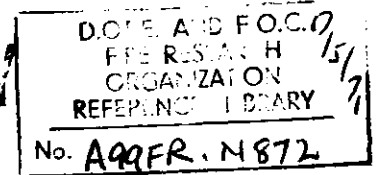


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# Fire Research Note No 872

MAINTENANCE OF STRUCTURAL STEEL  
MULTI-STOREY CAR PARKS

by

D. V. MASKELL

May 1971

# FIRE RESEARCH STATION

**Fire Research Station,  
Borehamwood,  
Herts.  
Tel. 01-953-6177**

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MULTI-STOREY CAR PARKS

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SUMMARY

Circular No. 17/68, issued by the Ministry of Housing and Local Government, now the Department of the Environment, permits, under certain conditions, the use of unprotected steelwork for the construction of multi-storey car parks. However, one of the biggest draw-backs to its usage has been the need to protect the steel against corrosion.

Besides providing some general information on the maintenance and running costs of a car park, this report seeks to establish the costs of periodically redecorating the steelwork.

Allowing for the limited number of car parks built in steel, the report shows that in terms of present day worth, about £9 per car parking place is added to the initial cost for this periodic redecoration.

KEY WORDS: Car park, building multi-storey, maintenance, steel.

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MAINTENANCE OF STRUCTURAL STEEL  
MULTI-STOREY CAR PARKS

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INTRODUCTION

Due to the normal processes of age and 'wear-and-tear', all structures require some degree of maintenance during their lifetime. The extent of this maintenance will depend upon these normal processes, coupled with the ever increasing vandalism. Public buildings, such as multi-storey car parks, suffer more from vandalism than the conventional domestic dwelling, and consequently it is becoming necessary to incorporate within the design of these buildings, allowances for this vandalism in order to minimize the cost. Certainly, this is true for the finishes, fixtures and fittings of the building design.

MAINTENANCE

For the purposes of this report, the maintenance bill has been taken to include those items which are directly concerned with the maintenance and running cost of the car park. The other items of expenditure, which might appear on the balance sheet - rates, insurances and loan charges - have been ignored.

Considering a typical car park, of concrete or steel, the maintenance costs will include the following:

- (i) Wages for attendance and cleansing
- (ii) Repairs and maintenance to the building structure
- (iii) Repainting bay markings and any necessary maintenance to the drive-ins, ramps and grounds, etc
- (iv) Repairs and maintenance to lifts, control gear, ticket machinery etc
- (v) Electricity and other services
- (vi) General cleansing materials and any necessary provisions for attendance
- (vii) Redecorating staircases, attendants offices, public rooms, etc
- (viii) Repairs and replacement of furniture and fittings (lights, signs, etc)

The proportion of each of these items to the overall bill will vary from car park to car park, depending on the particular circumstances. For example, an older car park will require more maintenance to the structure and machinery; whilst a car park in an area of constant demand will probably require more redecoration and repainting of lines, etc. Also where the local authorities, owning the car park, wish to charge more economic rates for parking, in the form of a graded scale, then the need for attendance will be increased, and this will raise the wages bill item.

Appendix A at the end of this report, lists the maintenance charges of two car parks. Using these examples and others supplied by various car parking concerns, certain characteristics can be detected, regarding the charges.

The most expensive item of the overall bill is that of wages, and this will include in most cases, an allowance for cleaning, as well as attendants on duty. The other sizeable items are: electricity and the repairs and maintenance to the structure. Electricity may be high if it includes under-floor heating (i.e. for the ramps) and lower if the car park is partially open thus reducing the need for lighting. Wages and electricity are largely dependent upon the demand and the other circumstances quoted earlier, but this third expensive item - maintenance to the structure - is also greatly influenced by the construction of the car park.

Concrete should not require maintenance and decoration if the concrete mix is accurate, and the structure well constructed. There are occasions when the appearance of a concrete car park would suggest that decoration might be useful, but the fault in these cases is not so much in the material but more in the way that it has been used. Unclad steel, on-the-other-hand, must be protected from the elements, otherwise corrosion will occur and this will ultimately affect the stability of the structure.

