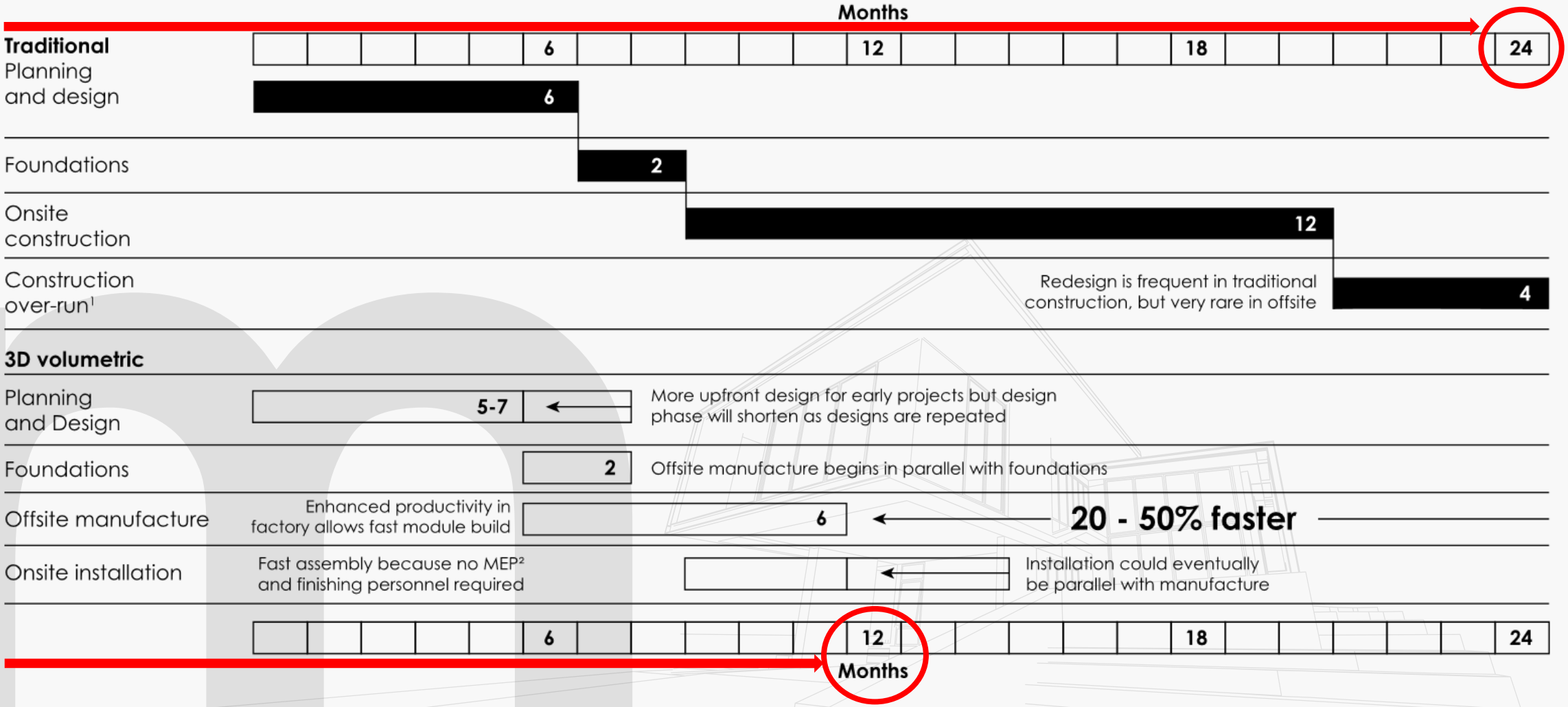
Modular and off-site construction

- Steel Assembly Structures: modular and off-site construction in practice

Example apartment project construction duration, traditional vs off-site 3D volumetric, months



Source: 2019 McKinsey & Co report
Modular construction: From projects to products

