DESIGNER'S GUIDE

Firefighting operations on multi-tiered vehicle stacking buildings

F5-13 GD

Introduction

When to use

Use this chapter to provide a consistent Fire and Emergency New Zealand position on multi-tiered vehicle stacking within enclosed car parking buildings. The primary objectives are to:

- outline the Fire and Emergency position on appropriate life safety design considerations for owners, designers and other building practitioners for car park buildings with multi-tiered vehicle stacking devices
- identify and overcome the limitations of the C/AS7 Acceptable Solution for Buildings Used for Vehicle Storage and Parking and C/VM2 Verification Method: Framework for Fire Safety Design methodology when considering the unusual challenges associated with multi-tiered vehicle stacking
- describe specific issues affecting firefighting operations in multi-tiered car stacking devices in car park buildings.

Scope

The scope of this chapter relates to all enclosed car park buildings with multi-tiered vehicle stacking devices. These are also known as car stackers or car stacker parking buildings.

NZ Building code performance requirements

Fire Safety C Protection from fire clauses C1 – C6 define NZ Building Code performance requirements of the Building Act 2004. C5 is the performance requirement on access and safety for firefighting operations.

Part 6 of C/AS1-6 Acceptable Solutions provides only limited information on requirements for firefighting operations therefore additional guidelines are required.

C/AS7 is the acceptable design solution for buildings used for vehicle storage and parking. Part 2 specifies a number of fire safety systems however it does not address firefighting operations (Part 6) in car stacker buildings, in its entirety. The following is a list of standards specific to building fire safety systems that are mandated for a variety of buildings including car stacking buildings. This is not an exhaustive list.

- NZS PAS 4509:2008 Firefighting water supplies code of practice
- NZS 4510:2008 Fire hydrant systems for buildings
- NZS 4512: 2010 Fire detection and alarm systems in buildings
- NZS 4541:2013 Automatic fire sprinkler systems.

Definitions

The following definitions apply for the purpose of this chapter. Defined terms (in italics) used throughout this document, are consistent with the Building Act 2004, New Zealand Building Code (NZBC) and Acceptable Solutions C/ASx.

British Research Establishment (BRE)	A research unit established by the UK government to consult, conduct research and testing for construction and the built environment.
Broken Hill Property Ltd (BHP)	Former Australian steel company now owned by BlueScope. BHP conducted a series of fire tests on steel structures including car fires in car park buildings.
C/ASx	New Zealand Building Code Fire Design Acceptable Solution parts 1 – 7 (x represents numbers 1 – 7).
Car stacking facility	Place where cars are stacked above one another inside a *building*, and can be one or several floors. A car stacking facility can also be found outdoors.
Car stacking parking building	A car park building with a multi-tiered vehicle stacking device or system.
Car park	Space or spaces within a *building* used for parking motor vehicles including private *household units*.
Multi-tiered vehicle stacking device/system	A mechanical device/system that stores vehicles either above or below others in a stacking arrangement. The process of stacking can be done manually however most large car stacking facilities are automated. There are three types of multi-tiered vehicle stacking devices (refer below).
Fire Engineering Brief (FEB)	A formal process as outlined in the International Fire Engineering Guidelines for all stakeholders to define the scope of work for the fire engineering analysis and the basis for analysis as agreed by stakeholders.
Fire Resistance Rating (FRR)	This is a defined term in the NZBC C Fire Documents. 'The term used to describe the minimum fire resistance required of primary and secondary elements as determined in the standard test for fire resistance', (refer to NZBC for full description).

Background

Parking cars within limited space

Traditionally, vehicles stored in car park buildings have typically been parked one vehicle in a single parking space. These spaces can be in dedicated parking buildings or on specified parking levels within a multi-purpose building. The growth of modern cities with more people migrating into the main centres increases pressure for more parking spaces thus more competition for inner city space. This has driven demand for innovative construction methodology to create more. The introduction of multi-tiered vehicle stacking devices allows multiple vehicles parked within a single vehicle storage space. Multi-tiered vehicle stacking is new to New Zealand cities although this is common in major cities worldwide.

Automated multi-tiered vehicle stacking devices (car stacking) is an efficient way of using limited space to provide car parks in buildings. It is growing in popularity amongst developers and building owners.

Safety issues

Multi-tiered vehicle stacking in car park *buildings* adds another challenge to firefighting operations at height or below ground, due to restricted access and poor or no ventilation.

