

The Case for  
**Concrete  
Roads**  
for Cement and Concrete  
Association of New Zealand





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# Infometrics

# Executive Summary

**This report investigated the high-level case for building concrete roads. It found in a baseline scenario comparing the economics of asphalt and concrete roads, that concrete is 25.1% cheaper than its asphalt counterpart.**

**The calculation took into account international prices, price volatility, the cost of carbon emissions and travel time disruption.**



The price volatility of oil compared with cement is a material factor. The future trend of oil and cement prices look to further enhance the case for concrete roads. Petroleum products prices have risen 180% since 1994 and look likely to continue to increase annually at 5.8%. This is compared to a rise of just 44% in cement prices over the same period, with a projected annual increase of 2%.

To a large extent, this price premium reflects the costs associated with an uncertain overseas supply market. In contrast, the low annual price increase of 2% associated with concrete construction is due to the stable nature of domestic sources.

Construction and maintenance costs constitute the largest components of roading investment, but increasing disruptions to travel time, caused by road maintenance, is a growing factor. The report found that an asphalt road has greater disruption to traffic over the road's lifetime, than its concrete counterpart.

Overall the difference in CO<sub>2</sub> emissions associated with concrete and asphalt roads is not significant. However, concrete roads have a range of environmental benefits, such as less tyre-rolling resistance and therefore lower fuel consumption, particularly for heavy vehicles, that further strengthen the case for concrete roads.

The report also found that some roading contracts include an escalation clause for the price of bitumen or oil. This transfers risk from the supplier to NZTA and can have the effect at the tendering stage of making asphalt pavement look cheaper than it really is. The escalation clause is in effect an implicit subsidy for one type of construction material in preference to any other.

# Objective

In this paper we look at the high level case for building roads with concrete pavement rather than asphalt pavement. We do not focus on fine detail – we are interested in whether there is a case for concrete pavement that is strong enough to be robust to minor changes in road construction detail.

Our base data comes from URS (2009).<sup>1</sup>

## Discount rates

We start with four fundamental properties of discount rates:

1. *When a project delivers returns that can be reinvested at the same rate and risk profile as the project itself, the cost of capital is an appropriate discount rate. This discount rate should incorporate a market based risk premium.*
2. *However the capital cost of the project must truly represent the opportunity cost of that capital used for other investment.*
3. *If the project delivers intangible consumption benefits, the cost of capital will usually be an inappropriate discount rate. A social discount rate will be more appropriate.*
4. *Infrastructure investments which are designed to lift the productive capacity of the economy should attract a lower discount rate to reduce the likelihood of locking the economy into a low growth path with a low capital-labour ratio. (This argument should not be pushed too far – it applies only to projects that deliver long lasting benefits and that would not be undertaken by the private sector).*

We look at how each of the above affects the asphalt versus concrete debate.

## Cost of capital

The standard Capital Asset Pricing Model (CAPM) is formulated in Treasury (2008) as:

$$r_i = [r_f (1-t_c) + \beta_i \cdot r_m] / (1-t_e)$$

$r_i$  as the cost of capital for project  $i$

$r_f$  is the risk free rate  
(e.g. on long term government stock)

$r_m$  is the equity market risk premium

$t_c$  is the corporate tax rate

$t_e$  is the effective tax rate

$\beta_i$  is the  $\text{cov}(r_i, r_m) / \text{var}(r_m)$  for assets of type  $i$ .  
A project with a high  $\beta$  has a return that is highly correlated with the market return.

1. URS (2009): *Final Report: Addendum to SH20 Alternative Pavement Report: 2009 Evaluation*. Report to CCANZ.

2. Treasury (2008): *Public Sector Discount Rates for Cost Benefit Analysis*

## Converting to a real rate: $R_i = [(1+r_i) / (1+\Delta p)] - 1$

We assume that the returns from a road do not vary with the type of pavement – at least to within a first order effect. Nevertheless it is important that the cost of capital be at least approximately correct as for two projects with different time profiles of costs their relative present values are not independent of the discount rate.

Adjusting the parameter values given in Treasury (2008) for the lower corporate tax rate generates a cost of capital for infrastructure of about 7%. Treasury assume  $\beta=0.65$  for infrastructure, which seems to be based on the experience of just one company in the transport business. Thus this is likely to be an over-estimate of the  $\beta$  for roading infrastructure projects, so cost of capital should actually be lower than 7%.