Case study and example: timeline for 138 unit, 123 room modular hotel

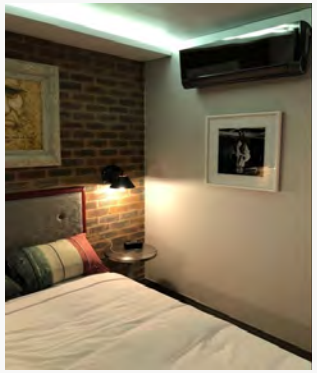
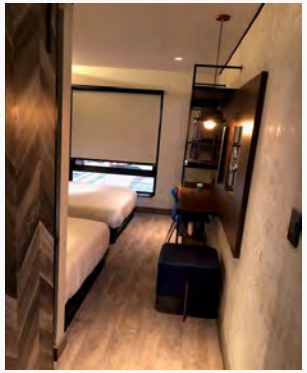
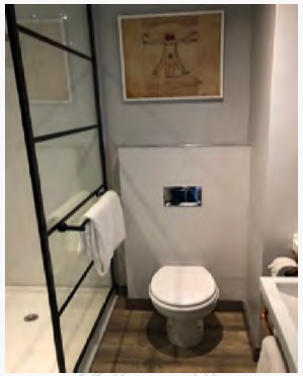
Client: Tsogo Sun

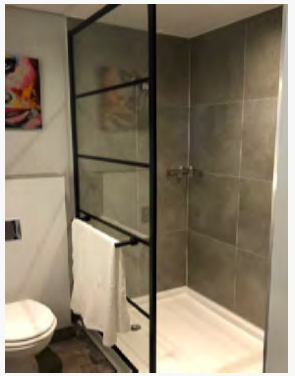
Contractor: Tiber Ohlhorst Modular

- Off-site production of 10 rooms per week
- Transported from Jhb to Montecasino
- Units placed in position under 30 minutes
- Due to lightweight construction the hotel was built onto an existing 2 storey parking structure at Montecasino
- Adheres to hotel chain Sound and Fire Proof requirements

Case study and example: timeline for 138 unit modular hotel

- Period: 2019
- Project: Hi Hotel, Montecasino
- Client: Tsogo Sun
- Main Contractor: Tiber / Ohlhorst
- 1st Modular Project



8 Month Modular Assembly versus +16 Month Traditional Build

Off Site Setup and Training

Off Site Modular Steel Engineered Assembly,
Fit Out – complete with bathroom & furniture x 130

April | May | June | July | Aug | Sept | Oct | Nov

Onsite 138 unit Placement and Connection, Passages, Atrium and 5 x Façades



Dec Complete

2019 Construction World Award
Highly Commended Project
https://www.tsogosun.com/hi-monte

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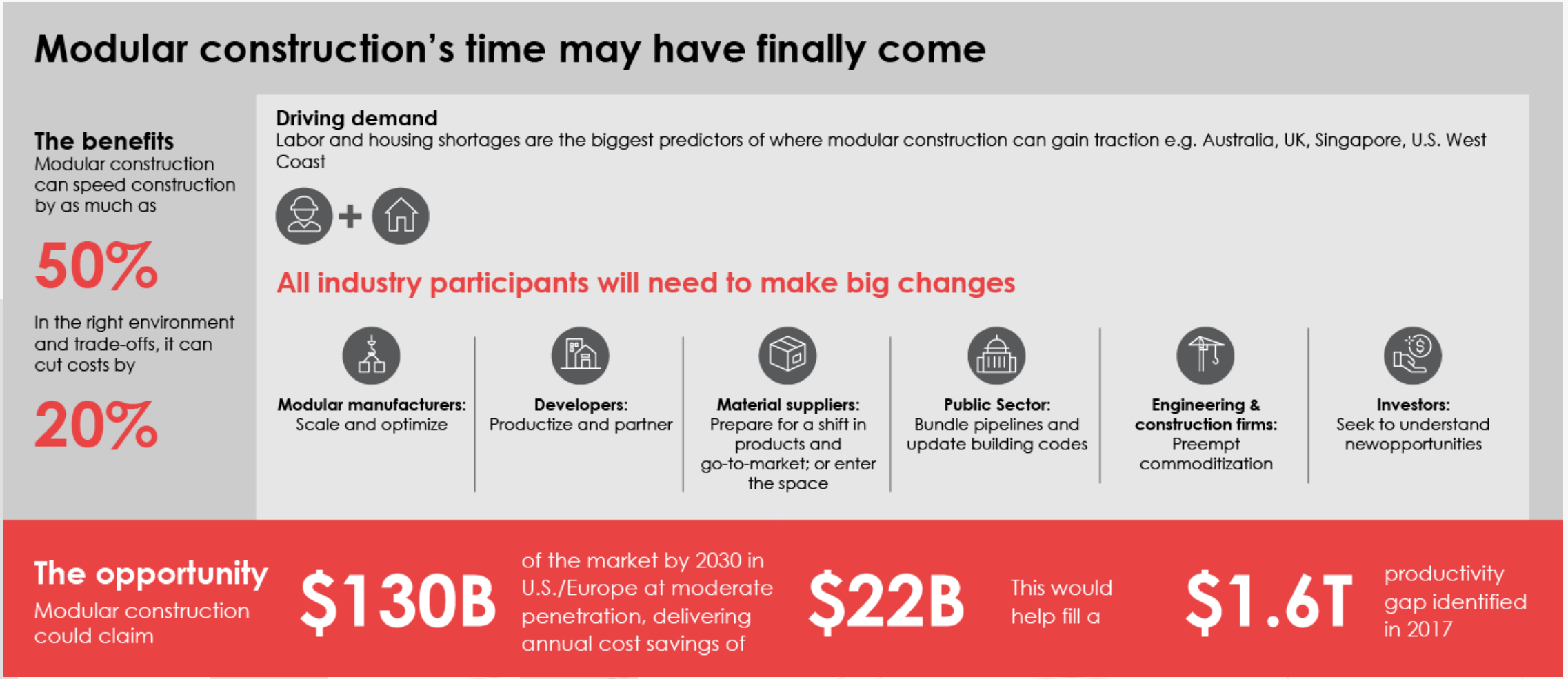
Modular construction: from projects to products

