



MODULAR CONSTRUCTION

-FIRE SAFETY CHALLENGES AND THE ONGOING NEED FOR INNOVATION



INTRODUCTION

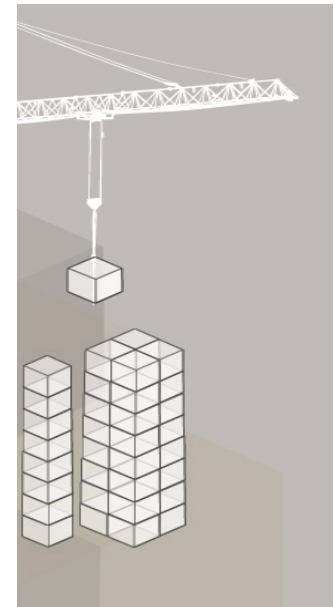
It has been interesting, sitting back and watching over the last 10 to 15 years, and where possible, participating with the supply of specialty building products, as Australia has embarked on its offsite prefabrication and modular construction journey.

My professional interest in modular construction is to develop passive fire safety systems to assist the designers of modular buildings; to allow easier, faster, more cost effective, (fire) safe, transport friendly and durable off-site construction and on-site commissioning of multiple rooms or volumetric units; joined together to complete the overall building.

WHY MODULAR CONSTRUCTION?

To maximise off-site prefabrication content, encompassing framing, cladding, services, fittings and finished assembly in factory conditions. This minimises the on-site building activity and use of trades. With advanced modular construction, complete building units or building modules are delivered to site as volumetric cubes; carefully bolted or fixed together to create an overall building. This is often referred to as 3D volumetric or three-dimensional modular construction, to differentiate it from prefabricated or flat, wall or floor assemblies.

This form of construction seeks to speed up construction, save money and improve the quality of as built construction utilising a factory environment.



INNOVATIVE, LIGHTER WEIGHT AND DURABLE BUILDING PRODUCTS AND SYSTEMS

Transport and on-site installation using cranes poses a design challenge for 3D volumetric modular construction and of course with lighter weight prefabricated structures. Attributes like impact resistance, flexural strength & vibration resistance especially where the interior lining wall, floor and ceiling boards or external cladding are screwed to framing, are new performance attributes sought for modular construction.

Passive fire protection, fire separation and fire resistance are another very important design attribute and challenge involved in modular construction; not to dismiss acoustics, waterproofing and energy ratings (R Values) as other important design challenges.

