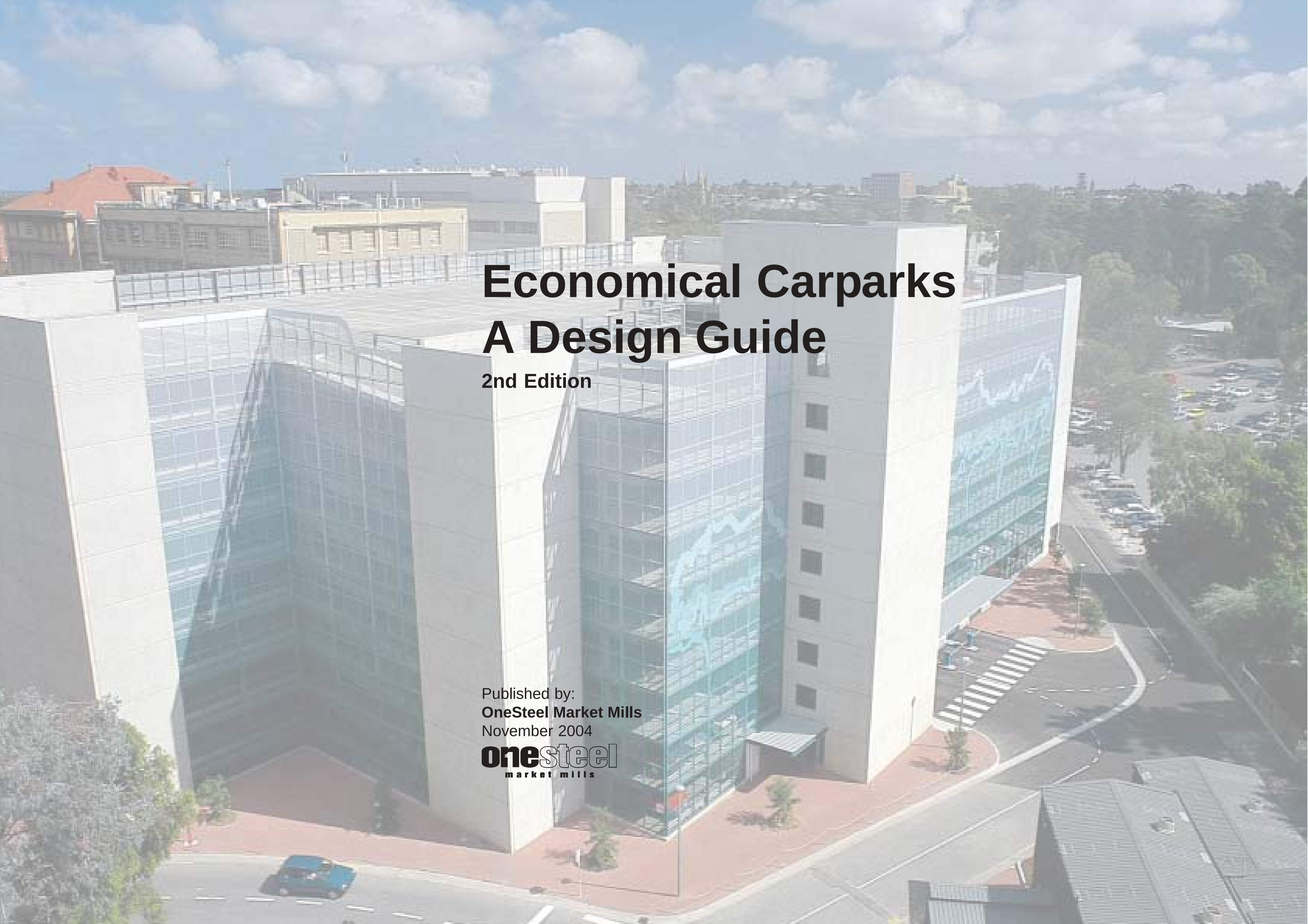

Economical Carparks A Design Guide

2nd Edition

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CONTENTS

FOREWORD

In 1998, BHP Integrated Steel published the First Edition of Economical Carparks – A Design Guide. Since its release countless developers and designers have utilised the publication to assist in the design and construction of carparks. Over the last seven years there have been some significant changes in design, construction techniques and in supply of the materials required to construct these carparks.