2019 McKinsey & Co report:



Source: 2019 McKinsey & Co report
Modular construction: From projects to products

The Structural Engineered Assembly System ENABLES contractors to deliver Modular and off site construction

- 3D Volumetric units are assembled in four hours creating +-20sqm floorspace with floor wall and ceiling structures

6mm/4mm/3mm + 0.8mm - 1mm Lightweight Steel Structure (LGS)

- Steel assembly of 4 corner posts and 8 beams with M12 bolt connections
- Steel assembly of 1mm and 0.8mm LSG floor joists, walls and ceilings
- Cold formed C section materials
- Hot rolled structural posts
- Cold formed +2mm beams

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Off-site factory production

Two completed and de-snagged rooms produced every day (3-line assembly plant), producing 10 completely finished hotel rooms per week.

The multiple advantages of the Light Steel Modular System: price, quality, easy assembly, logistics, environment and design possibilities

Price	• The total construction cost, including the project timeline, labour productivity, building foundation, soundproof floors & walls, effective insulation, plumbing and electrical works, can be 20% lower than the cost of using traditional materials and building methods.
Quality	• Energy efficient • Excellent sound insulation – hotel room specification • Designs are all fire-resistant, wind-resistant and earthquake-resistant • High quality and characteristics of the materials mean low(er) maintenance costs – galvanised steel
Assembly	• Clicking and screwing using numbered parts - all steel profiles are cold formed and exactly to specification ensuring parts fit only one way during assembly • The same applies to the installation of pipes, cables and wires: steel profiles have pre-drilled holes and the designed accessibility make for simple and quick installation • Less need for skilled or experienced employees • Construction is not dependant on weather conditions or drying times • The labour is less physically intensive than in traditional construction making (longterm) absence less likely
Logistics	• The design of the profiles follows the “flatpack” principle, creating easy and efficient transport
Environment	• Steel is 100% recyclable. The material used for walls, floors and ceilings is also suitable for re-use • Minimal use of concrete ensures a light foundation. A LSF structure is ± 90% lighter than a traditional brick and mortar structure • Logistic efficiency leads to less traffic movements and transport costs • Concept is energy efficient and is well suited for the application of heatpumps and solar panels • Fewer emmissions on-site due to a shorter and more efficient building method
Design possibilities	• Almost any building shape or form is possible using Light Steel; up to 10-storey seismic design possible • The finishes in terms of (commercial) façades and interiors are virtually infinite • Design and application of materials are easily adjustable making the concept future-proof

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Modular design and implementation process

- The design process is similar to traditional construction
- The construction process is simpler, cleaner, less physical, safer and faster

Process (simplified)

DESIGN PHASE

- Architect/Engineer designs in CAD
- Tiber Ohlhorst Modular (TOM) converts to (modular) LSF solution
- Additional possibilities in the design based on LSF and potential issues are discussed between the architect, commisioning party and TOM
- Check if plans/drawings are in compliance with permit requirements, demands/wishes from commisioning party, budget, etc.
- Final design after dialogue between architect, commisioning party & TOM

