PCA Portland Cement Association
Market Intelligence

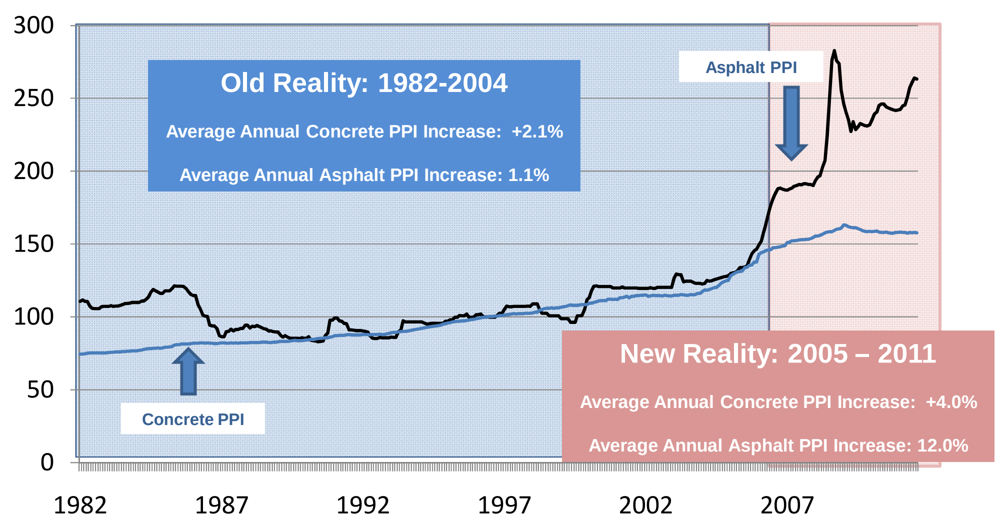
November 11, 2011

Paving: The New Realities

Overview

Until recently, asphalt enjoyed a lower "initial bid" and, according to some, a "life cycle" paving cost advantage compared to concrete[1]. Given these cost advantages, asphalt paved roads captured roughly 94% of all pavements in the United States. The environment and dynamics of world economic growth that resulted in asphalt's paving cost advantage no longer exist. The world economy has permanently changed with the emergence of strong growth among lesser developed and transitional economies. Economic growth among these countries translates into new demand for commodities, such as oil. Since asphalt is a by-product of oil refining, the new global realities suggest that asphalt's long held paving cost advantage over concrete has not only eroded – but has already reversed. This reversal has been

Paving Material PPI Price Comparisons
1996 = 100



Source: Bureau of Labor Statistics, Producer Price Indices

[1] Calculations for life cycle costs vary depending upon the method and assumptions used to calculate. According to PCA's run of Wisconsin's Department of Transportation's WisPAV paving software, asphalt held an initial bid and life cycle cost advantage over concrete until 2008.

amplified by changes in oil refining processes – further raising the cost of asphalt. The changes in the composition of world economic growth that have ushered in the new paving cost dynamics are just beginning. Increasingly, the longer term global economic trends suggest that concrete will enjoy a substantial paving cost advantage over asphalt.

The new dynamics of paving costs have already materialized. Liquid asphalt prices have increased at an average rate of 12% annually, or 137% since 2005, compared to a 4% average annual increase for concrete. This recent dramatic divergence in paving material costs is not a result of temporary cyclical conditions, but a symptom of structural changes in the market for asphalt.[2]

"Free market" comparative cost dynamics suggest that the growing concrete cost advantage could result in a dramatic increase in concrete's share of paved roads and cement consumption volume attributed to the paving market. As a consequence, state departments of transportation (DOTs) could save potentially billions of dollars annually in initial paving outlays and road maintenance costs – enabling them to spend scarce dollars on higher priorities. Unfortunately, the dynamics of "free market" economics favoring concrete is hindered by some DOT procurement practices that include escalators, not allowing bids with alternative materials, flawed life-cycle cost assumptions, and the lack of equivalent paving design. These practices could slow concrete's penetration of the paving market while costing states and taxpayers billions of dollars in unnecessary paving initiatives.