This Edition of the Design Guide is now published by OneSteel Market Mills who are the largest manufacturer of the structural steel beams referenced in this Guide. The standard base material for the decking profiles have changed, as has the number of different decking profiles available. The Australian Design Standards have also changed making it necessary to amend some of the design drawings. Also two new schemes offering column free parking spaces have been included in this Edition taking the total number of schemes to eleven.

This Edition includes the aforementioned changes as well as a new layout adopted to reflect the comments made by the users of the First Edition.

OneSteel Market Mills wishes to thank the many people who have contributed to the production of the First Edition and this Second Edition, in particular:

Ian Bennetts
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1. INTRODUCTION

This Design Guide has been prepared to assist engineers, architects, quantity surveyors, builders and developers produce and cost preliminary designs for steel carparks.

Eleven carpark schemes utilising re-entrant profiled steel decking on structural steel are presented with extensive information given for each scheme including:

- slab details;
- beam and column sizes;
- number of shear connectors;
- connection details;
- corrosion protection details; and
- cost indicators

These schemes can be used to produce designs for most carpark building layouts. Over the last two years there have been a number of new profiled steel decks launched into the Australian market which has provided many new alternative layouts. Nonetheless the schemes presented in this Guide provide an excellent starting point for the preliminary design, which may then be fine-tuned as required and in some cases, utilise the new profiled steel decks.

The use of the above information is illustrated by means of some worked examples, demonstrating some of the advantages associated with steel construction for carpark buildings.

The Appendices in this Design Guide give the detailed structural design criteria adopted for design solutions, information on designing for durability, costing data, a survey of existing carparks and examples of ramp configurations.

1.1 Steel Carparks

Since 1985 well in excess of 100 carparks have been constructed in Australia and New Zealand using structural steelwork. Advantages associated with steel carpark construction include:

Earlier Occupation: Repetition from bay to bay and floor to floor leads to reduced time in the production of shop drawings, fabrication of connections and the erection of steelwork. The time-savings offered by a steel solution results in reduced financial holding costs and hence provides an earlier return on investment.

Reduced Exposure to on-site risks: Off-site fabrication reduces the on-site labour, which reduces the cost of amenities and the amount of on-site supervision. The reduction in the on-site workforce, delays due to weather and the on-site congestion reduces the exposure to on-site risk.

Greater Space Utilisation: The sizes of steel columns are small compared with other forms of carpark construction and this results in a more functional carpark. The column free space offered by the long spanning capability of structural steel reduces the number of columns required and in some of the schemes eliminates all internal columns.

Future Proof Investment: Columns are easily strengthened and additional connections can be site welded to the existing steel structure providing flexibility for vertical or horizontal extension.

Reduced Foundation Costs: The reduced dead load associated with structural steel results in smaller foundations.

1.2 Layouts

The Australian/New Zealand Standard AS/NZS 2890.1:2004 provides guidance and minimum requirements for the design and layout of off-street parking facilities including multi-storey carparks. It classifies car parking facilities according to the type of use as shown in Table 1. Parking space and aisle widths are also given for each class. The nominal length of a parking space is 5.4m.

The following discussion covers some of the major requirements of the code which have a significant impact on the design of a multi-storey carpark.

1.2.1 Column Location

The location of the columns is one of the most critical decisions in achieving an economical and functional carpark.

Construction using large clear spans offers the following benefits:

- improved visibility;
- increased interior lighting efficiency;
- ease of cleaning and maintenance;
- better security; and
- greater number of cars per unit area of available floor space.

User Class	Examples of Uses	Space Width (m)	Aisle Width (m) (Parking at 90°)
1	Generally all day parking e.g. tenant, employee and commuter parking, universities	2.4	6.2
1A	Residential, domestic and employee parking - 3 point turn entry & exit	2.4	5.8
2	Generally medium term parking e.g. long term city and town parking, sports facilities, entertainment centres, hotels, motels, airport visitors	2.5	5.8
3	Generally short term city and town centre parking, shopping centres, hospitals and medical centres	2.6	5.8
3A	Short term, high turnover parking generally at shopping centres	2.6 2.7	6.6 6.2
4	Parking for people with disabilities	2.4 (+ 2.4 Shared area)	5.8

