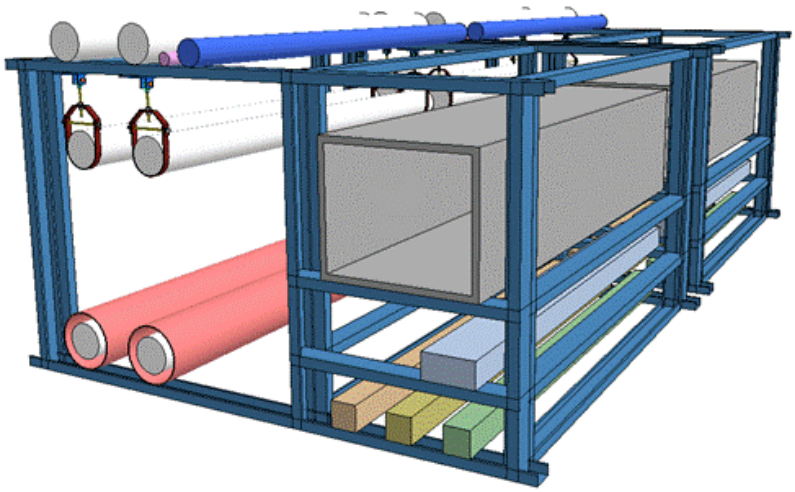
PRE-FABRICATED MODULES

1. INTRODUCTION

The construction industry has been moving towards the adoption of Design for Manufacturing and Assembly where most of the work is done off-site in a controlled manufacturing environment and are then transported and assembled on site. With more prefabrication, manpower and time needed to construct buildings are reduced, worksites are safer and more conducive, and there is less impact on the surrounding environment.

Prefabricated Mechanical Electrical and Plumbing (MEP) modules is one of the game-changing technologies that can significantly improve productivity. It adopts the design for manufacturing and Assembly concept where components in MEP services and equipment are integrated into a sub-assembly off-site, for easy installation on site.

This guidebook helps to have a better understanding on prefabricated MEP modules, its benefits and good industry practices on such systems.



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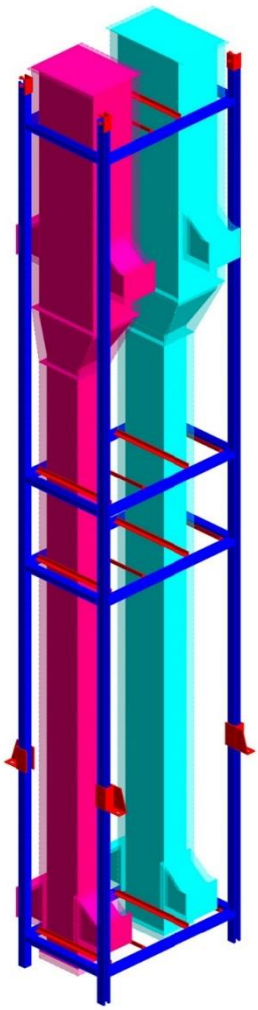
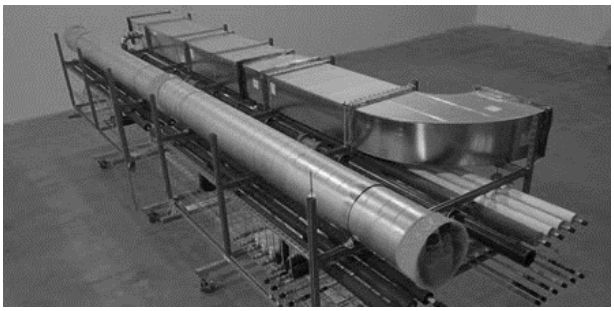
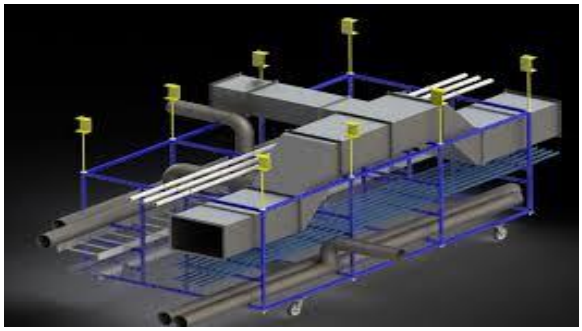
2. Types of prefabricated MEP modules / systems and their applications