In the past some designers provided no fire safety features or firefighting facilities for these types of buildings. This is a significant safety issue for firefighters and thus unacceptable, not providing the requirements outlined in this design guide. This past fire engineering design approach is completely inadequate and as such is one that Fire and Emergency New Zealand strongly discourages.

Car stacking systems

Car stacking is generally categorised into three types:

- simple – a system with two cars stacked in one available car space
- medium – two to three level system
- complex – a full storey unmanned fully automated car retrieval system. For more details of the three type, see Types of multi-tiered vehicle stacking systems in this chapter.

Firefighting operations risks

Firefighting operations in a traditional car park building are often challenging due to untenable conditions at the onset of fire. Poor or no visibility combined with excessive heat build-up, in an area that often has a low level ceiling height, all add to the complexity of the challenge that firefighters face as they try to locate the vehicle that is on fire.

Firefighting in a multi-tiered vehicle stacking building presents a much higher risk to firefighters as there is a larger number of cars parked closer together in a very confined space. A fire in a multi-tiered vehicle stacking building adds another layer of complexity to firefighting operations. In the past, these car parks have been designed with limited or no firefighter access. They are often located in basements, have minimal fire detection, no fire suppression systems with little or no consideration for firefighting operations. A full burn-out design philosophy using 400 kW/M^2 for 127 cars in a car stacker building with no firefighting facilities poses an unacceptably high level of risk to firefighters conducting firefighting operations and to occupants escaping from fire. This approach severely undermines the structural integrity of the entire building.

Firefighting operations in multi-tiered vehicle stacking buildings requires early detection and intervention systems *before* the arrival of Fire and Emergency crews. Firefighters will need specialised equipment for firefighting operations in car stacking car park buildings.

Types of multi-tiered vehicle stacking systems

There are three types of multi-tiered vehicle stacking devices; simple, medium and complex systems. They can be manually operated devices to complex fully automated intelligent vehicle stacking systems.

Type 1: Simple systems

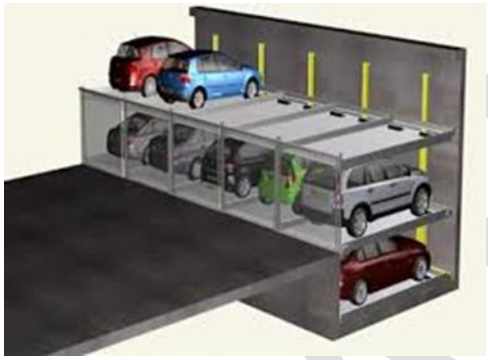
A single movement manually controlled hoist or ramp system for two vehicles. Ideal for residential apartment with limited space however these may also be installed in single garages of residential houses.

Cars parked (one at a time) onto the platform before manually operating hoist mechanism with individual key switch.

Type 2: Medium systems

A semi-automatic two to three level stacking system.

Operates in a similar manner as simple systems but maybe semi-automated. Some systems require a pit with cars stacked above and below ground level.

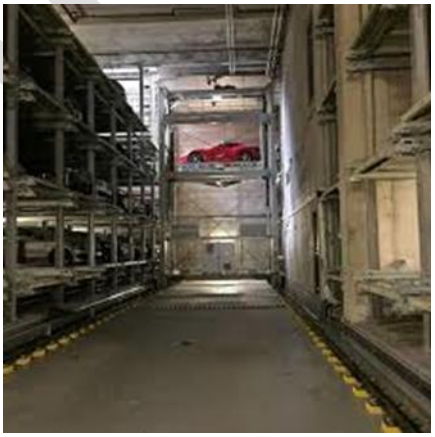


Type 3: Complex systems

Fully automated multi-tiered vehicle parking involving three or more basement or upper levels of the building.

Fully automated system where driver parks the car in the receiving bay and leaves the area. The automatic car stacking machine parks and retrieves the car from its pre-loaded location.

The automated parking machine can be a car lift or an automatic hoist operating in the central core (void) on tracks with access to all parking bays.



Design issues and considerations

Multi-tiered vehicle stacking car park buildings present unique challenges for building fire safety and firefighting operations. Car stackers are designed generally to suit basement areas in buildings however they can be found in a totally enclosed area above ground. The departure from traditional car park design creates additional risks requiring a different approach from designers.

The large number of cars within a confined space present higher risk for firefighting crews due to the higher fuel loading and limited access. Vehicle fires can spread very quickly to the surrounding vehicles producing a much larger heat release rate, reaching untenable conditions quickly. Designers must consider the following factors when designing for multi-tiered vehicle stacking buildings.