# Opportunity Cost

The cost of capital is also known as the social opportunity cost of investment; the implicit assumption being that government investment displaces other investment that would have earned a rate of return.

However, in the case of government investment in roading, this is unlikely to be the case. Funding to NZTA is 'dedicated' funding; secured from road user charges, fuel excise duty, and motor vehicles licensing and registration fees. The opportunity cost of this funding is likely to be lower private consumption, not lower (private) investment, albeit that road user charges in particular could have a small negative effect on private sector investment.

Thus the cost of capital is not the appropriate discount rate to use for NZTA projects, or at least it should be substantially reduced towards something like the social rate of time preference (SRTP), which is the appropriate rate for discounting when the opportunity cost of the project is in the form of less consumption.

The SRTP is usually expressed as:

$$r = d + \epsilon.g$$

$r$  is the social rate of time preference

$d$  is the rate at which future consumption is discounted over current consumption

$g$  is the annual growth of consumption per capita

$\epsilon$  is the elasticity of the marginal utility of consumption

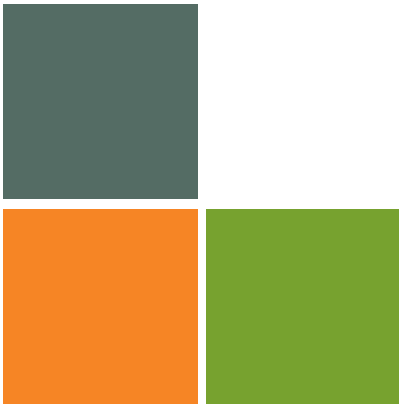
The variable  $d$  is frequently further disaggregated into two components:

$$d = \rho + C$$

$\rho$  is the pure rate of time preference

$C$  is the risk of a catastrophe which severely disrupts life on earth. See for example Stern et al (2006)<sup>3</sup> in connection with climate change.

There is much debate on the values of these variables, but this is beyond the ambit of this paper. The interested reader is referred to Parker (2009)<sup>4</sup> for example. Parker suggests that a reasonable value of the SRTP for New Zealand is around 3.0% – 4.0%.



# Intangible Consumption Benefits

Construction and maintenance costs constitute the largest components of roading investment and, as discussed above, they should be discounted at a conceptually appropriate rate for the cost of capital – not all countries have hypothecated taxation for investment in roading infrastructure.

Another cost component is the increase in leisure travel time that is caused by road maintenance. Leisure travel time is an example of an intangible consumption benefit. Savings in congestion costs associated with leisure travel cannot be reinvested for the benefit of future generations. Hence the discount rate for travel interruptions must therefore reflect inter-generational welfare comparisons. As above, there is no correct answer to what this discount rate – the social rate of time preference – is, but it is almost certainly less than the cost of capital.

As an asphalt road has greater disruptions to traffic over the road's lifetime, a lower discount rate applied to the cost of such disruptions will generate a more accurate estimate of their true value.

## Long Term Infrastructure Investments

Grimes (2010)<sup>5</sup> argues that New Zealand likes to compare its standard of living with that in Australia. If Australia has a lower discount rate for infrastructure projects than New Zealand it will become a more capital intensive society, with a higher capital-labour ratio and hence higher wages and a higher standard of living.

The important point is that even if the discount rate adopted in New Zealand is theoretically correct, if it is higher than that adopted in Australia for similar projects relative living standards will eventually diverge. Migration of New Zealanders to Australia can be expected.

As with the discussion on the theoretically appropriate cost of capital, concrete and asphalt roads have different time profiles of costs so their relative present values are not independent of the discount rate.

3. Stern, N. et al (2006): *The Economic of Climate Change. HM Treasury.*

4. Parker (2009): "The implications of discount rate reductions on transport investments and sustainable transport futures." *NZTA research report 392.*

5. Grimes (2010): "The Economics of Infrastructure Investment: Beyond Simple Cost Benefit Analysis." *Motu Working Paper 10-05.*

# Historical Price Trends



Figure 1: Price Trends (SNZ: Quarterly PPI)