MEP technologies at the higher end of the design for manufacturing and assembly continuum such as advanced prefabricated systems and integrated sub-assembly systems can achieve higher productivity improvement. Examples of the of prefabricated MEP modules/systems and their applications are illustrated below:

- Corridor Horizontal modules
- Vertical Riser modules
- AHU & FCU modules
- Tunnel modules
- Apartment/Residential modules
- Chiller plant room modules comprising pump modules & associated M & E services.







3. REQUIREMENTS OF DIFFERENT MODULES

1. The structural requirements of the MEP modules including the weight of the modules and their dynamic loading should be provided to the Qualified Person (QP) Structural to design the building structural requirements.

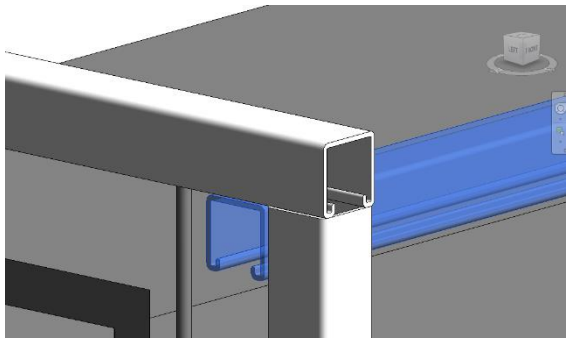
2. The support system of the modules must be firmly installed, according to the approved shop drawings endorsed by Professional Engineer engaged by the main contractor.

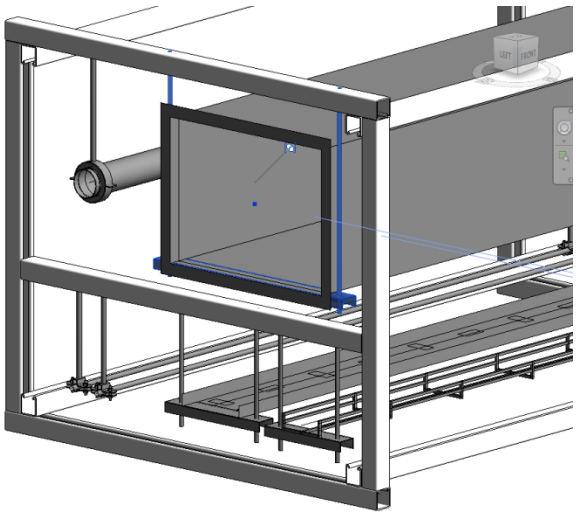
3. Structural design of supports should utilize standard strut components and hardware, with all mechanical connections and bridging from the modules. As much as possible, the supporting frame should allow a certain level of flexibility in adjustment, should more space be required between tiers.

4. The supporting system should be as lightweight as possible to allow easier installation, reduce loading on building structure and minimize material wastage.

5. If welded connections are used in the assembly of the support system, measures to prevent corrosion to the welded connections are required, e.g. painting with cold galvanizing zinc.

