D. COSTING

D.1 Methodology

The costing of the different carpark schemes is based on a rational costing method, proposed by Watson et al. (1996), which divides the costs up into the following components.

Steel Supply
Steel sections are costed in dollars per lineal metre, whereas plate and profiled sheeting are costed in dollars per square metre.

Fabrication
This item covers shop drawings and transport, as well as the fabrication activity. It is an activity-based costing system. The time to undertake each activity has been derived from a detailed survey of practices within the Australian fabrication industry.

Surface Treatment
Rates per square metre of treated area are used to determine the cost of these activities.

Erection
This item covers all activities carried-out on site such as steel erection, laying and fixing of profiled steel sheeting and welding of shear studs.

The advantages of the above methodology in costing are that it :

- provides more reliable and accurate costs;
- provides continuity of approach from initial project costing through to fabricator's detailed costing;
- provides a clearer focus on the elements that will have a significant effect on the final cost; and
- allows reliable determination of contract variation costs.

A Microsoft Excel 7.0 spreadsheet program was used to determine the costs of each of the carpark schemes using the above methodology. Each scheme is costed on a separate sheet and this information is brought together on a summary sheet. The costs are based on data given by Watson et al. (1996) with an updated fabrication hourly rate of $60 and 2004 supply costs.

The accuracy of these costs has also been verified independently by a number of fabricators. As significant attention has been given to minimise the cost of the details recommended for use, the cost of the fabrication is sometimes less than the fabricator's initial approximation. However, a more detailed examination reveals that the costs are realistic.

D.2 Costs

A summary of the base costs is given in Table D1. The base costs are derived for schemes with a Category C exposure classification and no web penetrations. This information has been taken from the summary sheet of the spreadsheet program.

D.2.1 Schemes with Edge Columns (Schemes S1 & S4)

From the base costs in Table D1, it can be seen that, the 4 car space schemes (S1B & S4B) with edge columns are the most economical. The 3 car space schemes (S1A & S4A) are only slightly more expensive. This goes against conventional wisdom since one would expect the 3 car space schemes to be cheaper as there is less steel. The beam

Scheme	Floor Costs $/m²				Column Costs $/m² for No. of storeys				TOTAL COSTS (Floor and Columns) $/m² for No. of storeys			
	Beams	Decking	Slab	TOTAL	2	4	6	8	2	4	6	8
1A	83	40	55	178	12	15	17	19	190	193	195	197
1B	81	40	55	176	9	12	15	17	185	188	191	193
1C	101	40	55	195	9	12	14	17	204	207	209	212
2	94	40	55	189	10	11	12	15	199	200	201	204
3A	73	49	58	180	22	19	24	25	202	199	204	205
3B	132	40	55	226	8	10	12	14	234	237	239	240
3C	135	40	55	230	7	9	10	13	237	239	240	243
4A	84	39	55	177	9	12	15	19	187	190	192	196
4B	80	39	55	174	8	11	15	18	182	185	189	192
4C	97	39	55	191	8	10	14	16	199	201	205	207
5	87	39	55	181	9	10	12	15	190	191	193	195

NOTE: To obtain the total cost of the carpark floor and columns, multiply the cost for the relevant number of storeys by the total area.

Table D1 - Summary of Indicative Costs (Surface treatment: Refer to Table B2 Category C)

supply cost for Schemes S1A & S4A is $35 per square metre whereas for schemes S1B & S4B it is $40 per square metre. However, with these schemes there is the same amount of fabrication and erection per module. Yet the module area for the 4 car space module is one third larger than the 3 car space module. Therefore, the additional supply cost for the beams in the 4 car space scheme is offset by the reduced fabrication costs and the total cost for the beams is the same. In addition, with the 4 car space schemes there are fewer members to erect for a given carpark and hence construction speed is increased.

The cost for the beams includes allowance for the cost of the connections to the columns. Therefore the column costs include only the supply cost of the column, the fabrication costs associated with the end splice, erection costs and surface treatment costs. It can be seen from Table D1, that the column cost per square metre for the 4 car space schemes is less than that for their respective 3 car space scheme.

The 5 car space schemes suffer a significant cost penalty of up to $20 per square metre over the 4 car space schemes. This is largely due to the increase in steel supply cost of $10 per square metre. The remainder is made up of increased fabrication and surface treatment costs due to the larger members and connections.

Schemes S1B, S1C, S4B and S4C offer a small improvement in utilisation of the floor area (see Table 3) which should be taken into account when comparing the different schemes.