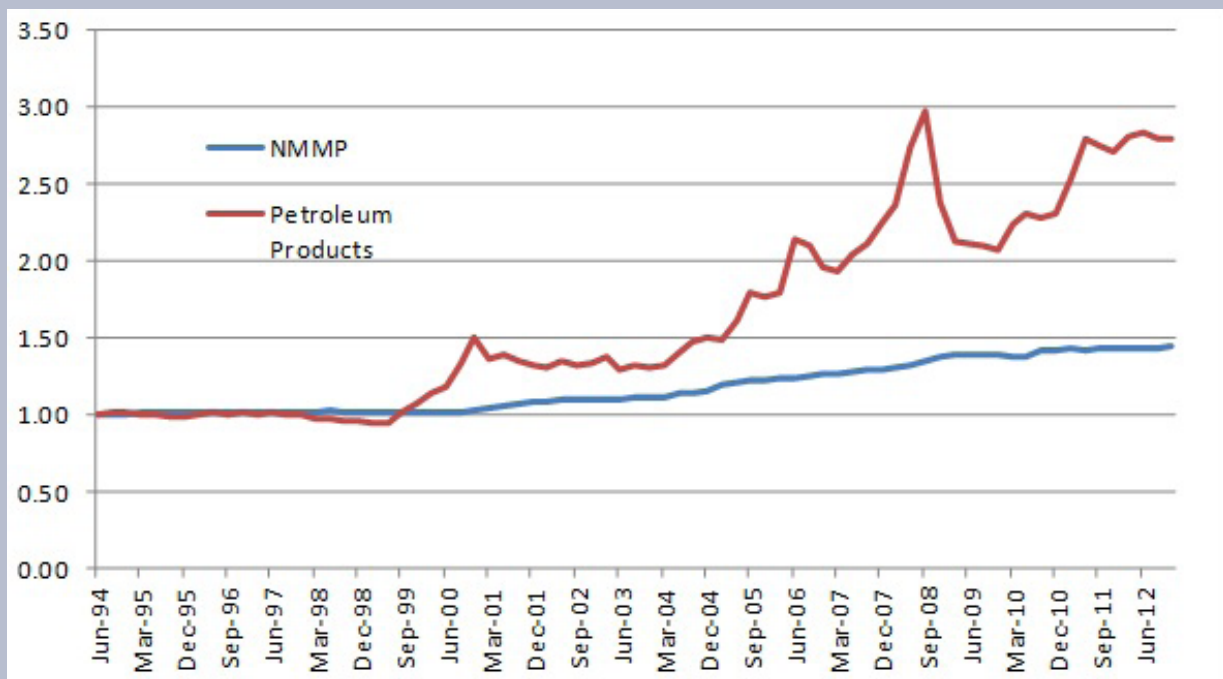


Figure 1 shows the trend in prices for output from two industries, Petroleum Products and Non Metallic Mineral Manufacturing. These series should be reasonable proxies for the price trends in bitumen and concrete respectively.

Since 1994, NMMP prices have risen by about 44%, whereas Petroleum Product prices have soared by 180%. Looked at it from another angle, if one was positioned back in 1994, contemplating roading investments over the next 20 years or so (the type of horizon over which the RONS are being rolled out), every extra year of delay adds an extra 2.0% to the cost of concrete, but an extra 5.6% to the cost of asphalt.

The cost of asphalt typically represents 52-68% of costs for asphalt pavement, and the cost of concrete is around 58% of the cost of continuously reinforced concrete pavement. As these proportions are similar we may infer that the cost of asphalt pavement is as sensitive to the price of oil as the cost of concrete pavement is to the price of cement.



# Price Volatility

Price volatility is a separate issue from price trends. Some cost-benefit practitioners adopt a higher discount rate to allow for volatility in input prices, but this shows a poor understanding of the concept of discount rates and can generate very perverse results. In particular if the discount rate for asphalt pavement was lifted above that for concrete pavement because its cost was more uncertain, the effect would be to lower the discounted cost of the former, thereby encouraging its use!

The correct way to deal with this sort of risk is to undertake sensitivity analysis with different assumptions about the prices of the inputs in question (with no change in the discount rate). An extra level of sophistication could include Monte Carlo analysis, especially where more than one input has uncertain values.<sup>6</sup> The result would be a distribution of present values for the project, rather than a point estimate. Investors could then decide how much risk they are willing to accept.

Figure 1 suggest that the even after allowing for trends in prices, the Petroleum Products price is more volatile than the NMMP price. The summary statistics in Table 1 show that this is indeed the case, with the standard deviation of the de-trended NMMP price index being only about one fifth of that for the de-trended Petroleum Products price index.