PREPARATION PHASE

- Final design
- Steel produced, profiles to exact specification
- Steel profiles are named and numbered for Quality Control & convenient assembly
- QC before shipment and delivery
- Delivery on-site or off-site

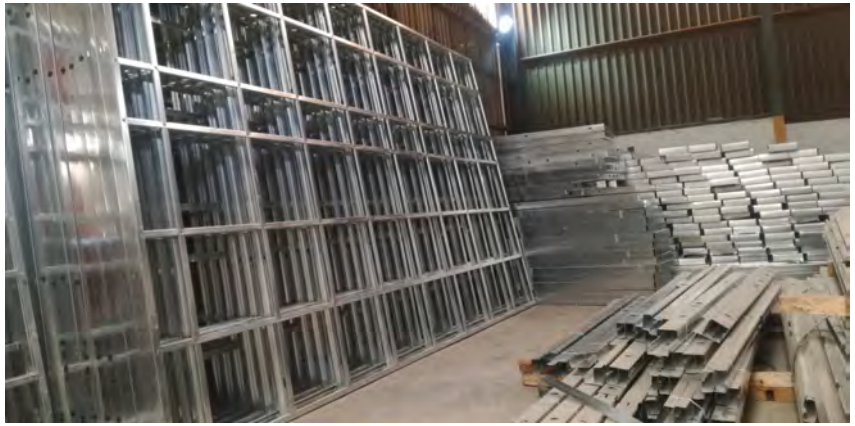
CONSTRUCTION PHASE

- Assembly on-site or off-site using assembly plans supplied
- Shop drawings for assembly per modular room / unit no.
- Assembly using assembly plans and specially designed steel profiles with dimples and connection screws. Standard assembly tools are also used
- Just bolt connections, LSF (light steel frames) clicking and screwing, no welding

How it works

- The quality and characteristics of light gauge steel frames and the structures it produces:
  - Lightweight class materials – extreme
  - Structural and load bearing ISQ550+ (Mpa)
  - Spanning capability – façade, roof, floor and wall application
  - Galvanised
  - Green. Recycled/able
  - Non-Toxic. Non-Organic.
  - Accurate to 1 mm
  - Flat surface for cladding or sheeting
  - Multiple profiles
  - Multiple thickness gauge 0.6mm-1,9mm