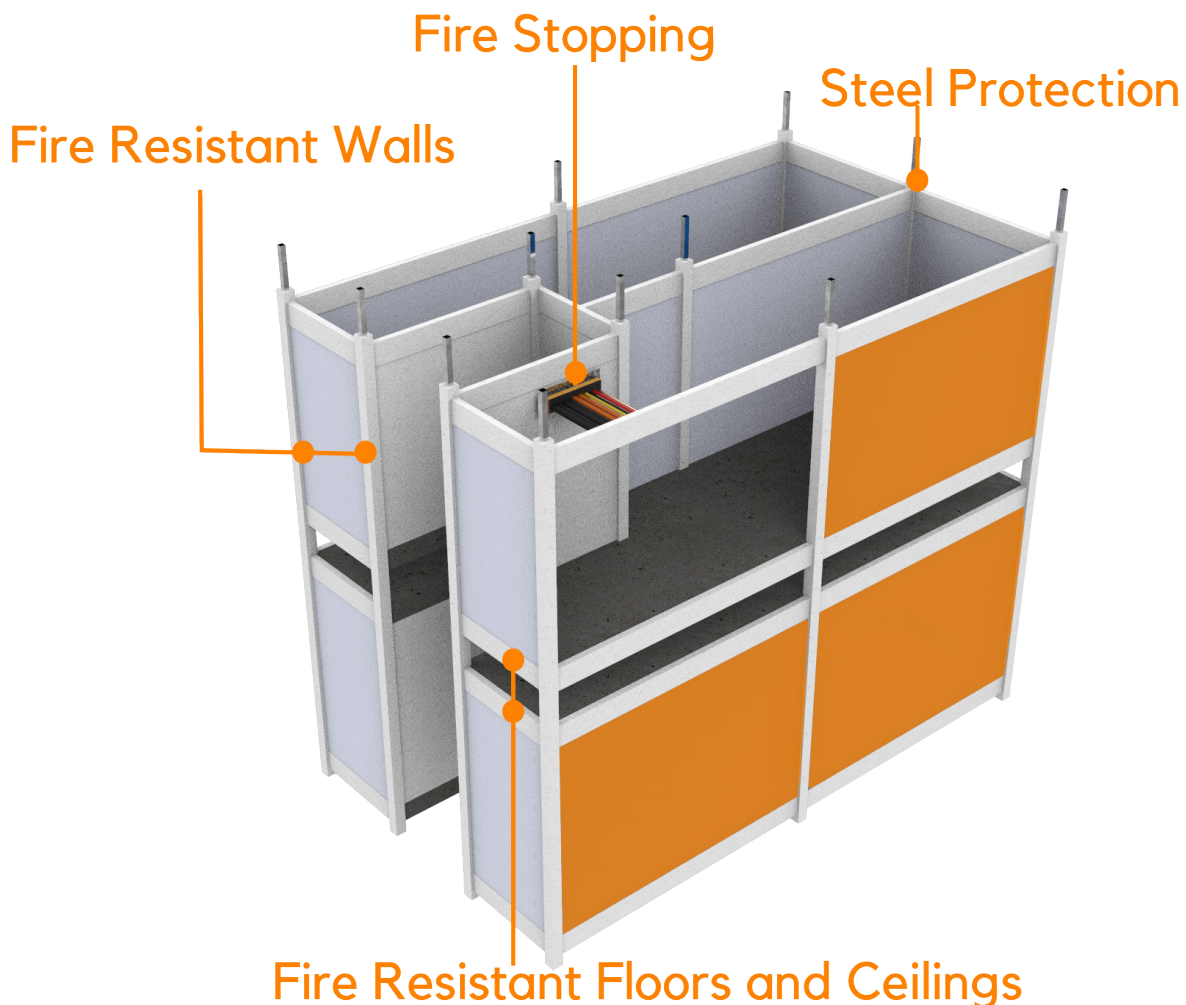
Conventional building materials, like concrete, lightweight aerated concrete and even pink rated plasterboard have proven to be too heavy, too slow, or not suitable to cater for vibration and structural loads imposed by moving modules into place on the construction site.



New, innovative engineered and lightweight structures utilising proprietary and specialised building boards for example have proven more suited, and many of these are newer and less known to the wider construction professional and industry generally.

PASSIVE FIRE PROTECTION OR FIRE SEPARATION CHALLENGES

Many unique design challenges manifest themselves relating to the requirement of the NCC or BCA to provide fire separation or passive fire protection measures. These as most of us know manifest themselves as system FRL requirements, commonly referred to incorrectly as fire ratings. One hour and two hours fire ratings are often thrown around in conversation, but many of us know there are many different parts of an FRL depending on the building elements including, structural adequacy, fire integrity, insulation or non-fire side temperature rise controls, resistance to incipient spread of fire in ceiling and other cavities and of course smoke containment. Some of the passive fire protection measures will be discussed in more detail below along with some of Trafalgar's system or product offerings.





STEEL STRUCTURES AND ITS STRUCTURAL FIRE RESISTANCE AND FRL

Modular construction will typically use a steel supporting structure. This structure under the NCC or BCA requires compliance with AS4100 and a requisite FRL.

The AS4100 section of fire, requires a series load bearing steel fire sections to be fire tested to AS1530 Part 4-2014 or more severe fire testing regime, and the results are then converted into a fire assessment report by a Registered Testing laboratory using mathematical regression analysis. The output of this fire testing and assessment provides the necessary relationships for steel section size, referred to in AS4100 as the ESA/m ratio (or HP/A), limiting steel temperature and required thickness of fire proofing material for a given duration; the NCC requisite FRL or fire rating in minutes of fire exposure.