**Table 1:**  
**De-trended Series Summary Statistics**

	NMMP	Petroleum Prods
Mean	-0.004	-0.019
Standard Deviation	0.042	0.216

6. An example is provide in Lindsey, L. , R. Schmalensee & A. Sacher (2011): *The Effects of Inflation and its Volatility on the Choice of Construction Alternatives*. Concrete Sustainability Hub, MIT. While the illustration of Monte Carlo analysis is useful, this paper unfortunately combines volatility and trends which potentially corrupts the distribution of results as autocorrelation is ignored.

# Covariance

The volatility in commodity prices raises the question as to whether their volatility is correlated to the volatility in real GDP.

The relationship between commodity prices and economic growth is not straightforward. Fast economic growth can put upward pressure on prices, but rising prices can lead to lower growth. Thus correlation could be positive or negative and may depend on an appropriate treatment of lags. However, our interest is not in the covariance between trends, but in the covariance between the de-trended series.

Table 2 shows some simple correlation coefficients between real GDP (de-trended and de-seasonalised) and commodity prices (de-trended). While the coefficients are not particularly strong it is clear that commodity prices lead GDP with a negative effect. Correlation coefficients with commodity prices lagging GDP are generally below 10% and are of inconsistent sign.

**Table 2: Correlation Coefficients**

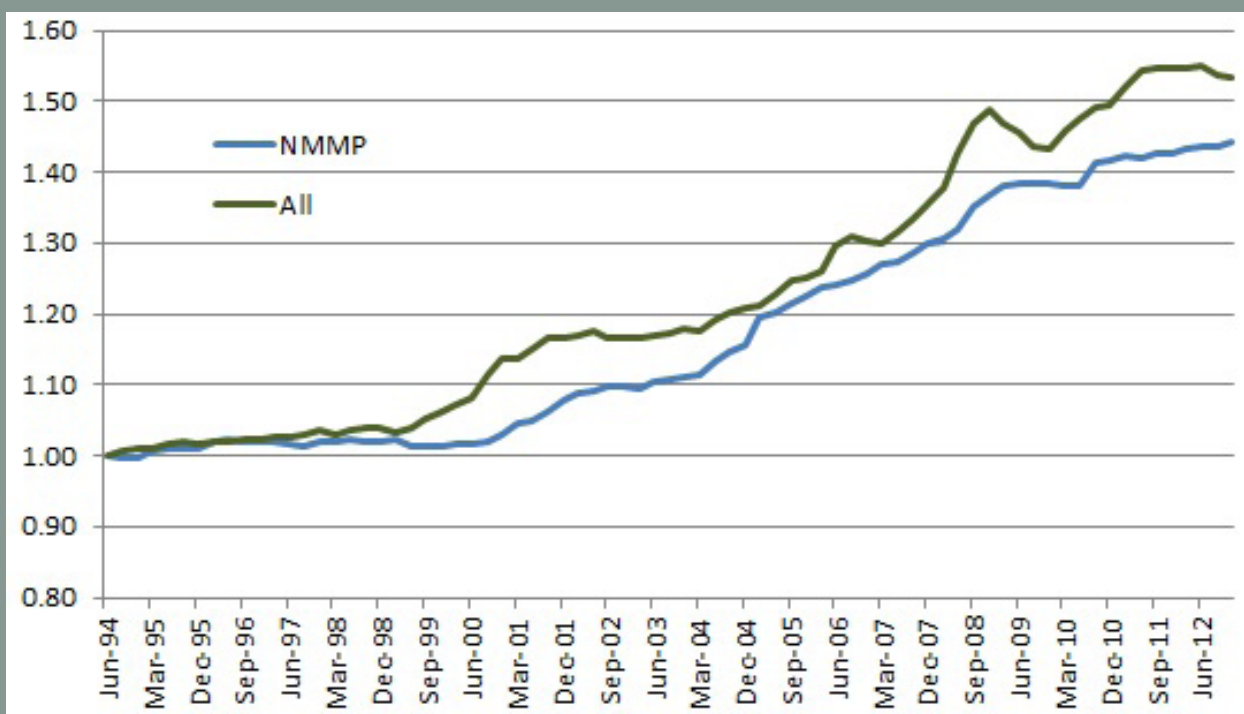
Commodity price lead or lag	NMMP	Petroleum Prods
Lag 4 quarters	0.081	0.071
Lag 3	-0.027	0.050
Lag 2	-0.138	-0.022
Lag 1	-0.236	-0.131
Contemporaneous	-0.309	-0.229
Lead 1	-0.370	-0.313
Lead 2	-0.426	-0.355
Lead 3	-0.473	-0.361
Lead 4	-0.514	-0.352