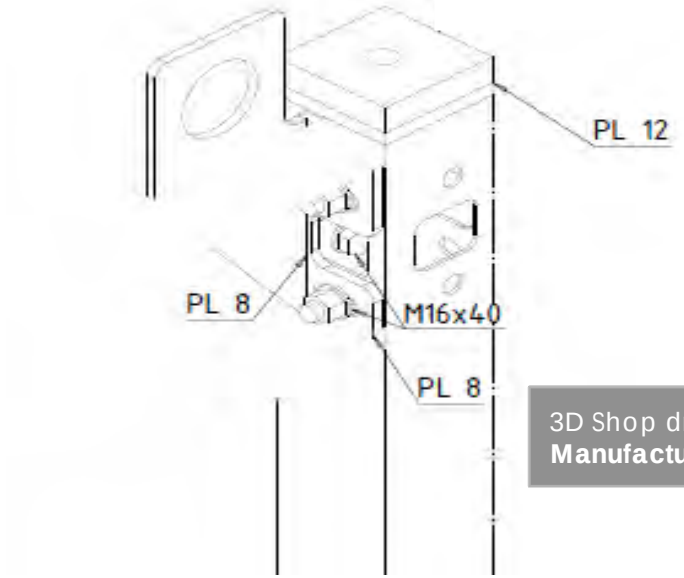


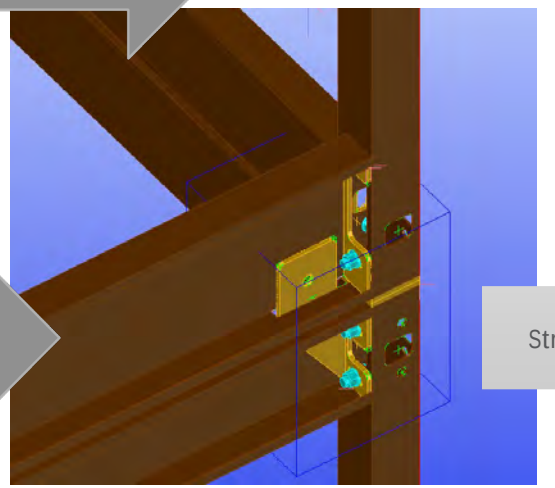
How it works

- Pre designed MEP services and connection points

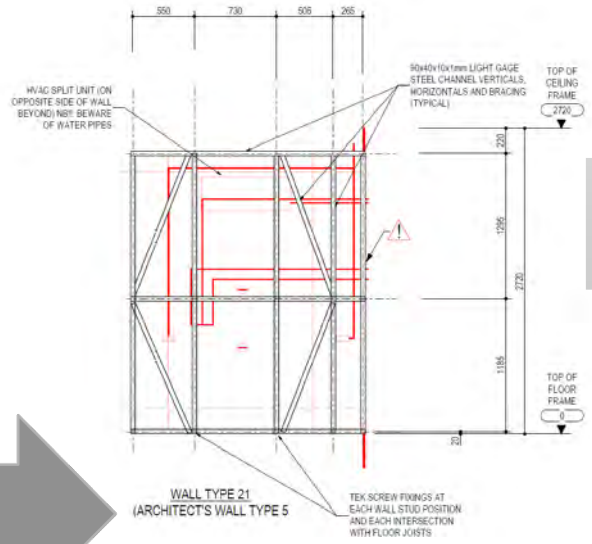
  Shop drawing, Assembly & MEP Services Coordination



3D Shop drawing: **Manufactured**



Assembly plans Coordinated



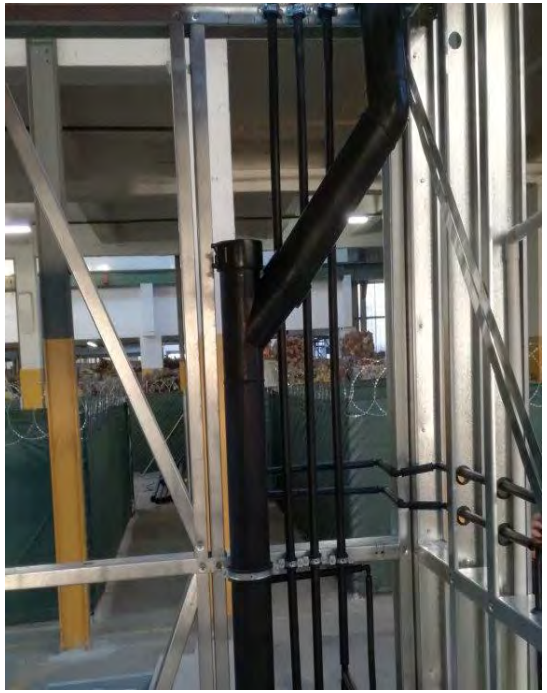
Service Position Determined by LGS

Structural Assembly

Structural Assembly

How it works

- MEP and other services required in floors, walls and ceilings
  - Services for electrical, plumbing and gas for internal walls, ceilings, floors and roof are all coordinated
  - Pre-punched in steel sections and manufactured according to service design coordination.
  - This speeds up MEP service installation (reduces labour) for electrical, plumbing and others, and guarantees the exact position and quality of position for fittings as per design criteria