6. The overhead components should be independently supported. Modules can be linked in tandem for a continuous service run





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3.1 HORIZONTAL MODULES

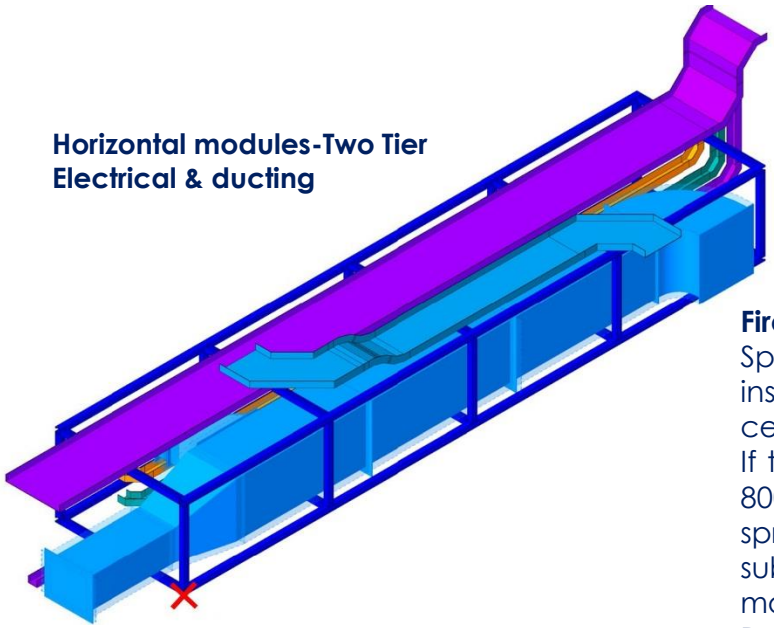
A horizontal ceiling module should aim to include most, if not all, of MEP services components in the ceiling

Components that can be included are:

- Sprinklers
- Chilled water supply & return pipes
- Condensate drain pipe
- Sanitary drains
- Plumbing
- Medical gas systems
- Electrical, extra low voltage cabling with trunking, tray or cable ladders(typically, cables are inserted only after installation of modules on site to minimize cable jointing)
- Air –conditioning /mechanical ventilation ductwork

Horizontal Multi purpose module

Horizontal modules-Two Tier Electrical & ducting



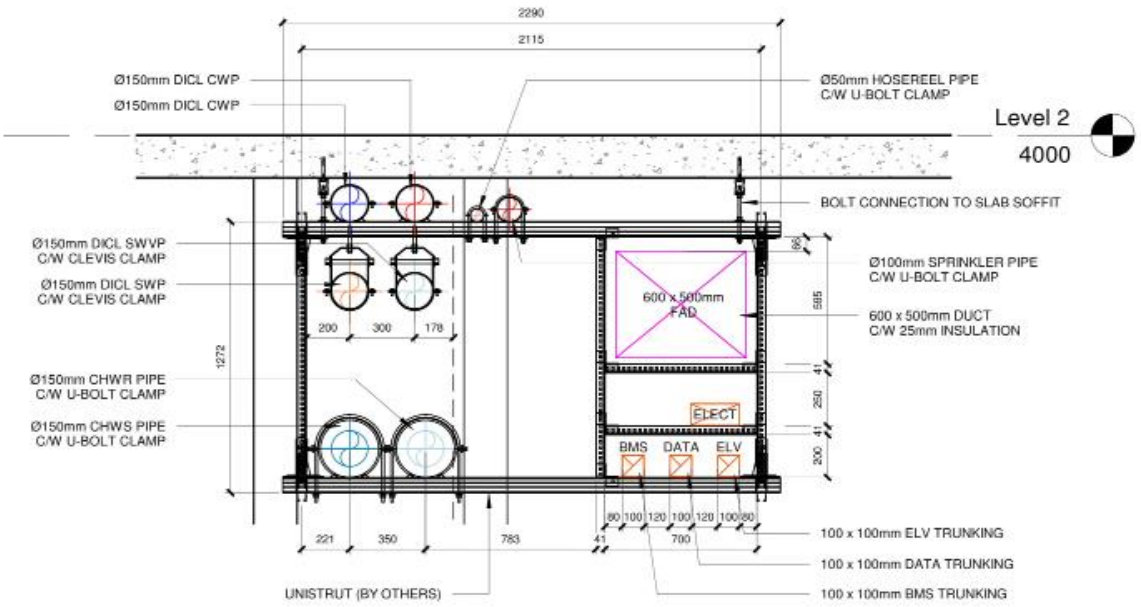
Fire safety

Sprinkler piping can be pre-installed in the same horizontal ceiling module as other services. If the height of module exceeds 800 mm, a second layer of sprinklers must be in place, subject to the complexity of modules. Consultation with Civil Defense should be sought for any non-compliance to the fire safety requirements.