#### MAINTENANCE TO THE STRUCTURE OF UNCLAD STRUCTURAL STEEL CAR PARKS

At the present moment, the most economic means of protecting steel against rust is painting. Therefore, the annual maintenance bill will need to include an allowance for repainting the steel work, although again, the usual processes of wear-and-tear, age (or weathering), and vandalism will play their part in the degree of protection required.

Table 1<sup>2,3</sup>, (extracted from various advisory reports on painting metalwork) provides three paint specifications to protect heavy structural steel for different exposure conditions.

TABLE 1

Severe	Moderate	Mild
(i) Metal-sprayed +(ii) Etch primer +(iii) MIO <u>or</u> AL  <u>or</u> 2/3 coats heavy duty bitumen	As severe; <u>or</u> (i) 2 coats RL,ML, <u>or</u> CP +(ii) 2 coats MIO,CR <u>or</u> AL  <u>or</u> (i) 2 coats ZR +(ii) MIO	As moderate; <u>or</u> (i) 1/2 coats RL,ML, <u>or</u> CP +(ii) MIO,AL <u>or</u> gloss
<p><u>Severe:</u> Areas affected by direct salt spray; general heavy industrial pollution, or close proximity to chimneys and some industrial processes.</p> <p><u>Moderate:</u> Areas of high rainfall or continuous high humidity in industrial or urban conditions, or close to fresh water or calm sea water.</p> <p><u>Mild:</u> Inland areas of low rainfall and no special causes of corrosion.</p> <p>Abbreviations: Finishes:-</p> <p>MIO = Micaceous iron oxide and undercoat;</p> <p>AL = Exterior aluminium paint; Gloss = Exterior alkyd gloss paint;</p> <p>CR = Chlorinated rubber paint;</p> <p>Primers:-</p> <p>RL = Red lead; ML = Metallic lead; CP = Calcium plumbate; ZR = Zinc-rich.</p>		

These specifications will be executed in full on the erection of the structure but subsequent applications may need only to include the finishing coats and an item for preparing the surface and touching up the priming coat as necessary. The longer the period between applications, ie the cycle, the less expensive becomes the overall process of maintaining the building. Thus, it will pay to ensure that the specification is more than adequate and that the surface is well prepared and fully primed.

In the mildest conditions a car park might be satisfactory with a specification including one finishing coat, but normally two finishing coats plus any preparation, the surface may require, would be considered the minimum. Obviously with the most severe exposure conditions the surface preparation must be very thorough and it may be necessary to re-apply the priming coats.

As regards the cost of redecorating the steel, the number of existing unclad structural steel multi-storey car parks<sup>4</sup> is very small and to draw any conclusive evidence regarding this cost is difficult due mainly to the recent completion dates of most of them. However, quotations have been obtained by some of the authorities concerned, and these, coupled with estimates made, based on the known quantities of exposed steelwork requiring painting, and the known exposure conditions of the sites, have enabled approximate cost limits to be calculated.

The lowest limit which would be for the cheapest paint specification, is about £3 per car parking place whilst the most expensive so far encountered is £5 per place. In terms of a 350-400 bay car park, these figures would give overall costs of between £1,000 and £2,000 for redecorating the exposed steelwork and for a 500-600 bay car park, between £1,500 and £3,000.

#### PRESENT DAY WORTH

The figure that influences most decisions in the design of a car park, is the initial outlay, i.e. whether it will cost £150,000 or £200,000 to build. If, on-the-other-hand, the car park is valued over its lifetime, then the necessary maintenance required can be equated with the initial cost. This is important since it enables a comparison to be made between different designs with varying maintenance and running costs.

As an example, one design may initially cost £500,000 and another £535,000. With the first design, the structure is cheaper and is going to require constant maintenance, so although at first the decision may be for the cheaper structure, when maintenance costs are reduced to the level of this initial outlay the situation changes. The cheaper car park costs £500,000 plus £85,000 for the maintenance and running costs giving a total of £585,000, whereas the more expensive car park costs £535,000 plus only £40,000 for the maintenance and running costs giving a smaller total of £575,000. Thus, with these two designs, the more expensive solution is in fact, in the long term, the more economic.