Although cementitious or vermiculite fire spray materials are cheap, they are not typically used in modular construction as they are messy to apply in a factory environment, take a long time to dry, and are not suited to transport as they are friable and prone to cracking due to vibration.

Two systems of choice are either intumescent coatings or specialty fire rated board materials; developed and fire tested especially for the modular market.

Trafalgar offer it's Corex glass reinforced gypsum fire resistant board material for protection of the steel structures in modular and offsite construction. Trafalgar Corex is paper free board, which can be scored and snapped like conventional plasterboard, but has the added advantages of having excellent strength when fixings (either screws or specialty staples) are employed which will not vibrate lose or pull through during transport. The impact resistance provided by the glass reinforcing makes it capable of being bumped without cracking and piercing of the surface.

Trafalgar's fire testing is second to none, and allows thinner steel square and rectangular hollow sections, often used for modular construction steel framing to be protected with thinner thicknesses and for long FRL requirements.





VERTICAL WALLS AND SERVICE RISER SHAFTS REQUIRING AN FRL

As discussed earlier, conventional fire rated plasterboard has been shown to not travel well in transport as the fixing screws work loose during vibration from transport and flexural loads the walls of the module are subjected to when cranes are used to load, unload and place modules in position on the construction site. The impact resistance is also quite poor.

Trafalgar has developed some comprehensive systems to use our Corex glass reinforced gypsum fire resistant board material to allow manufacture impact resistant and fire rated solid walls, conventional stud and track partitions and service riser shafts with requisite NCC or BCA FRL's. FRL's for -/60/60, -/90/90 and -/120/120 are available.

As Trafalgar specialise in overall systems, service penetrations, control joints and module to module joints have been or are in the process of being addressed to provide an overall FRL for each part of the module and module to module joints.

HORIZONTAL AND LOAD BEARING FLOOR / CEILING SYSTEMS REQUIRING AN FRL

Many modular fabrication companies are still having to use concrete for the load bearing and modular floor / ceiling systems requiring an FRL.

With conventional concrete, fire testing required by AS1530 Part 4-2014 is limited to fire exposure from below only. The use of new and innovative lightweight flooring systems for modular construction, negating the need for concrete, provide a new fire spread concern. This fire concern I will call fire from above, or downward fire exposure of the lightweight floor assembly, to contrast from fire from below.

Trafalgar has some load bearing floor / ceiling assemblies with fire test system approvals to AS1530 Part 4 – 2014 for both fire from below, and downward fire exposure or fire from above.

The floor can be constructed using beams, joists, purlins or beams at 450mm or 600mm centres depending on structural design requirements. Fire rated system are available using solid timber, LVL or Posi-strut joist or more conventional steel purlins, steel beams or open web trusses.

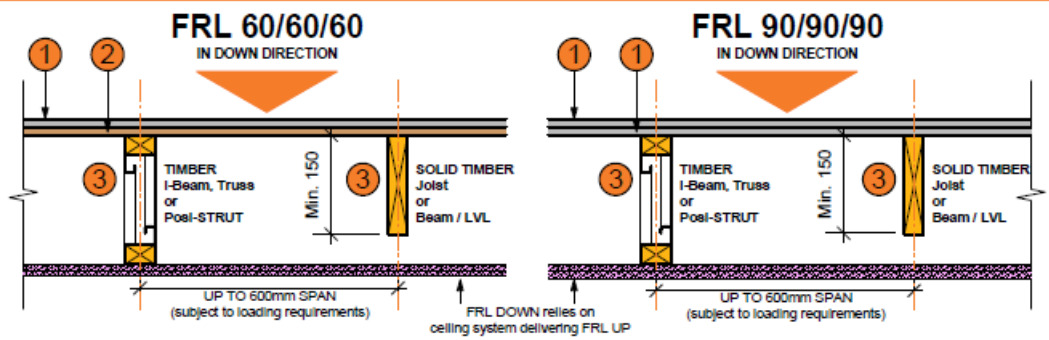


The downward fire performance is provided by Trafalgar INEX fire board, a proprietary lighter weight specialty (non-Portland) cement-based fire board, which depending on the FRL requires one or two 19mm thick layers; the former utilising 19mm thick, tongue and groove chipboard or structural plywood to provide the second layer. There is no need to use very heavy compressed fibre cement board as part of the systems.