Also, the negative correlation between NMMP prices and GDP is slightly stronger than that between Petroleum Product prices and GDP, so there might be an argument for not only lowering the  $\beta$  for roading infrastructure in general (as discussed above), but to also have a lower value for concrete pavement than for asphalt pavement. (Note that the correlation coefficients in Table 1 are not actually  $\beta$  values). However, this adjustment would apply only to the social cost of capital, not to the social rate of time preference. And we have already proposed that the latter is more appropriate for NZTA's roading investments.

# Future Price Trends

With regard to future projects on NZTA's books and the RONS in particular, what are the likely future paths of prices for bitumen and concrete?

Figure 2: PPI Output for NMMP and All Industries



## Concrete prices

Figure 2 reproduces the NMMP producer price index from Figure 1 and adds the All Industries producer price index, as a measure of general price inflation. The trend rate of increase in NMMP prices has been 2.0% per annum, just under the rate of 2.3% pa for all industries.

A naive assumption of continued slow escalation in NMMP prices, below the general rate of inflation, would seem a reasonable forecast. We are not aware of any imminent changes in the industry that could lead to a different projection.

It is also worth reiterating the assumption that changes in the price of output from the Non Metallic Mineral Products industry are a reasonable proxy for the changes in the price of concrete.

## Bitumen prices

Bitumen price forecasts present a rather greater challenge, as there are two significant underlying prices involved: the oil price in US dollars and the US\$/NZ\$ exchange rate.

Figure 3 depicts oil prices in both \$US and \$NZ. It suggests a closer trend correlation than one might have expected, given the well publicised volatility of the New Zealand dollar.

In \$NZ terms the oil price has risen by an average 5.8% per annum since 1987, but with considerable volatility and a decade from 1987 to 1997 of almost no change.



Figure 3 Oil Prices - Brent Crude (\$/bbl)



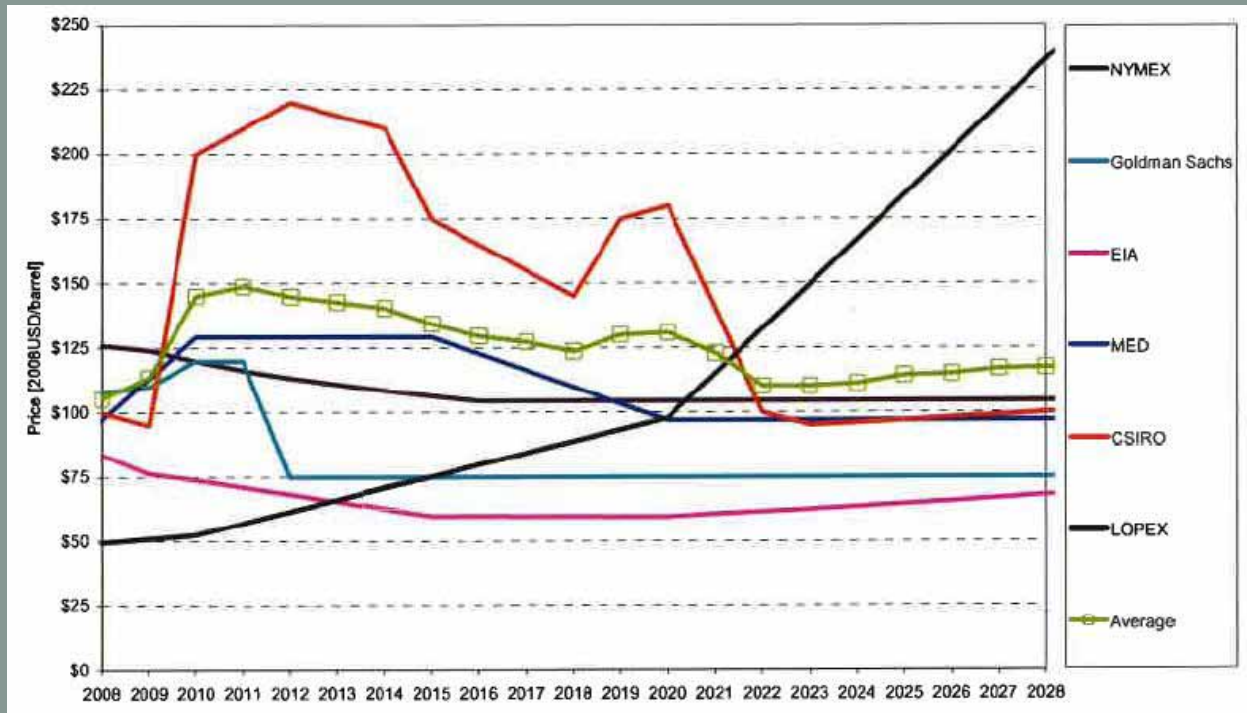
In the years preceding 2008 there was widespread belief that “peak oil” had been reached and that high prices – and rising prices – were here to stay. The global financial crisis led to a sharp reduction in oil prices and, coupled with the production of oil from non-traditional sources and techniques has so far prevented the oil price from reaching its previous peak.