In addition, if a fire-rated duct runs through the module, the entire module frame and associated supports must be fire-rated. If the horizontal ceiling module is used in fire-rated spaces such as smoke stop and firefighting lobbies, a fire-resistant board must be incorporated, in accordance with the Standard Code of Practice for Automatic Fire Sprinkler System and Code of Practice for Fire Precautions in Buildings.

Water leakage

The arrangement of services within a horizontal ceiling module should consider the potential risk of undesirable leakages from mechanical services e.g. sanitary waste pipe and potable water pipe.



For example, in corridors with limited width, electrical services should always be installed above any plumbing and sanitary services. Additional acrylic/zinc sheet can be installed between water pipe joints and electrical services above or nearby. If the width of corridor accommodates, electrical services can be installed on one side of the 'red zone' in the module while mechanical services e.g., sanitary and plumbing can be installed on the other side, as shown in the diagram.

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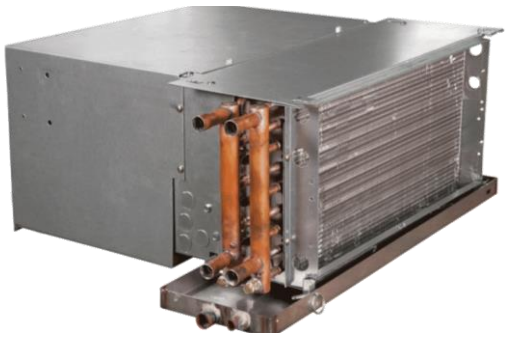
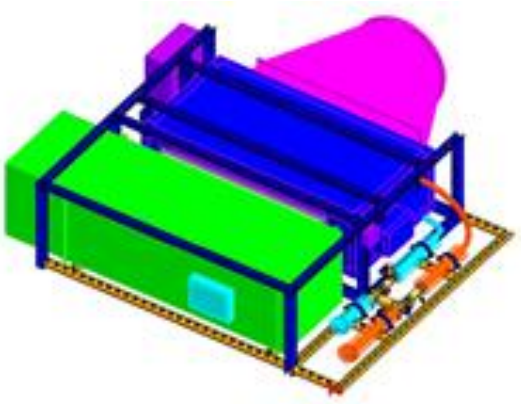
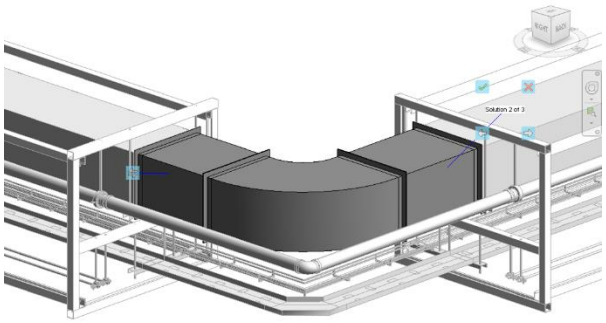
Access provisions

The distance between vertical tiers of the module should be at least 100 mm to allow access for further works – such as drawing cables and interfacing between modules, and future maintenance. If welding works for pipe jointing are to be carried out, more clearance around the pipes will be required.





The horizontal ceiling modules should comprise components that allow adjustment to the height of services to compensate any offset due to unevenness of the structural ceiling. Examples of such components are vertical threaded rod and flexible coupling which accommodates misalignment of jointing pipes, as seen on the next page.