Table 1 - Carpark Classifications and Dimensions

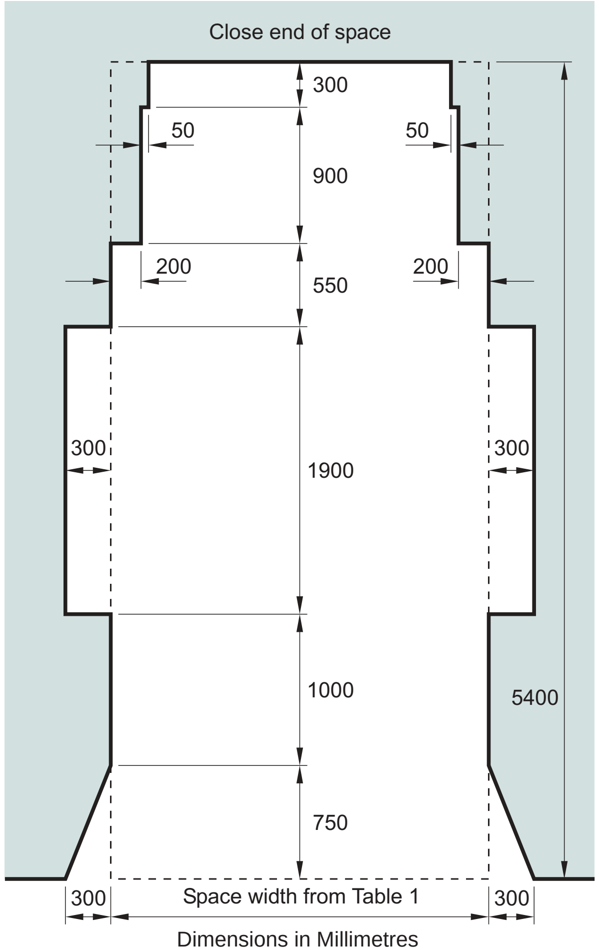


Figure 1 - Design Envelope, AS/NZS 2890.1:2004

Where clear span construction is not practical, the columns should be carefully located so as to cause minimal interference with traffic circulation, parking manoeuvres and driver visibility. Figure 1 gives the design envelope around a parked vehicle which shows a shaded area where columns, walls and other obstructions should be placed.

1.2.2 Headroom

The minimum height clearance for cars and light vans is 2.2m. Car spaces for people with disabilities require a clearance of 2.3m from the carpark entrance/exit to their designated space and 2.5m above the designated car space.

With a steel carpark, sprinklers, lights, etc. can be placed within the depth of the steel beams. This not only protects these items, but also means that these items do not control the floor-to-floor height. Therefore the critical height clearance dimension is to the bottom of the steel beams.

1.2.3 Ramps & Circulation

Ramps play a major role in the efficient circulation of traffic through a carpark allowing traffic to flow from one level to the next. Ramps can be designed in various configurations to facilitate the required circulation of traffic. A typical example of a ramp arrangement and circulation for a split system carpark is shown in Figure 2. Additional common ramp configurations for both one-way and two-way traffic flow are presented in Appendix F.

The Australian/New Zealand Standard AS/NZS 2890.1:2004, Clause 2.5.3 provides details on allowable gradients on ramps. For straight ramps in public carparks, not part of a parking module, from one level to the next the maximum gradient is:

Ramps longer than 20m -	1 in 6
Ramps up to 20m -	1 in 5

For further details refer to Clause 2.5.3 of AS/NZS 2890.1:2004.

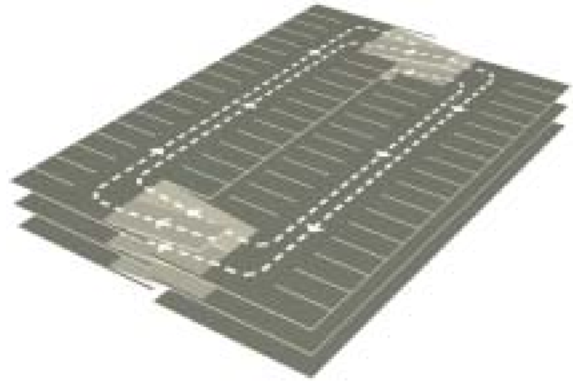


Figure 2 - Example of a Ramp Arrangement and Circulation

One-way ramps should be at least 3m wide between kerbs, while two-way ramps should be a minimum of 5.5m between kerbs. For minimum width of ramps on curve refer to Clause 2.5.2(b) of AS/NZS 2890.1:2004.