There is a comprehensive discussion and analysis of oil prices in NZTA (2008)<sup>7</sup> to which we defer. It has seven projections for the price of oil up to 2028, as replicated in Figure 4 on page 9. The projections scan a wide range from US\$70/bbl and US\$240/bbl, with an average of about US\$115-120/bbl (all in 2008 prices).

Most of the projections, including the average have the price peaking in real terms around 2013 or earlier. Thus these projections imply a declining real price of oil in US dollars for the next decade and a half.

7. New Zealand Transport Agency, 2008: “Managing transport challenges when oil prices rise.” *Research Report 04/08*, Wellington.

Figure 4 Oil Price Projections (US\$/bbl)



Therefore, barring any major collapse in the value of the New Zealand dollar against the American dollar, such as occurred over 2000-2001, the future trend path of bitumen prices would not look too dissimilar to the forecast path for concrete prices.

However, given New Zealand's on-going balance of payments deficit and high level of foreign debt, and the fact that the current strong value of the dollar is due more to the weakness of the American dollar, Euro and British Pound than to underlying strength in the New Zealand currency, it is highly likely that at some point a correction will occur. A longer term average rate of 0.65-0.70 for \$US/\$NZ is not at variance with recent history, but any correction could well see a temporary over-shooting (volatility).

Accordingly a scenario, in which the average value of the New Zealand dollar over the next decade or so is 20%-25% lower than it is currently, is probably more realistic than a scenario with no change. This would add an average 2% per annum to the price of bitumen.

Another factor that may be important is the potential for refineries to process the heavier waste components of crude oil into transport fuel, which is more valuable than bitumen. Additional pressure on bitumen prices could result, but the size of any effect is not known at this stage.

**There are also two institutional issues that could be affecting the price of asphalt pavement:**

1. We understand that some roading contracts include an escalation clause for the price of bitumen or oil. This transfers risk from the supplier to NZTA and can have the effect at the tendering stage of making asphalt pavement look cheaper than it really is. While there is an argument for this type of risk re-allocation, it does need to be properly costed which means that NZTA must undertake the type of scenario testing described above if road users are to receive value for money.
2. Quite independently of the direct cost impact of an escalation clause, a possible indirect effect is that a segment of the road construction industry could be artificially priced out of the market, implying less competition and (*ceteris paribus*) higher tender prices.

**To understand the price impacts of these issues more fully requires discussion with industry and NZTA.**



# Climate Change

Both bitumen and concrete are relatively high in CO<sub>2</sub> emissions, although the CO<sub>2</sub> released in the construction and maintenance of roads is about two orders of magnitude smaller than the emissions released by vehicles that use the road. The following data is from Eupave.<sup>8</sup>

**Table 3: kt of CO<sub>2</sub>e /km (30 years)**

	Concrete	Asphalt
Construction	2.1 – 2.8	1.4 – 1.7
Maintenance	0.1 – 0.2	0.9 – 1.4
Total	2.2 – 3.0	2.1 – 3.1

While concrete roads emit considerably more emissions in their construction than asphalt roads (driven by the calcination of lime and the high use of energy – often coal – in the production of cement), the excess is cancelled out by the much lower amount of maintenance required for concrete roads.

Overall the difference in emissions is not significant, with the relative net effect depending on the amount of recycled material used and on the specifics of the road’s composition and structure.