Factor	Description
Heat release rate (HRR)	Standard modern vehicles have a much higher fuel loading compared to older model cars. The increased use of plastics and foam inside the passenger compartment means the average HRR for a modern car is in the vicinity of 8 MW. Earlier analysis of HRR for older cars was around 3 – 5 MW. Generally, fuel loading analysis for car park buildings is based on the older HRR rather than using the modern car HRR. This anomaly increases exponentially in multi-tiered vehicle stacking devices where the fuel loading of closely stacked vehicles are generally underestimated in regulation and design. Multi-tiered vehicle stacking buildings fall outside of building regulations; they are specialist buildings requiring an alternative design.
Fire statistics	According to the Australasian Fire Authority Council (AFAC), Australian statistics have shown approximately 60% of fires in Class 7a – car park buildings are caused by vehicle fires. A quarter of these vehicle fires start in stationary vehicles. It is fair to consider that there is great risk of a vehicle fire occurring in a multi-tiered car stacking building where cars are stacked much closer to each other. Furthermore it is highly likely that fire will spread faster due to the parking arrangement.
Fire spread	BHP and BRE vehicle fire tests show that fire can spread quickly involving several cars. These conditions create fast generating and larger heat release rates, producing dense toxic smoke that reduces visibility. This is a significant risk to firefighting operations and for the occupants needing to evacuate safely.
Exposed steel structure	The majority of multi-tiered vehicle stacking devices are of steel construction. They are not fire rated or given fire protection or other building fire safety features to protect the exposed steel work. It is also important to note whether the floor plate of each park is complete or if it is a mesh type or fully open as this will impact even more cars in a fire due to drop down of burning items.
Fuel other than petrol	With large numbers of vehicles there is increased potential for other fuel sources to be available within the vehicle stacking device. These include diesel, LPG, hydrogen, battery and other fuel types from hybrid cars. The high use of plastic (including petrol tanks) and foam material in vehicle interiors creates pool fires as materials decompose during the fire.
Smoke ventilation/ exhaust systems	Sudden build-up of heat combined with thick dense smoke is a challenge for firefighters particularly in basement fires. Designers must provide adequate ventilation or exhaust extraction systems designed specifically to exhaust heat and other fire products.

Firefighting considerations

Successful firefighting operations in multi-tiered vehicle stacking buildings depend on fire safety features installed in the buildings. The Australasian Fire and Emergency Service Authorities Council (AFAC) has published a draft position on multi-tiered vehicle stacking devices. Fire and Emergency New Zealand is an AFAC member and fully supports the AFAC position. A copy of this position is included as Appendix A.

Designers are required to consider firefighting operations to ensure compliance with the NZ Building Code. Fire and Emergency recommends that designers meet with the Fire Service as early as possible in the Fire Engineering Brief (FEB) process to discuss firefighting requirements.

Minimum Fire and Emergency multi-tiered vehicle stacking buildings requirement

Minimum Fire and Emergency requirements for multi-tiered vehicle stacking buildings:

- A reliable automatic fire suppression system covering the entire building complex, for control or complete extinguishment. A fully compliant system in accordance with NZS 4541:2013 provides early fire suppression and control reducing the likelihood of fire spread.
- A building hydrant system in accordance with NZS 4510:2008; outlet inside a safe path stairwell. Complete extinguishment requires firefighters to enter the stacking area. Firefighters must enter from protected safe path stairs with a fully operating firefighting hose delivery.
- A fully compliant fire detection system, in accordance with NZS 4512:2010, provides early warning for building occupants. A detection system monitored by Fire and Emergency will raise an early response from the nearest fire crews. Fire and Emergency is committed to reducing false alarms therefore it is important to select the most suitable detection system that is fit for purpose.
- Firefighters require good access into the car stacking area. This is normally from a safe place via a pressurised safe path stairwell:
    - Multi-tiered vehicle stacking buildings <500 m^2 and <10 metres below ground require 1 x safe path pressurised safe path stair.
    - Multi-tiered vehicle stacking buildings >500 m^2 and >10 metres below ground require 2 x pressurised safe path stairs.
- Stairs pressurisation in accordance with AS 1668:1. Firefighters must be able to enter and operate from a safe path stairwell to the lowest part of the building or basement. Vision (viewing) panels are required in the safe path stairwell allowing firefighters to gain first-hand knowledge on possible location of the fire and fire development. Entry Control Officer (ECO) sets up and operates from the safe path stairs in a multi-level building.
- Basement fires are difficult to locate as visibility is lost very early often before the first crew arrives. Heat and smoke have very little opportunities to escape particularly from the basement area. An automatic smoke ventilation or smoke exhaust/extract system in a multi-tiered vehicle stacking building will assist with firefighting operations. Firefighters must have full access and ability to control the ventilation/extraction system if required.
- Multi-tiered vehicle stacking systems or devices are powered by electricity with some having dedicated standby power supply. Firefighting operations must be able to isolate vehicle stacking devices and any other power supply to the car stacking areas. The Fire Service requires access to and full control of power including emergency supply to the devices. Fire and Emergency also requires access to controls to all other utilities in the building.
- Construction of the car park deck/floor must be of non-perforated and non-combustible material. Solid floor pans reduce fire spread to lower vehicles.
- Car stacking facilities outdoors require a different set of rules for firefighting operations as multi-tiered vehicle stacking devices have no walls. The main focus for firefighting operations in outdoor car stacking facilities is the exposure to nearby structures and having sufficient firefighting water supplies.