This figure, added to the initial outlay, and which constitutes the maintenance costs, is called the present day worth<sup>5,6</sup> and it is calculated on the basis of what would need to be invested at the outset of the building's life in order to provide sufficient capital to pay for these maintenance charges, i.e. £1 invested at 5 per cent will, after 40 years be worth £7. Considering the calculation in reverse, in order to have £1 at the end of 40 years,  $14\frac{1}{2}$  new pence needs to be invested at 5 per cent. This  $14\frac{1}{2}$  new pence is called the present day worth.

In terms of car parks, the client may not be so concerned about the source of money for maintenance and running costs, since these will probably be met by the rates or off-set by the income received. However, the principle of reducing maintenance costs to present day worth still applies even though the actual process is unlikely to be carried out.

Steel, as has already been stated, will require periodic redecoration and the value of this can be reduced to a present day worth. Hence, it can be calculated what additional sum needs to be added to the overall cost of an unclad structural steel car park, to allow for this protection. Several factors will affect the size of this figure:

- (a) Interest
- (b) Life
- (c) Maintenance period
- (d) Painting specification

(a) Interest: This is the interest rate which would be available for investment, and a 7 or 8 per cent interest rate should be obtainable these days, although with public buildings the figure might be a little less.

(b) Life: The lifetime of a building is somewhat indeterminate and is usually dependent more on changing needs and the changing environment, than the age of the structure. For the purposes of calculating present day worth, a lifetime of 60 years is usually considered reasonable. However, car parks are a very functional building and are usually built with present needs in mind. An authority may calculate that it will need 5000 car parking places by 1975, i.e. in 5 years time, but it is most unlikely to calculate its needs for the year 2030 i.e. in 60 years time. With the increasing use of the car as a means of transport, present car parking capacities may well become totally inadequate long before the year 2030. It is suggested in a report<sup>7</sup> that the total number of vehicles will double in 10 years and treble in 20 years. Thus, the spaces taken up by present car parks will probably be required for absorbing more parked cars long before the 60 year life has been reached.



With this in mind, it would seem somewhat unrealistic to assume a life of 60 years for a car park, irrespective of the material composing the structure. A more realistic period may be of the order of 30 or 40 years or even as little as 20, but even before then, car parks are likely to be inadequate in size. This may suggest an advantage for the use of demountable car parks with a considerably shorter life. The effects of this varying lifetime, can be seen in the examples that follow:

- (c) Maintenance period: This is the cycle on which the painting will need to be carried out, and will depend on the speed of deterioration, which in turn will depend on the exposure of the site.

Since it is more economical to use a good painting specification and increase the cycle, a 4 or 5 year period would be considered as reasonable. In areas of extreme exposure - in marine or chemically aggressive atmospheres - a shorter period of perhaps 3 years may prove necessary.

- (d) Painting specification: This also will depend on the exposure of the site and using the cost information obtained seems to vary from £3 per car parking place to £5. The previous main section considers this in greater detail.

Appendix B and Table 1 shows the present day worth factors for the cost of redecorating the unclad steel work of a multi-storey car park under these varying conditions, i.e. interest, life, maintenance period and specification.

## RESULTS

Appendix B and Table 2 shows a large range of additional costs due to periodic redecoration of the steelwork, varying from a little over £2 to a little under £40. However, a maintenance cycle of 2 years or even 3 years would be expensive and a cycle of 6 years or greater would be most optimistic. Similarly, a reasonable life for the building as has already been discussed, would be 30 or 40 years, and therefore by applying these limitations it is possible to reduce the range of variation to a more realistic and fairly narrow margin.