3.2 Requirements of vertical riser modules

A riser module comprises vertical riser ducts and pipes. The vertical services in each riser module can be installed horizontally at ground level in the factory and branch out to multiple floors.
A riser module can be installed prior to, and independently of, the erection of block walls of the riser shaft. Another method of installation is to lower the riser modules into the riser shaft through designated openings in the top floor. Therefore, lifting lugs and bracket should be incorporated in the design of vertical riser modules.
A vertical riser module comprises of vertical riser ducts and pipes. The vertical services in each riser module can be installed horizontally at ground level in the factory and can be installed prior to, and independently of the erection of riser shaft block walls. Also, riser modules can be lowered into the riser shaft through designated openings in the top floor. Therefore, lifting lungs and brackets should be incorporated in the vertical riser module design.

3.3 Requirements of plant modules

Prefabricated MEP plant modules are fully pre-assembled with control panels, and instruments mounted on skids with lifting eyes for piping connections, valves cable termination for power supply, and interfaces for building automation system and fire alarm system, where applicable.
The pre-assembled and pre-wired equipment with control panels include:

a) Water services pump sets for boosting and transfer including hydro-pneumatic tank
b) Fire hose reel pump set including hydro-pneumatic tank
c) Vacuum pump sets
d) Air compressor including air receiver
e) Cooling towers
f) Chillers
g) Chilled water and condensing water pumps
h) Air-condensing unit
i) Air handling units (AHUs)
j) Fan coil units (FCUs)

Two or more modules can be combined using flexible connections on site to complete the installation in a plant room. All the valves/pipework connections to the equipment can be pre-installed in the factory including the control panels and internal wiring.
When the equipment is delivered to site, contractors will only need to connect the pipework and the incoming power supply, then the system is ready for testing and commissioning. As compared to the conventional way of installing plant and equipment, prefabricated MEP plant modules save time on site, and reduces the number of trips to deliver individual materials and components such as valves, pipes and control panels to the plant room for assembly.
The site will also be neater and material waste can be minimized.

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4. FABRICATION AT THE MANUFACTURING PLANT

4.1 Adopt good management practices to improve productivity

Before production commences, detailed manufacturing drawings for each module are produced and finalized by all key parties. After the MEP modules have been produced in the factory, the manufacturing drawing should be pasted on the respective modules and the services labelled accordingly for reference by other trades.

The production schedule and manpower planning are also critical. The adoption of advanced machineries in factory can help improve productivity and reduce reliance on manpower.

The labels should be positioned at the location of ceiling access panels or maintenance panels, according to the ceiling plan.

4.2 ENSURE QUALITY CONTROL

Inspection test plans should be developed for all modules by the prefabricator and endorsed by MEP trade specialists and consultants to ensure that they are applicable for the project.

Tests and inspections of the individual services and support system e.g. steel frames of the modules, should be conducted according to the respective technical specifications and codes of practice. These include the material's compliance with regulatory requirements, project specifications, pipe pressure test, air tightness test for ductwork, and gradient of condensate drain pipe, sanitary waste pipe and kitchen waste pipe.

Factory acceptance tests should be verified by an engineer's representative to ensure that the modules have achieved their performance requirements. Should the modules fail to meet the performance requirements, rectifications should be carried out accordingly, prior to the delivery of the modules.

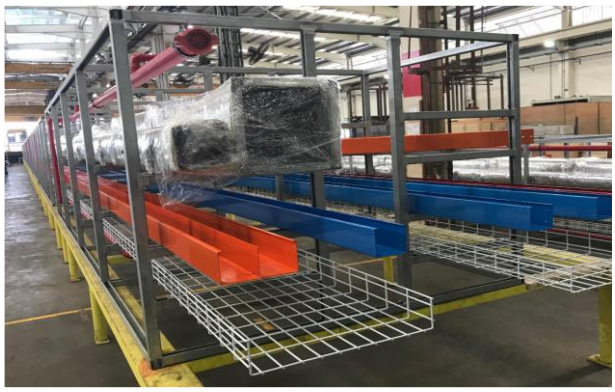
A mock-up should also be produced for inspection and approval by the Qualified Person (QP) prior to mass production

4.3 Align MEP modules properly before delivery to site

To ensure a smooth installation on site, a template or jig could be used when lining up the modules in the factory to check for proper alignment.