D.2.2 Schemes with a Cantilever Edge (Schemes S2 & S5)

This layout is only given for a 3 car space scheme as the cantilever size proved uneconomical for larger module widths. The steel supply cost was only slightly more than for the edge column solution. However, the fabrication costs increased considerably with the moment connections. For the multiple module Scheme S5, this additional cost is spread over a greater floor area and hence is not as obvious as the single module Scheme S2 which has two cantilevers in a single module.

D.2.3 Scheme with a Clear Span (Scheme S3A, S3B & S3C)

Clear span solutions offer a very efficient layout with more car spaces in a given footprint. These schemes are also very appealing to the user as there are no internal columns that are a potential source of damage to cars. For this reason they are popular in carparks with high turnover, particularly in shopping centres.

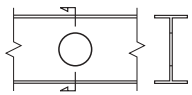
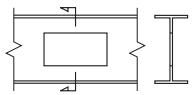
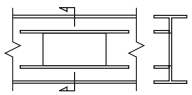
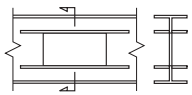
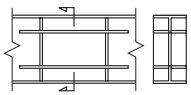
The total cost of Scheme 3A is very sensitive to the component cost of propping the slab during construction, however if this is well managed the more efficient usage of space almost pays for the additional cost over the schemes that are not clear span.

The additional cost of schemes 3B and 3C are generally accepted by owners on the basis of the additional appeal it offers the users of the carpark.

Scheme	Protection System Costs $/m^2							
	Atmospheric Corrosivity Category					Add. Top Coat A[1]	Add. Top Coat Oth[2]	Hot-dip Galvanized
	A	B	C	D/F	E			
S1A	9	14	15	20	21	8	11	14
S1B	10	15	16	21	23	9	12	14
S1C	12	18	20	25	27	12	16	25
S2	10	15	16	21	22	9	12	16
S3A	6	9	10	13	14	6	8	12
S3B	14	22	24	32	34	14	19	31
S3C	14	21	23	31	33	14	19	30
S4A	10	15	16	21	22	9	12	15
S4B	10	15	17	21	23	9	12	15
S4C	11	17	18	24	25	11	15	23
S5	9	14	15	20	21	9	12	15

Notes:
1. Cost of additional top coat applied over Category A finish
2. Cost of additional top coat applied over all other surface finishes except Hot-dip Galvanized

Table D2 - Surface Treatment Costs

Penetrations	Unreinforced				Reinforced					
Section mass (kg/m)	Circular		Rectangular		Rectangular		Rectangular		Rectangular	
	Hours	$	Hours	$	Hours	$	Hours	$	Hours	$
< 60.5	0.4	24	0.7	42	2.0	120	3.4	204	4.2	252
60.6 to 160	0.5	30	0.8	48	2.4	144	4.1	246	5.7	342
160.1 to 455	0.7	42	1.2	72	3.7	222	6.1	366	8.5	510
Diagram										

Note: Based on an hourly rate of $60

Table D3 - Cost of Penetrations

D.3 Different Surface Treatment Systems

The cost of surface treating or painting the steelwork has a major influence on the initial cost of a carpark. The cost of different paint systems for each of these schemes is given in Table D2. It should be noted that an additional $5/m^2 allowance to mask the top flange and to later treat with a weld through primer has been included in the costs for all paint systems except for category A. Scheme 3A is significantly less than the other schemes as there are fewer members involved. This makes this scheme more attractive if the more expensive protective systems need to be used.

D4 Penetrations

The cost of large reinforced penetrations in the webs of steel beams can have a significant influence on the cost of a floor. However, in a carpark, such penetrations are usually not required. Circular and rectangular unreinforced penetrations that will generally cater for the necessary hydraulic services in a carpark can be economically provided in the primary beams. For example 200 diameter penetrations in each of the primary beams will cost in the order of 25 cents per square metre over the entire carpark. The indicative costs of different types of penetrations that are commonly used are given in Table D3.