Considering examples in this more limited range, we have as follows:

### Example 1

A proposed structural steel car park, with an anticipated life of 40 years is to be built in a fairly exposed location, such that a maintenance cycle of 4 years is considered reasonable. The cost of periodically redecorating the steelwork has been estimated to be £4 per

car parking place. Assuming that an interest rate of 7% can be obtained, then from Appendix B and Table 2 the present day worth of this extra maintenance would be £11.7. This means that the cost of redecorating the steelwork, over the lifetime of the building is equivalent to £11.7 per car parking place added to the initial cost. If this car park has 500 places then the total present day worth is £5,850 (11.7 x 500), and if the initial cost is £150 000 then this extra maintenance is equivalent to adding another 4% (£6,000) to the initial cost.

#### Example 2

A structural steel car park with a proposed life of 30 years, a maintenance cycle of 5 years, a painting specification of £4 and a 7% interest, then compared with Example 1, the life has been shortened and the maintenance cycle increased.

From Appendix B and Table 2, the present day worth would be £8.1 per car parking place which for 500 cars would mean an equivalent of £4,050 (8.1 x 500) added to the initial cost.

#### Example 3

A structural steel car park with a proposed life of only 20 years, but with the same maintenance cycle, paint specification and interest rate as example 2 gives a present day worth of £6.3 or an overall value, for 500 cars, of £3,150.

#### Example 4

A structural steel car park with a proposed life of 40 years, a maintenance cycle of 5 years, a paint specification of £4 and an interest rate of 8%, gives a present day worth of £7.9 or an overall value, for 500 cars, of £3,950.

#### Example 5

A structural steel car park with a proposed life of 40 years but in a sheltered position so having a 5 year maintenance cycle and a £3 paint specification. With an interest rate of 7% the present day worth would be £6.8 per car parking place.

#### Example 6

A structural steel car park with a proposed life of 40 years, a cycle of 4 years, a £3 paint specification and an interest rate of 8% gives a present day worth of £7.8 per car parking place.

## CONCLUSIONS

(i) From the examples quoted, the additional maintenance cost due to the need to periodically redecorate the steel, on a present day worth basis, varies from £6 to £12, depending on the exposure of the site and therefore the specification cost and maintenance cycle (i.e. period between redecorations); the expected life-time of the building, and the interest rate available at the time of investment. The shortest life expectancy, coupled with the cheapest paint cost, the longest maintenance cycle and the highest interest rate gives the least present day worth, and the reverse of these factors provides the maximum figure. Taking the average of these two extremes, the additional cost due to redecoration is about £9 per car parking place.

(ii) Relating this present day worth figure of £9 to the approximate cost advantage of between £50-£55 per car parking place<sup>4</sup>, held by unclad steel over concrete, the extra maintenance required means that this cost saving drops by 17% to around £44. Although, certainly a noticeable drop, the resultant saving is still quite considerable and still constitutes an economic advantage for the use of unclad structural steel in multi-storey car parks.

(iii) From the information given concerning the maintenance bill of a car park, the most significant factors are:-

- (a) The growing trend in vandalism and the need to make some allowances in future design, and
- (b) the size of particular elements of the bill viz:  
wages, electricity and the maintenance of the structure.

As regards the size of the maintenance bill itself, if we ignore the most variable item - that of wages - the cost seems to vary between £4 and £8 per place per year. The age of the car park, the degree of attendance, the standard of lighting, lifts and general mechanical installation will all effect this portion of the bill. A reasonable average, based on the figures available, would be about £5. 5. per place and a similar average, but including wages would be around £13.

A paint specification of £4 based on a 4 year maintenance cycle means that £1 per year, per car parking space is spent on redecorating the steel. This, when compared with the general maintenance cost of £5. 5. suggests that redecorating steelwork forms a noticeable amount (about 18%). However, the figure sinks into relative insignificance when compared with the overall bill of £13 (7½%).

Despite, therefore, the lack of unclad structural steel multi-storey car parks, one can reasonably conclude that the need to protect the steelwork from corrosion does not involve considerable cost. There still remains a distinct cost advantage, and the proportion devoted to this redecoration is quite small when compared with the overall cost of the maintenance bill.