4.4 Protect modules against weather elements

Modules should be covered with shrink wrap, tarp etc. to protect them against exposure to weather, prior to delivery to site. Alternatively, the modules can be always kept in a sheltered condition.



4.5 Facilitate transport, handling and installation

To ease transport and handling, modules can be pre-installed with castor wheels that can be taken off after installation. Equipment such as pallet jacks and forklifts also facilitate the maneuvering and lifting of modules in the factory and on site.

Sometimes, to facilitate the installation of MEP modules in tight working spaces, the builder and prefabricator can work together to integrate other works into the MEP modules. For example, part of a partition wall can be integrated with the MEP modules, as shown in the diagram below.

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QUALITY CHECKLIST

Description	Tick if Yes
1. General Checklist	
Adequate clearance between different MEP services	
All open ends are capped and free from damage	
All debris are removed from modules	
Final visual inspection of all welded joints	
Final visual inspection for physical damage (corrosion, damage, paintwork, insulation)	
Module reference code and weight are clearly indicated	
Transit supports (bolts, nuts) are in place	
Labels are affixed on respective services, and in positions where any ceiling access panels or maintenance panels is located	
2. Support System	
Correct specification of bolts and nuts	
Correct sequence and torque of bolts and nuts	
All brackets are installed as shown on the shop drawings	
Inertia bases and vibration isolators are secured for transport	
3. Accessories (Flange, Valve, Damper, Test Points)	
Flanged joints have standard bolts fitted and correct torque specification Directional valves are fitted correctly	
Valve handles have clearance to operate fully and be maintained properly	
Tested points are fitted and accessible by test	

5. GOOD INDUSTRY PRACTICES – INSTALLATION

5.1 Adopt Just-In-Time (JIT) concept

Adopting a just-in-time (JIT) concept, where MEP modules are delivered according to the construction sequence, eliminates congestion in the factory and minimizes damages to the modules on site. BIM can be used to simulate the actual on-site installation to identify potential problems in the access route.
Close co-ordination between parties at the project site and factory is critical to ensure a smooth supply of modules to the site and minimize downtime due to missing modules on site.

5.2 Plan for logistics in advance

The method statements and risk assessments for lifting, installing and storing (if applicable) the modules on site require the builder's inputs on the capacity of cranes, availability of access platforms on each floor for landing of modules, delivery routes of modules to their designated positions, and other logistics constraints.
Delivery of large pump skid and modules that may require traffic escorts should be planned.

5.3 Conduct visual inspections of modules delivered to site

Visual inspections should be conducted by an engineer's representative to ensure there are no defects to the modules during transportation, prior to moving the modules to their designated location for installation.

5.4 Mark and set out modules' position

The positions of the supporting rods on the modules, as shown in the BIM drawings, can be marked out on the slab soffit or columns using laser marker equipment. This will ensure faster and proper alignment of supporting rods with module frame eyelets as well as connections between modules.

5.5 Install and connect modules and to the mains

The installation of MEP modules should be carried out by workers who are familiar with the connection details of the modules and have been trained by the MEP prefabricators.

5.6 Testing and commissioning

A testing and commissioning plan should be developed and the Qualified Person (QP) or his representative should be present to witness the testing and commissioning of the MEP system.
A distribution system such as full system pressure testing for pipework and air tightness test for ductwork shall be commissioned on site.
Commissioning can take place by zones and a full system-wide commissioning should be done when the building envelope is made weather-tight.