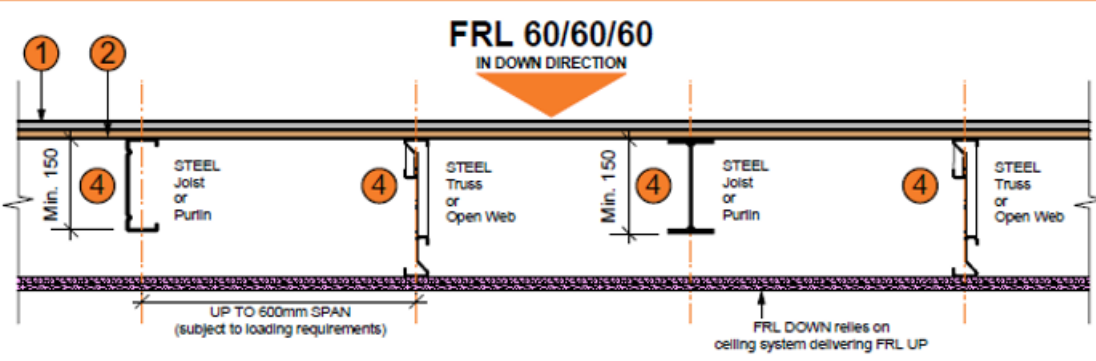
Joist spanning and loading capabilities of the system are the best available on the market.

Acoustic performance of the floor ceiling system have market leading and fully certifiable airborne sound resistance ($R_w + C_{tr}$) and impact sound resistance ($L_n, w + C_i$).

FRL DOWN SYSTEMS – TIMBER JOISTS



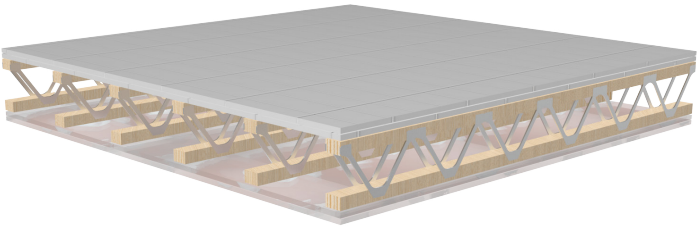
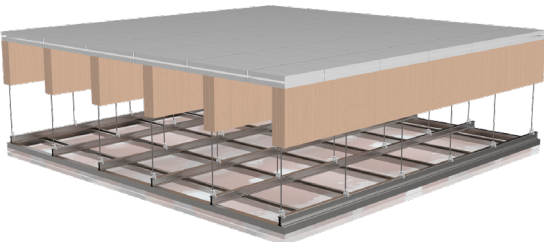
FRL DOWN SYSTEMS – STEEL JOISTS



Fire from below, can be provided by either fire rated plasterboard, the number of layers and construction depending on the manufacturer’s fire tested and published system data, or by use of Trafalgar Corex glass reinforced gypsum fire resistant board material.