D.5 Column Splices

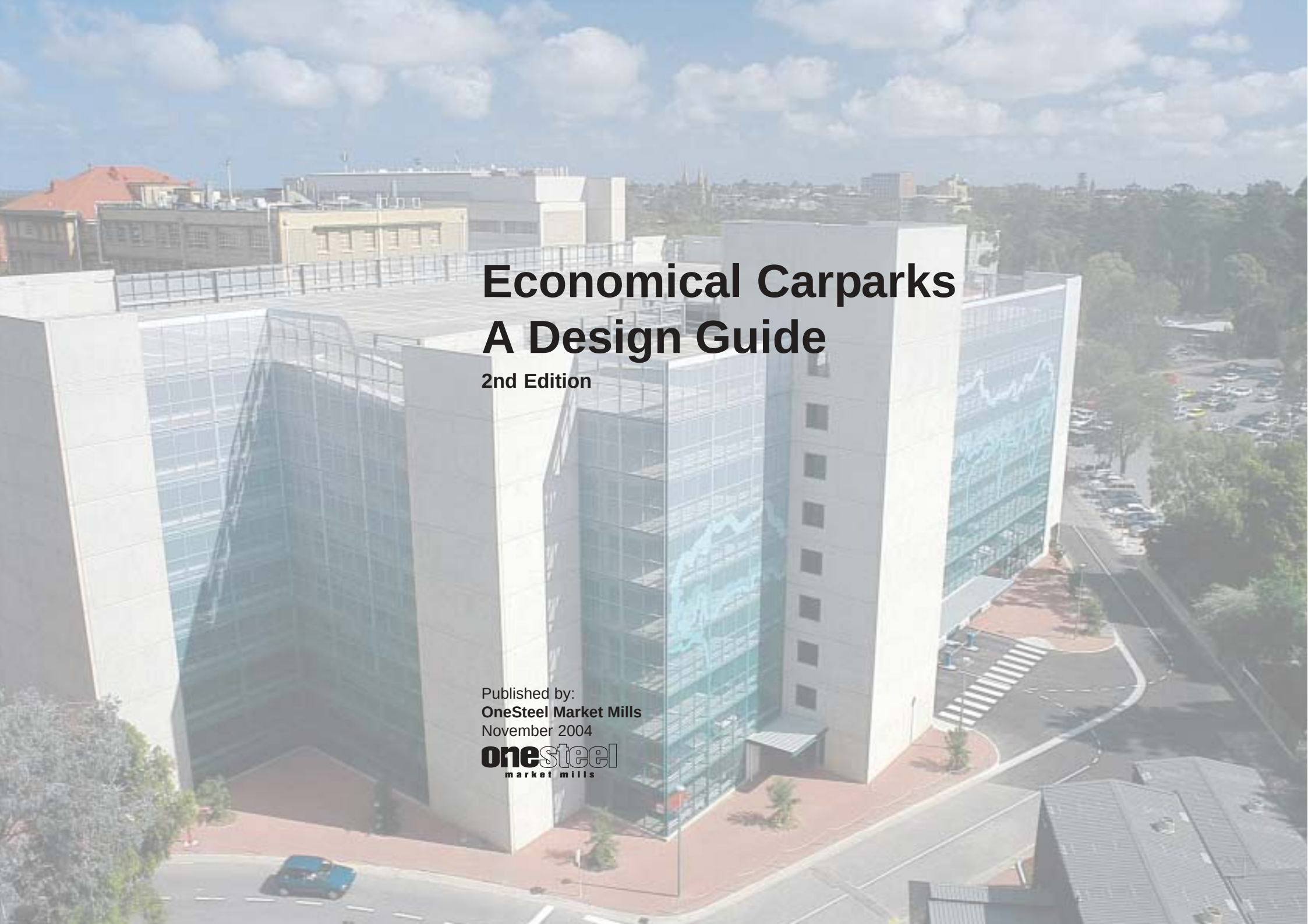
The cost of column splices is quite substantial. The fabrication cost is generally between $240 and $320 per splice. To this the additional cost of shop drawings, transport and erection has to be added. This brings the total cost of a splice to between $520

and $800. Therefore, in general it is better to minimise the number of splices rather than the mass of the column.

The maximum length of column section that is readily available and still easy to handle is 18 metres. Therefore, it is recommended that for carparks less than four levels high, the columns are made from one length (without splices). With a six level carpark, the cost of a non-prismatic column with splices is similar to that of a prismatic continuous column. The choice will depend on the scheme being adopted and the time allowed for fabrication and erection. For an eight level carpark, it is suggested that a splice be provided at mid-length for maximum economy.

References

Watson, K. B., Dallas, S., van der Kreek, N. & Main, T. 1996, “Costing of Steelwork from Feasibility through to Completion”, *Journal of Australian Institute of Steel Construction*, vol. 30, no. 2



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