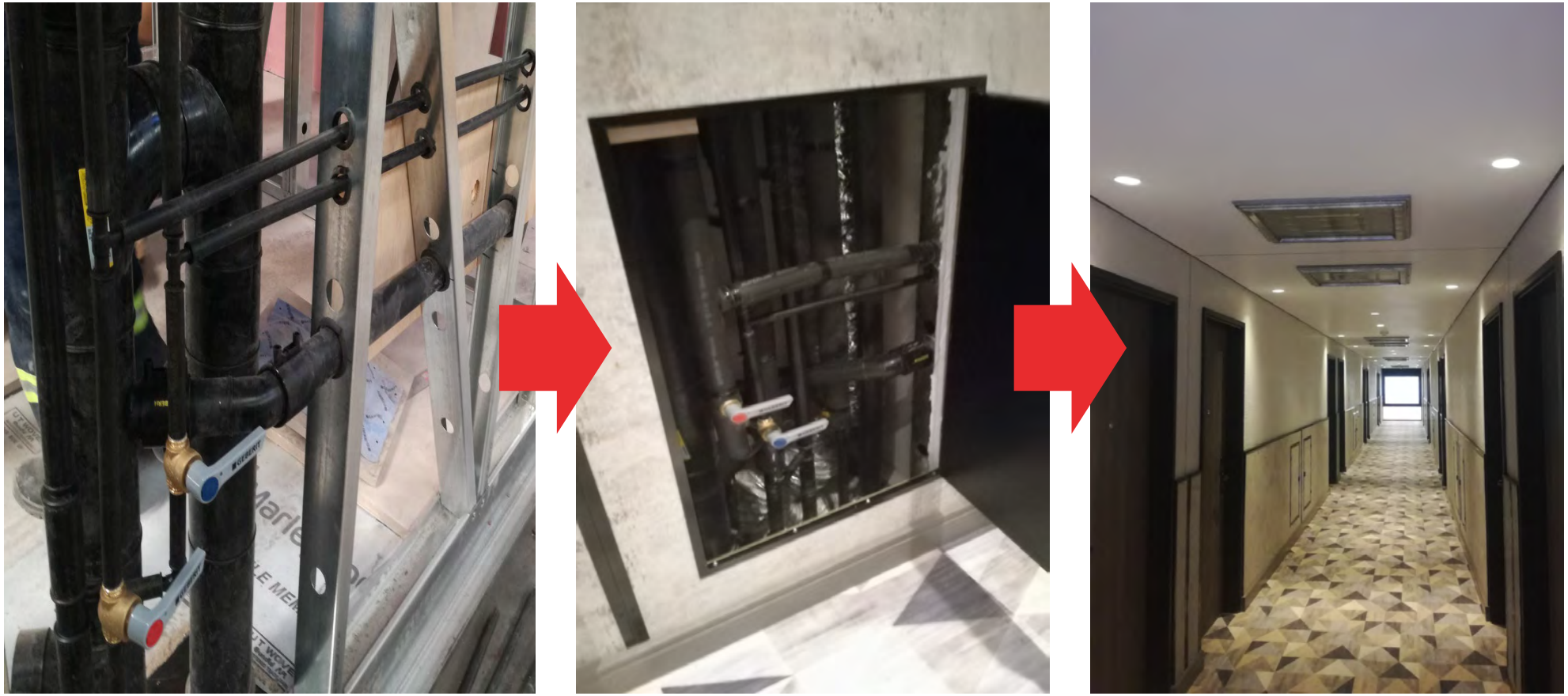


How it works

- MEP and other services placed in floors, walls and ceilings; ready for quality control and pressure test

How it works

- MEP and other services: Coordinated in design to exact final access and control positions



How it performs

- Sound reading by independent sound engineer
- Test performed January 2020

unit to unit (walls)	58 dB Rw
unit ceiling from room above	62 dB Rw
unit floor to room below	61 dB Rw

The median performance of ceilings, floors and walls of the Modular hotel was Rw60 dB in situ

The ratings below are based on similar performances and are extracted from Laboratory or Test results done by recognized Industry bodies / National test institutes. Note that this data excluded typical electrical chase and service penetrations through the detail which typically reduces these ratings 3-6dB. A 3dB difference in Rw is experienced as a halving in perceived noise level by hotel guests. To be considered when comparing isolation performance between different details... 3dB is a very big difference in what is heard and experienced by the human ear.

Comparison to traditional material

- Wall Rw60 Rating:
  - 254mm Concrete Masonry grout filled blocks plastered to depth of 12mm on either side (approx. 549kg/m2)
  - 305mm Concrete Masonry sand filled blocks plastered to depth of 12mm on either side (approx. 659kg/m2)
  - Two leaves of 280mm brick, 56mm cavity, no ties, outer faces plastered 12mm (approx. 420kg/m2 and would achieve Rw57 not Rw60)
  - GYPWALL FIRESTOP HISPEC 102/F120S55 102mm stud,102mm cavity batt, 2x15mm board per Side (approx. 58kg/m2 and rated for Rw55... a typical hotel partition wall specification)
- Floors/Ceilings Rw60 Rating:
  - 300mm concrete slab (approx. 690kg/m2 with Rw56.) note: Typically a drywall ceiling subassembly of 8mm drywall on 300mm void below this slab to get isolation close to Rw60)
  - 200mm concrete slab (approx. 460kg/m2 with Rw54)

Façade for Modular construction

External façade completed 100% off-site

EIFS / ETICS Façade example

The Structural Engineered Assembly System ENABLES contractors to deliver modular and off-site construction