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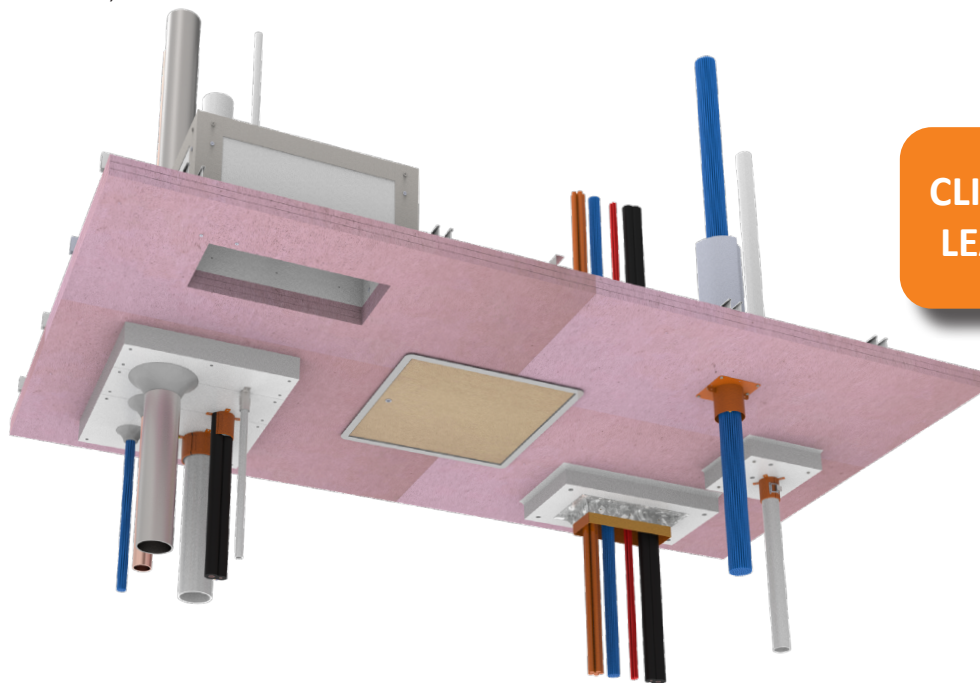
At the time of writing, Trafalgar is developing some systems incorporating CLT construction coupled with both Trafalgar Corex and Trafalgar INEX fire board materials.





SERVICE PENETRATIONS THROUGH TRAFALGAR SYSTEMS TO MAINTAIN THE FIRE BARRIER FRL

Trafalgar have some innovative fire stopping system developed for new construction which are particularly suited to modular and lightweight construction methods. Many allow services to move during transport and do not utilise wet caulks, mastic or sealants.



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JOINTS, CAVITIES, VENTILATIONS GAPS AND OTHER VOIDS

Often overlooked by some, and maybe the least glamorous of passive fire protection system components, but for modular construction, joints, especially module to module joints are very important to limit fire spread and to provide an overall FRL for discrete modular construction elements when bolted or joined together.

Trafalgar has some world class and patented fire stopping materials for joints, cavities and ventilation gaps in it's stable of passive fire protection products. We are continually fire testing new interfaces, gap sizes and FRL requirements to meet the need of the modular market.

Trafalgar have partnered with Siderise to provide systems with AS1530 Part 4 – 2014 fire testing for cavity barriers to prevent fire spread between the external façade and internal wall of buildings.

Trafalgar has a proprietary graphite impregnated foam material, FyreFOAM, manufactured locally and incorporated in our own FyreBOX fire transit systems which has shown good promise in recent fire testing to allow are dry, sealant free, compressible fire rated joint systems.



RECOMMENDATIONS AND CONCLUSIONS

Modular construction is an evolving method of construction, that generally relies on lightweight construction elements. Therefore, the method used to achieve the required fire resistance needs to be considered, in particular for floor separation between levels and resistance to impact damage. As the wall system used in some forms of Modular Construction are rarely tested in accordance with the relevant fire standards.

Australia has some good players who are developing innovative ways to provide 3D volumetric and modular elements of construction.

Fire safety and FRL requirement governed by the NCC allow a great platform for innovation of new lightweight, impact and vibration resistant, fast, clean, sustainable and economics materials and system to be developed. We cannot ignore thermal efficiency and acoustic and they need to be considered as part of the system development.

There is a huge opportunity for those involved in modular design construction and certification, and other interested parties to innovate and develop some world leading materials, systems and method of providing effective passive fire protection measures in modular construction.

Sadly, the design for passive fire protection of the opening for services and the joints, ventilation gaps and cavities are more often than not neglected or at best an after-thought.

A more interactive approach involving architects, fire safety engineers, the modular construction companies, certifiers and of course Trafalgar as a leading manufacturer and developer of fire stopping systems can see design and development of a more holistic or complete fire cell created by modular construction.

Trafalgar wants to collaborate and help solve the challenging passive fire safety concerns that modular construction and new lightweight building materials provide. Trafalgar is only a phone call away – reach out today for solutions and allow us to solve even the smallest of problems; like cavities, joints and voids for example.

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