1.2.4 Gradients (Excluding Ramps)

The maximum gradient within a parking module is:

Measured parallel to the angle of parking -	1 in 20
Measured in any other direction -	1 in 16

Parking spaces for people with disabilities the maximum gradient should not exceed - 1 in 40

The minimum recommended gradients to allow the floor to drain adequately are:

Outdoor area floor -	1 in 100
Covered area floor -	1 in 200

1.3 Parking Modules

A parking module is defined in AS/NZS 2890.1:2004 as a parking aisle together with a single row of parking spaces on one or both sides. In this document only parking on both sides of the aisle is considered. The parking module excludes any ramps or circulation roadways which take off within the module.

Many variations could be developed for the different classes of carpark to cover all situations. In this document, a user Class 3 module for parking at the preferred angle of 90^{o} to the aisle is considered. The standard module in this publication consists of:

Parking space width	2.6m	
Parking space length	5.4m	
Aisle width	5.8m	
Parking module length	16.6m	(2x5.4 + 5.8)

This configuration is considered to cover most practical cases, and allows the designs and costs given in Section 2 to be quickly and accurately adopted at an early stage of a project. It is noted that the new Class 3A in the latest edition of AS/NZS 2890.1:2004 exceeds the dimensions of this adopted module, and the designs should be adjusted accordingly. As the design progresses, the beams and columns would of course be designed for the actual layout of the project. The costs per square metre are generally not very sensitive to small changes in dimensions.

The other major simplifying assumption is a standard allowance for a column width of 300mm. Whilst this is usually adequate, a small number of columns exceed this dimension at the bottom of an eight level carpark and this would need to be allowed for in the final design. Alternatively, the columns could be redesigned to fit within the 300mm width.

Module Type	Scheme Description	SCHEME NUMBER			
		Bay Width			
		2 car	3 car	4 car	5 car
SINGLE	Internal and edge columns, Figure 3(a)	-	S1A	S1B	S1C
	Internal columns and cantilever edges Figure 3(b)	-	S2	-	-
	Clear span with edge columns, Figure 3(c)	S3A	S3B	S3C	-
MULTIPLE	Internal and edge columns, Figure 5(a)	-	S4A	S4B	S4C
	Internal columns and cantilever edges Figure 5(b)	-	S5	-	-

Note: Refer to Section 2 for full details of each of the schemes.

Table 2 - Carpark Schemes

Carpark layouts can be divided into single and multiple module designs:

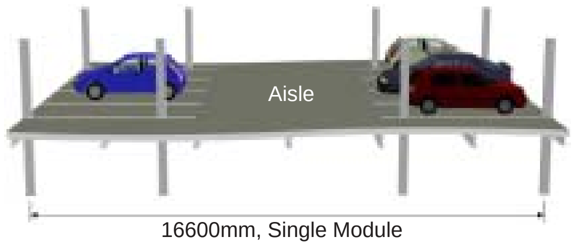
1.3.1 Single Module Schemes

Three different single module schemes have been developed, viz:

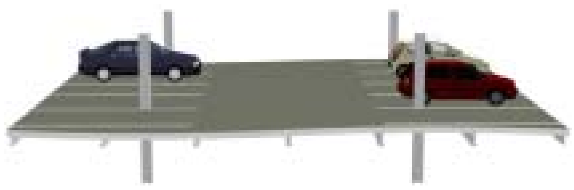
- Scheme S1 - Internal columns with edge columns, see Figure 3(a);
- Scheme S2 - Internal columns with cantilevers, see Figure 3(b); and
- Scheme S3 - Clear span with edge columns, see Figure 3(c).

These schemes were developed for various bay widths as shown in Table 2.

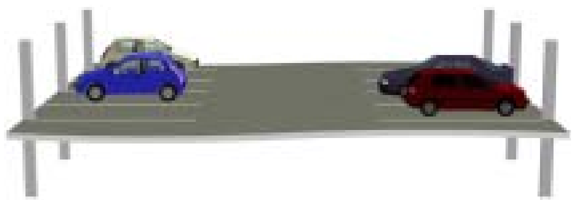
A carpark may consist of a number of single modules as shown in Figure 4, each module consisting of an aisle and a row of parking each side. These modules can either be horizontal; see Figure 4(a), or sloped to form a long ramp between the different levels; see Figure 4(b) & 4(c). The single modules provide considerable flexibility in achieving different layouts.