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6. ROLES OF DIFFERENT PROEJCT PARTIES

STAGE 1 :Tender to engage consultants, builder, subcontractors and MEP prefabricator

- Consider potential cost increase in the tender bids due to different work activities associated with the prefabricated MEP system where applicable:
- Development of detailed BIM models
- Additional resources and time required for collaborative design processes
- Supervision of works at manufacturing facility offsite and project site.
- Identify the areas where MEP modules can be applied
- Review the schedule and deliverables for progress claim certification

STAGE 2 :Design

- Develop coordinated services drawings) that are endorsed by the relevant project parties prior to the production of modules

STAGE 3: Production of prefabricated MEP modules offsite in a manufacturing facility

- Equip manufacturing facility with adequate space for fabrication and storage of modules, and necessary tools and equipment such as jigs and welding machine
- Maintain minimum inventory of frequently-used and pre-approved materials such as cable trays, conduits, pipes/ fittings etc. to ensure no disruption due to shortage of materials
- Production should comply with a robust quality assurance and control plan which includes factory acceptance tests on individual modules and integrated modules
- An engineer's representative should be deployed before production to verify the tests and inspections.

STAGE 4: Construction on site

- Work closely to ensure just-in-time delivery of modules to project site
- Install modules on site and integrate systems
- Provide accurate site measurements for prefabrication of interfacing between modules and elements of the building structure, if applicable

STAGE 5: Overall testing and commissioning of services

- Conduct testing and commissioning of services according to the performance requirements and regulations

7. BENEFITS OF PRE-FAB MEP MODULES

Increases productivity significantly

Construction is faster as the production of prefabricated MEP modules/systems in the factory is done concurrently with other activities on site

Installation of prefabricated MEP modules/systems on site is easier and quicker, and leads to significant manpower and time savings of up to 60%, depending on the complexity of projects

Improves workplace safety

Construction sites are safer and more conducive as most work is done off-site, and less time is spent working at height

Reduces impact to the environment

Dust and noise pollution, as well as other dis-amenities to the surroundings are minimized as more activities are done off-site

Less construction waste is generated as there is less rectification work

Enhances quality control

Higher quality control is achieved as most work is done in a controlled factory environment

Sequence of work can be planned more efficiently with better logistics co-ordination

TRADITIONAL **VERSUS** **MANUFACTURED**

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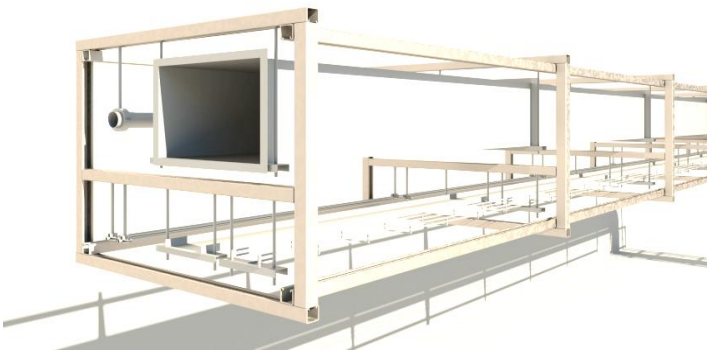
PRE-FABRICATED MODULES

SASCO's Factory-produced pre-engineered MEP modules that are delivered to a site and assembled are an intelligent and advanced form of construction methodology.
The key aim of the SASCO prefabricated module is increasing the quality, efficiency and productivity; reduce wastage; and improve health and safety.



Prefabrication is an impactful innovation in the construction industry, with the potential to greatly reduce waste while speeding up projects. Prefabrication can be applied in many areas of construction projects, and the method has also been implemented successfully for building systems - mechanical, electrical and plumbing (MEP) installations.

What is MEP Prefabrication?
Prefabrication consists of manufacturing and assembling components offsite, and then transporting them to the construction site for installation. These assemblies are known as MEP modules or prefabricated MEP modules. Prefabrication takes part of the MEP installation process to a controlled factory environment, in isolation from external factors.

Typically, a module is a system of steel frames that have pipes, ventilation ducts and cable trays attached in one unit and is usually 2 to 12 metres long, depending on the transport logistics allowances. Designing an MEP module involves coordination, connection methods between modules and the calculation of the size and weight of steel beams to make the mounting frames. Installation is performed by duct lifters, chain blocks or tower cranes for modules in shafts.