- Steel Assembly Structures: modular and off-site construction in practice

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Modular Prototype - 2011

- Product development and research with a continued focus on:

- Structural engineering
- Lightweight materials
- Sound and Fire Proofing
- Durability
- Transport and lift proof
- Energy efficiency

Modular and off-site construction environment benefits

The built environments we create with our systems are:

- Energy efficient
- Sound insulated
- Healthy
- Safe and Fire proof
- Earthquake resistant
- Economical
- Modern and Stylish
- Future proof and adaptable
- Can be produced in any form or shape

hi Hotel Monte Casino Jhb 2019:
Modular Hotel

Modular construction: greatest potential cost savings

- **Structures with a degree of repeatability**
  - The trade-offs involved favour modular construction in particular when the type of structure has:
    - a degree of repeatability
    - a unit size that suits land transport
    - a value density where the savings of shifting activities to the plant outweigh logistics cost
  - Any building being manufactured needs to be designed for the manufacturing process and hence constrain the number of different variations required.
  - For example, affordable housing, student housing, and hotels are highly standardized and repeatable.
  - This doesn't mean that all modular buildings need to be the same
  - Understanding the level of customization desired by the end customer and what can be built into the manufacturing process is a key element of developing the modular solution.
  - In terms of unit size, narrow hotel rooms, for instance, are easier to pre-produce than wide lobby halls.
  - Bathrooms with a high built value are more feasible for modularization than simple structures.

Source: 2019 McKinsey & Co report
Modular construction: From projects to products

Modular construction: greatest potential cost savings

- **Labour force:**
  - In a modular build, up to 80% of the traditional labour activity can be moved offsite to the manufacturing facility
  - The most skill-intensive and expensive types of work (including mechanical, electrical, and plumbing) can be handled by lower-cost manufacturing workers, reducing the wage bill
  - More importantly, the more standardised, automated, and controlled operating environment of a factory can double productivity when compared to traditional builds, eliminating a great deal of on-site downtime
  - On-site, assembly of modules also requires a lower-skilled, hence lower-cost, labour force.
  - Transitioning to off-site manufacturing reduces the labour costs on a project by up to 25%.
  - Further savings are made when more of the high-value activities such as electrical, plumbing, and HVAC installation can be migrated offsite
- **Lifecycle costs**
  - When looking at the cost of any project it is important to focus on the full-life cost, not just the construction costs
  - The increased precision of construction which happens in a factory environment can have a significant impact on the performance of the building (Structural, MEP, Sound and Insulation improvement)
  - Clients have shown lowered energy bills in buildings by 25% after the transition to modular construction

Source: 2019 McKinsey & Co report
Modular construction: From projects to products

Summary of off-site modular construction benefits

- Documented benefits of off-site construction vs traditional on-site construction include:
  - **Shorter construction schedules $**
  - **Greater degree of predictability & cost**
  - **Reduced material waste $**
  - **Optimised material use $**
  - **Consistent quality units – improved quality versus site-exposed finishes**
  - **Reduced carbon emissions $**
  - **Reduced site disturbance**
  - **An increase in safety and security**
- Labour productivity has shown an increase of 30% at off-site projects when compared with on-site projects.
- Ultimately, risk is reduced with off-site construction.

(McGraw Hill 2009; FMI 2013; Mortenson Construction 2014; Quale et al 2012)

Modular Construction Today and Tomorrow

Recent modular projects have already established a solid track record of accelerating project timelines by 20–50%.

The approach also has the potential to yield significant cost savings.

Mckinsey analysis suggests that leading real estate players that are prepared to make the shift and optimize for scale will be able to realize more than 20 percent in construction cost savings, particularly as everyone involved moves up the learning curve.

Capturing the full cost and productivity benefits of modular construction is not a straightforward proposition. It requires carefully optimizing the choice of materials; finding the right solution between 2D panels, 3D modules, and hybrid designs; and mastering challenges in design, manufacturing, technology, logistics, and assembly. It also depends on whether builders operate in a market where they can achieve scale and repeatability.

In many countries, modular construction is still very much an outlier. But there are strong signs of what could be a genuine broad-scale disruption in the making. It is already drawing in new competitors—and it will most likely create new winners and losers across the entire real estate and construction ecosystem.

Prefabricated housing has achieved a sustainable foothold in only a few places, including Scandinavia and Japan. It has been in and out of favour in markets such as the United States and the United Kingdom since the post-war era.