(a) Scheme S1

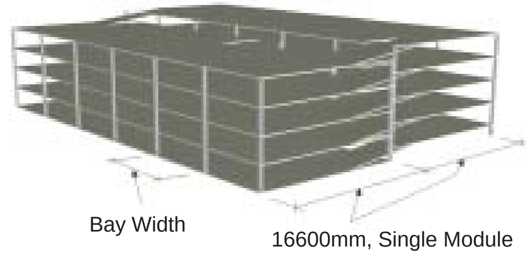


(b) Scheme S2

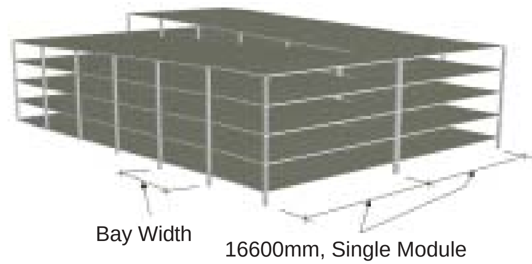


(c) Scheme S3

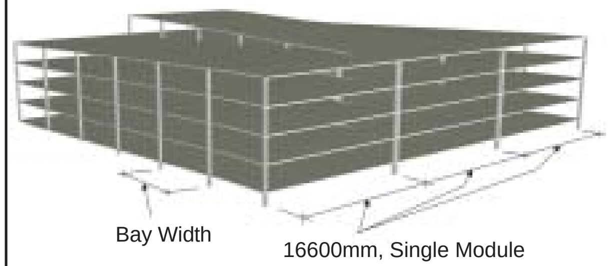
Figure 3 - Single Module Schemes



(a) Horizontal Floor - 2 x Single Module Carpark



(b) Sloping Floor - 2 x Single Module Carpark



(c) Sloping Floor - 3 x Single Module Carpark

Figure 4 - Single Module Carpark Combinations

1.3.2 Multiple Module Schemes

Multiple module schemes are used when there are a number of aisles in the same plane. They are often used at shopping centres, hospitals and educational institutions where the carparks are relatively large in plan compared to their height.

Two different multiple module schemes have been developed viz:

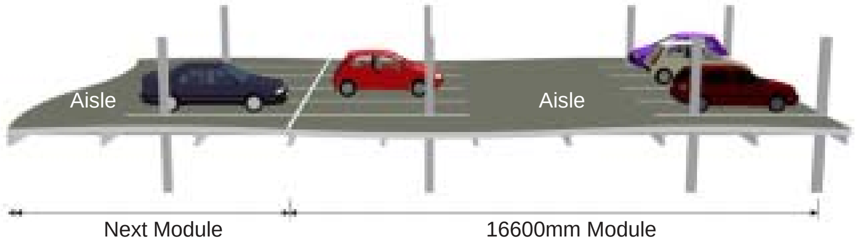
- Scheme S4 - Internal columns with edge columns, see Figure 5(a); and
- Scheme S5 - Internal columns with cantilevers, see Figure 5(b).

1.3.3 Carpark Space Utilisation Efficiency

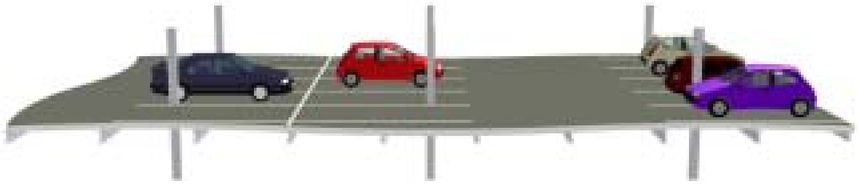
Table 3 gives the square metres per car space together with their relative module efficiency, for each of the schemes. It can be seen that Schemes S3A, S3B and S3C provide up to 4% more car space in a given area. This is the most efficient scheme as the columns do not impinge on the design envelope (see Figure 1).

Reference

Standards Australia/Standards New Zealand 2004, *AS/NZS 2890.1:2004 Parking facilities - Off-street car parking,* SAI/Standards New Zealand, Sydney/Wellington



(a) Scheme S4



(b) Scheme S5

Figure 5 - Multiple Module Schemes

Scheme	Square metres per car space	Relative module efficiency
S1A	22.4	96%
S1B	22.2	97%
S1C	22.1	98%
S2	22.4	96%
S3A	21.6	100%
S3B	21.6	100%
S3C	21.6	100%
S4A	22.4	96%
S4B	22.2	97%
S4C	22.1	98%
S5	22.4	96%

Table 3 - Relative Layout Efficiency Of Different Schemes