#### ACKNOWLEDGMENTS

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APPENDIX A

Maintenance Bill for multi-storey car parks

		Estimated figures 1970/71	
		Car park A (700 places)	Car park B (300 places)
(i)	Wages for attendance and general cleaning	4,730	2,350
(ii)	Repairs and maintenance to the building structure	950	500
(iii)	Repainting bay lines and general ground work	225	100
(iv)	Repairs and maintenance to plant & machinery (lifts, control gear, ticket machines, etc)	600	300
(v)	Electricity and other services	1,400	850
(vi)	General cleaning materials and provisions for attendants. (Clothing, telephones, etc)	320	included
(vii)	Redecorations to staircases, offices, etc	200	100
(viii)	Replacement of furniture and fittings (lights, signs, etc)	100	50
		£3,795	£1,900
Total excluding wages:		£8,525	£4,250

Car park A maintenance bill is equivalent to nearly £5.5 per place excluding wages or about £12 overall, whilst car park B is equivalent to just over £6.25 per place or about £14 overall.

Notes:

- (a) The labour element - item one - normally consists of green card holders i.e. men who are partly disabled.
- (b) Item two does not include repainting steelwork.
- (c) Item six is a general sundries item taking into consideration most of the smaller aspects of maintenance. These may be included within other figures as is indicated in car park B.
- (d) Item seven, and possibly item three, may appear as large sums at periodic intervals, when painting, etc, would be deemed necessary. The figures inserted have taken this into consideration.

APPENDIX B

Table 1: Maintenance cost factors

Interest %	Life (Yr)	Maintenance Cycle (Years)					
		2	3	4	5	6	
6	20	5.2561		2.3101	1.7229		
	21		3.4011				
	24					1.5524	
	30	6.5078	4.1496		2.2677	1.7994	
	32			3.0645			
	40	7.2068		3.3422	2.2519		
	42		4.6957			2.0962	
	50	7.5971			2.7418		
	51		4.9158				
	52			3.5774			
	60	7.8150	5.0461	3.6640	2.8367	2.2867	
7	20	4.8595		2.1276	1.5838		
	21		3.1288				
	24					1.4061	
	30	5.8633	3.7283		2.0265	1.6032	
	32			2.7335			
	40	6.3737		2.9357	2.2515		
	42		4.1259			1.8220	
	50	6.6331			2.3659		
	51		4.2707				
	52			3.0923			
	60	6.7650	4.3494	3.1446	2.4240	1.9191 1.9450	
8	20	4.5044		1.9643	1.4587		
	21		2.8865				
	24					1.2772	
	30	5.3111	3.3681		1.8190	1.4348	
	32			2.4524			
	40	5.6347		2.6002	1.9859		
	42		3.6587			1.5967	
	50	5.8577			2.0632		
	51		3.7544				
	52			2.7049			
	60	5.9378	3.8022	2.7366	2.0990	1.6609 1.6766	
9	20	4.1893		1.8177	1.3468		
	21		2.6709				
	24					1.1639	
	30	4.8402	3.0586		1.6412	1.2903	
	32			2.2120			
	40	5.1151		2.3203	1.7656		
	42		3.2718			1.4106	
	50	5.2313			1.8181		
	51		3.3353				
	52			2.3907			
	60	5.2802	3.3645	2.4100	1.8402	1.4534 1.4629	