Yet there is reason to believe the current revival could be different. The industry is adopting new materials as well as digital technologies that enhance design capabilities and variability, improve precision and productivity in manufacturing, and facilitate logistics.

Countering the old reputation of prefabricated housing as an ugly, cheap, poor-quality option, some builders are focusing on sustainability, aesthetics, and the higher end of the market.

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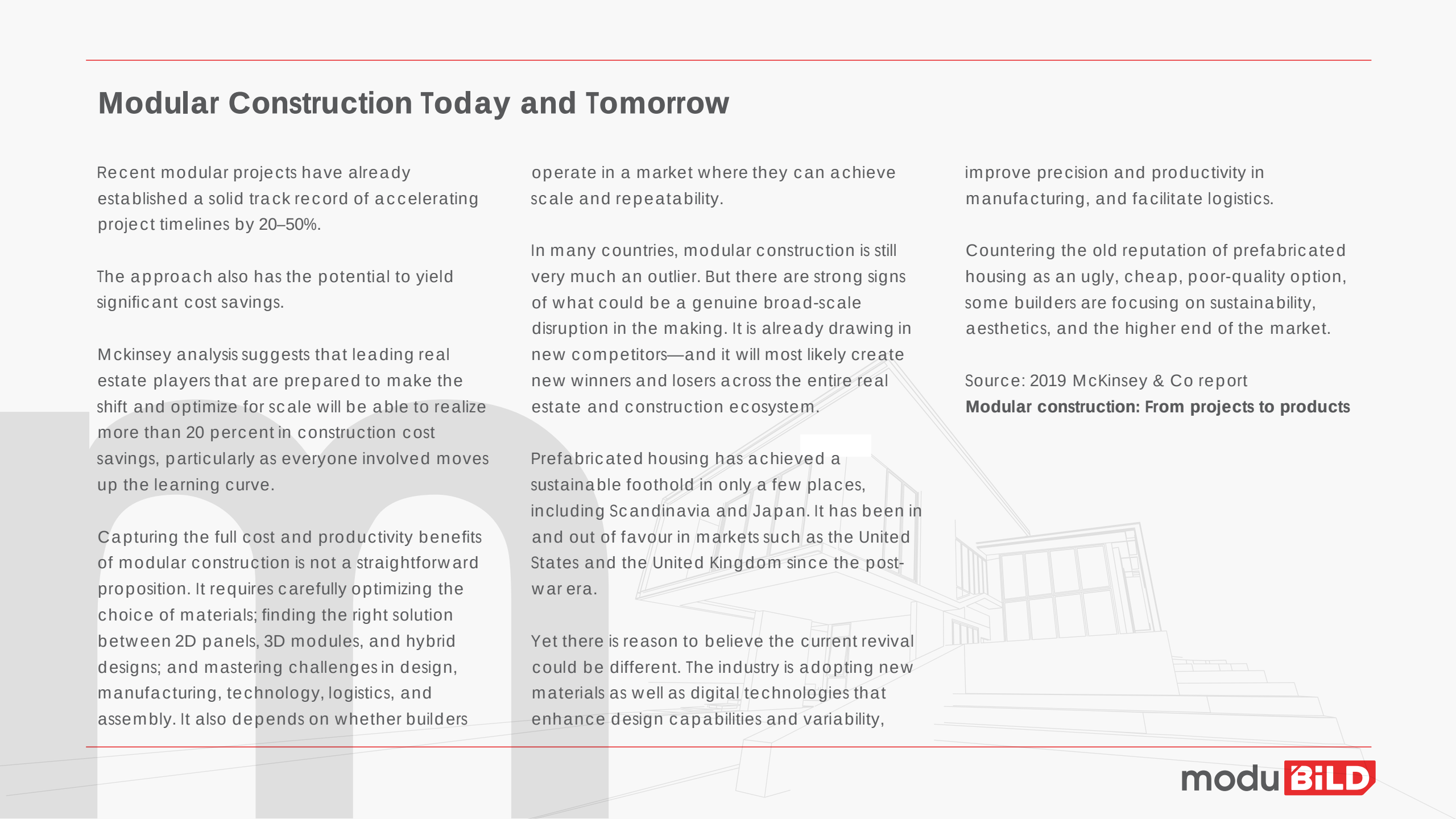
Modular construction: From projects to products



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