Conclusion

Fire and Emergency New Zealand strongly recommends designers to support the FEB process by meeting with Fire and Emergency personnel at the earliest possible time to discuss proposed projects such as multi-tiered vehicle stacking car park buildings. Fire and Emergency is committed to provide a safe solution for firefighting operations in car stacker car park buildings.

Fire and Emergency criteria for fire safety design features for car stacker car park buildings are:

- an automatic fire suppression (sprinkler) system
- an automatic smoke control (ventilation)system
- provision of a building hydrant system
- provision of pressurised safe path stairs for safe access
- a reliable early detection system
- a design fire using a 5 – 8 MW HRR as a realistic representation of the fuel load in a modern car.
- a higher level of FRR, reflective of the greater risk given the higher fuel load in a restricted space.

Appendix A: AFAC position on multi-tiered vehicle stacking devices

AFAC's position on multi-tiered vehicle stacking devices (car stacking buildings):

- A sprinkler system complying with the current edition of relevant standard (AS 2118.1 for Australia or NZS 4541:2013 for New Zealand) must serve the entire car park, which also incorporates appropriate sprinkler heads (e.g. combination of pendent and sidewall heads as required) situated in strategic locations, providing full spray coverage to all tiers (including stacker pits) of multi-tiered vehicle stacking arrangements.
- For Australia, the Australian standard for sprinkler systems in residential buildings (AS 2118.4) currently allows a building classified as 'residential' to be provided with a residential sprinkler system extended throughout the entire building (including the car park). The overall sprinkler system performance (particularly within the car park) shall be validated to ensure it meets the relative design intent for the specific hazard and storage commodity.
- Multi-tiered vehicle stacking devices shall use non-perforated and non-combustible materials, thus minimising the likelihood of direct impingement of flame from the vehicle situated on the lower tier to the vehicle located on the upper tier. A non-perforated, non-combustible tier deck will also minimise the likelihood of any fuels, lubricants and oils dripping on the vehicle below.
- Where penetrations through fire rated car park barriers exist, appropriate protection commensurate with the FRR of the specific construction element shall be provided. Where pipework penetrations exist, suitable fire collars shall have a Certificate of Test appropriate to AS 4072.1 (applicable to both Australia and New Zealand). The fire collar installation is to consist of the same materials and is to be installed using the same methods as a tested prototype assembly.
- Smoke exhaust shall be provided and meet the smoke exhaust system requirements of the relevant building regulations.
- At least two firefighter access points should be provided irrespective of the car park location (above or below ground). Where stair travel is required to access the car park, fire rated construction shall be considered with a complementing self-closing, fire rated door system.
- An occupant warning system shall be provided to simultaneously warn all occupants of the building of a fire emergency in the car park. In Australia, the occupant warning system shall comply with AS 1670.4 Sound Systems and Intercom Systems for Emergency Purposes. In New Zealand an automatic fire detection and alarm system complying with NZS 4512:2010 shall be installed.
- Emergency procedures including an evacuation scheme shall be prepared and implemented for the building. In Australia, the emergency procedures and evacuation scheme should comply with AS 3745 Emergency control organisations and procedure for buildings, structures and work places.
- There shall be no private storage areas within car parks.