APPENDIX B

Table 2: Present day worth maintenance costs

Interest	Life	Present worths based on a cycle of - years costing £--- per car parking place																			
%	(yrs)	2 year cycle				3 year cycle				4 year cycle				5 year cycle				6 year cycle			
		£2.	3	4	5	£2	3	4	5	£2	3	4	5	£2	3	4	5	£2	3	4	5
6	20	10.5	15.8	21.0	26.3	6.8	10.2	13.6	17.0	4.6	6.9	9.2	11.6	3.4	5.2	6.9	8.6	3.1	4.7	6.2	7.8
	30	13.0	19.5	26.0	32.5	8.3	12.4	16.6	20.7	6.1	9.2	12.3	15.3	4.5	6.8	9.1	11.3	3.6	5.4	7.2	9.0
	40	14.4	21.6	28.8	36.0	9.4	14.1	18.8	23.5	6.7	10.0	13.4	16.7	5.1	7.7	10.3	12.9	4.2	6.3	8.4	10.5
	50	15.2	22.8	30.4	38.0	9.8	14.7	19.7	24.6	7.2	10.7	14.3	17.9	5.5	8.2	11.0	13.7	4.5	6.7	9.0	11.2
	60	15.6	23.4	31.3	39.1	10.1	15.1	20.2	25.2	7.3	11.0	14.7	18.3	5.7	8.5	11.3	14.2	4.6	6.9	9.1	11.4
7	20	9.7	14.6	19.4	24.3	6.3	9.4	12.5	15.6	4.3	6.4	8.5	10.6	3.2	4.8	<u>6.3</u>	7.9	2.8	4.2	5.6	7.0
	30	11.7	17.6	23.5	29.3	7.5	11.2	14.9	18.6	5.5	8.2	10.9	13.7	4.1	6.1	<u>8.1</u>	10.1	3.2	4.8	6.4	8.0
	40	12.7	19.1	25.5	31.9	8.3	12.4	16.5	20.6	5.9	8.8	<u>11.7</u>	14.7	4.5	<u>6.8</u>	<u>9.0</u>	11.3	3.6	5.5	7.3	9.1
	50	13.3	19.9	26.5	33.1	8.5	12.8	17.1	21.4	6.2	9.3	<u>12.4</u>	15.5	4.7	<u>7.1</u>	9.5	11.8	3.8	5.8	7.7	9.6
	60	13.5	20.3	27.1	33.8	8.7	13.0	17.4	21.7	6.3	9.4	12.6	15.7	4.8	7.3	9.7	12.1	3.9	5.8	7.8	9.7
8	20	9.0	13.5	18.0	22.5	5.8	8.7	11.5	14.4	3.9	5.9	7.9	9.8	2.9	4.4	5.8	7.3	2.6	3.8	5.1	6.4
	30	10.6	15.9	21.2	26.6	6.7	10.1	13.5	16.8	4.9	7.6	9.8	12.3	3.6	5.5	7.3	9.1	2.9	4.3	5.7	7.2
	40	11.4	17.1	22.7	28.4	7.3	11.0	14.6	18.3	5.2	<u>7.8</u>	10.4	13.0	4.0	6.0	<u>7.9</u>	9.9	3.2	4.8	6.4	8.0
	50	11.7	17.6	23.4	29.3	7.5	11.3	15.0	18.8	5.4	8.1	10.8	13.5	4.1	6.2	<u>8.3</u>	10.3	3.3	5.0	6.6	8.3
	60	11.9	17.8	23.8	29.7	7.6	11.4	15.2	19.0	5.5	8.2	10.9	13.7	4.2	6.3	8.4	10.5	3.4	5.0	6.7	8.4
9	20	8.4	12.6	16.8	20.9	5.3	8.0	10.7	13.4	3.6	5.5	7.3	9.1	2.7	4.0	5.4	6.7	2.3	3.5	4.7	5.8
	30	9.7	14.5	19.4	24.2	6.1	9.2	12.2	15.3	4.4	6.6	8.8	11.1	3.3	4.9	6.6	8.2	2.6	3.9	5.2	6.5
	40	10.2	15.3	20.5	25.6	6.5	9.8	13.1	16.4	4.6	7.0	9.3	11.6	3.5	5.3	7.1	8.8	2.8	4.2	5.6	7.1
	50	10.5	15.7	20.9	26.2	6.7	10.0	13.3	16.7	4.8	7.2	9.6	12.0	3.6	5.5	7.3	9.1	2.9	4.4	5.8	7.3
	60	10.6	15.8	21.1	26.4	6.7	10.1	13.5	16.8	4.8	7.2	9.6	12.1	3.7	5.5	7.4	9.2	2.9	4.4	5.9	7.3