A 40 year horizon rather than the assumed 30 year horizon would presumably tilt the balance somewhat in concrete’s favour.

There is some evidence that because concrete roads are harder than asphalt roads they generate less tyre rolling resistance, implying less fuel use, especially by trucks. They may also require less lighting at night due to greater light reflection. However, whether these effects are large enough to outweigh the uncertainty range in Table 1 is not known.

Given these results we expect that the pure impact of a price on emissions is roughly neutral between the two options, and indeed is likely to depend more on the allowances and special treatment that each industry receives under the New Zealand Emissions Trading Scheme than on the actual carbon price.

The Refinery is largely exempt from the ETS, coming under a Negotiated Greenhouse Agreement which obliges it to move to ‘world best practice’ production technology – an arrangement that preceded the ETS. The two New Zealand cement plants receive a generous allocation of free emission units.

Thus neither concrete nor asphalt is significantly exposed to a carbon price; a situation that is unlikely to change in future even under higher prices, provided the two industries retain comparable amounts of shelter. There is no indication that they will not.

<sup>8</sup>. European Paving Concrete Association (date unspecified): Life Cycle Assessment for Road Construction and Use.

# Scenario Analysis



We present the results of a number of scenarios based on the points raised above. For our baseline we adopt the numbers in URS (2009) for two options for the SH20 Mt Roskill project; Structural Asphaltic Pavement and Continuously Reinforced Concrete Pavement with Exposed Aggregate finish – this being the most expensive of the four concrete options presented. Thus we deliberately weight the analysis against concrete pavement.

The following scenarios are tested:

1. *Baseline scenario with a discount rate of 8% and a 30 year horizon.*
2. *A lower discount rate (7%) to reflect a lower cost of capital in line with updated parameter values in the CAPM model, or reflecting the desire not be relatively capital-shallow with regard to infrastructure, compared to Australia. Arguably 7% is still too high. The value of  $\beta$  is not changed from Treasury's assumption.*
3. *An extension of the horizon to 40 years to better capture the longer life of concrete pavement, although this is probably still too short.*
4. *For congestion caused by road maintenance, a reduction of the discount rate to a rate approaching the social rate of time preference, in line with the benefit of leisure travel being an intangible consumption benefit. (Note that not all travel is leisure travel, so the result could be over-stated).*
5. *For the projects as a whole, a reduction of the discount rate to a rate approaching the social rate of time preference, in recognition that NZTA funding comes largely from displaced consumption rather than displaced investment.*



Table 4 summarises the results. As may be seen in the first two lines we cannot replicate the URS calculations exactly, but the differences are immaterial.

**Table 4: Cost of Asphalt v Concrete Pavement**

Scenario	Discount Rate (%)	Horizon (years)	Asphalt (\$m)	CRCP (EAP) (\$m)	Difference
Cost as per URS	8.0	30	52.725	39.483	-25.1%
1 Our 'replication'	8.0	30	52.720	39.482	-25.1%
2 Change cost of capital	7.0	30	55.442	40.623	-26.7%
3 & change horizon	7.0	40	57.325	41.580	-27.5%
4 & maintenance discounted at 4%	7.0/4.0	40	58.318	41.580	-28.7%
5 All discounting at 4%	4.0	40	72.197	47.746	-33.9%

In the baseline scenario the concrete option is 25.1% cheaper than the asphalt option. Lowering the discount rate by one percentage point raises the cost difference to 26.7%.

Extending the time horizon has a small additional effect on the cost difference, but in the main illustrates the point that extending the time horizon for the analysis is a largely academic exercise as long as the discount rate sits around the social cost of capital.

With the discount rate set closer to the theoretically more appropriate social rate of time preference, the cost difference widens to 28.7% if the lower rate is applied only to maintenance disruption costs, and to 33.9% if it is applied to all cost components.

With these sorts of differences the so-called uncompetitiveness of concrete pavement is a mystery.

As discussed above, expected price volatility is likely to further enhance the case for concrete, simply because the oil price is likely to be more volatile than the cement price.

Because the cost of asphalt pavement is as sensitive to the price of oil/bitumen as the cost of CRCP is to the price of cement/concrete, there is no additional relative advantage or disadvantage to either type of pavement. For example, if the cost share of concrete in CRCP was less than the cost share of asphalt in asphalt pavement, volatility in raw material prices would be more of an issue for the latter.