MEP Prefabrication VS Traditional Methods

Traditionally, MEP construction has been a process with multiple steps, where different specialists bring their skills at a certain point during the project. Coordinating multiple teams is a challenge, and some common problems include inefficient use of labor, weather delays, unsafe working conditions, inefficient waste management, high traffic onsite, and maintaining a high quality. All these issues can raise project costs, while causing delays.

SASCO's MEP prefabrication provides an alternative to traditional methods. MEP components and modules can be designed, manufactured, inspected and tested offsite. Plumbers, HVAC technicians, electricians and other tradesmen can work together more easily in a controlled manufacturing environment. Coordination and collaboration between trades is completed faster, speeding up MEP installations

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Traditional MEP installation system	Prefabricated MEP Modules
▪ Collision of services ▪ Clash of trades ▪ Cost and time control ▪ Surprise costs ▪ Labor risk ▪ Skills shortage ▪ Productivity ▪ Quality ▪ Safety ▪ Waste management ▪ Tight project schedule	▪ Fully coordinated and pre-engineered solution ▪ More accurate cost and delivery ▪ Schedule benefits ▪ Improvements in quality ▪ Improvements in health and safety ▪ Improved predictability = LESS RISK ▪ Improved project performance ▪ Greater schedule certainty

ADVANTAGES

1. Eco-friendly
Prefabricated MEP modules are energy efficient reduce wastage. With significantly accurate construction, the joints are tighter and there is improved air filtration, enabling more effective wall insulation and increased energy efficiency.

2. Faster Project Construction
Effective planning, elimination of on-site climate conditions and faster fabrication of MEP modules contribute to overall savings in time, sometimes up to 50 percent when compared to traditional construction. Multiple modules are created at the same time and delays associated with subcontractors are neutralized. Prefabrication can begin off site early, without waiting for MEP clearance from the civil team.

3. Reduced Costs
Modular construction can be tailored for any budget. Even the faster construction time resulting from the use of modules saves construction costs.

4. Adaptability
The ease of disassembly and relocation of modules cuts down on the need for and transport of raw materials and saves time. The project's design can be flexible when using modules. When these modules are manufactured with a flexible flat pack design, they can be used with great success in cramped spaces that are difficult to reach.

5. Reliable Quality
Modules are built to a uniform quality due to a controlled manufacturing environment and processes for specific standards.. All services are supported and clearly installed. Offsite manufacture means early testing, commissioning and project assurances.

6. Minimal Site Disruption
Reduced vehicular traffic and fewer on-site personnel associated with equipment and material suppliers result from manufacturing modules in a factory. Noise, pollution and waste on site are reduced, while productivity increases. When large components are broken into smaller modules, they can be easily installed in tight spaces without disturbing other trades on site. Errors and damages to services by different trades are minimized. Also, there will be less people on scaffoldings.

7. Safety
Dry materials used in the controlled environment of a factory result in reduced problems with moisture, environmental hazards and dirt. Workers are not exposed to health risks associated with weather and there are reduced risks of accidents. Injuries to workers are prevented due to strict procedures, reduction of high-heat tasks in restricted areas and minimal scaffolding work.

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Overall reduction in schedule – M&E works starts simultaneously with the civil works, in the off-site factory

- **Fully coordinated and pre-engineered solutions** – 100% BIM Implementation

- **Mass production** – Modules are standardized and manufactured at offsite factory

- **Less worker traffic on site** – the services are installed in off-site Factory

- **Less weather dependency** – offsite factory with overhead crane provision

- **Greater schedule certainty** – due to BIM and Off-site manufacturing

- **Improved predictability** - less risk

- **Safer work environment** – working at height is kept to minimum

- **Improvement in quality and productivity** – better control over the deliverables in factory setup

- **Ceiling space utilization** – better utilization of the ceiling spaces for M&E services.