Furthermore, a University of Texas study concludes the potential of a miles per gallon (MPG) improvement for passenger cars and trucks that travel on concrete pavements compared to asphalt pavements – amplifying the potential economic and environmental benefits associated with concrete paved roads[3]. Preliminary Massachusetts Institute of Technology (MIT) research on pavement-vehicle interaction tends to support the study's conclusions[4]. While the potential MPG improvement is small, it could be multiplied by billions of vehicle miles travelled annually, saving fuel costs and CO2 emissions.

The purpose of this Flash Report is to provide material specifiers accurate information about the implications surrounding the impact of changes in world growth on initial bid and life-cycle paving costs. This report also targets DOT strategies to stretch government infrastructure dollars.

Point 1: Investment in America's Infrastructure is at a Crisis Point.

Substantial investment in our infrastructure is required immediately, or the rate of our nation's economic growth and standard of living will slow. The rational is simple. We are now running a 21st century economy with 1970s infrastructure support systems. For decades, investment in highways and roads has not kept pace with demographic changes. During the past 28 years, licensed drivers increased 37%, vehicle registrations increased 55%, vehicle miles travelled increased 51%, yet highway lane miles increased only 4.9%. Lack of investment in highways has led to increased traffic congestion, wasted fuel, higher CO2 emissions, wasted time, and increased logistical costs to the detriment of economic growth. According to the Urban Mobility Report[5], during the past 28 years:

- Traffic delays facing the average commuter increased from 14 hours in 1982 to 34 hours in 2010.
- Wasted fuel accrued to congestion delays increased from 400 million gallons in 1982 to more than 1.9 billion gallons in 2010.
- Emissions attributed to congestion delays increased from 4.5 million metric tons of CO2 in 1982 to 22.4 million metric tons in 2010 – a nearly five-fold increase.

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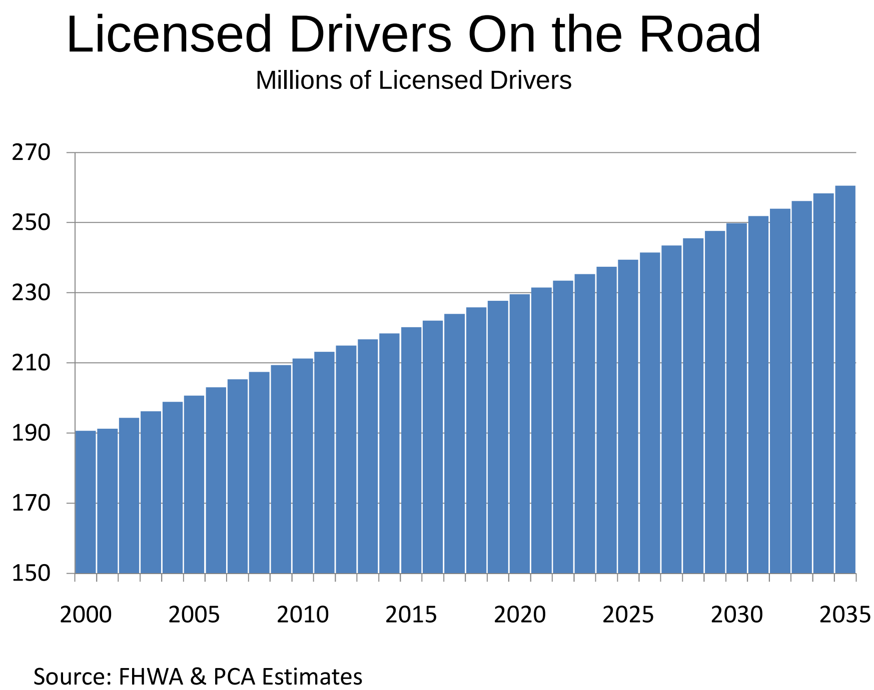
[2] Nustar Energy's10-K filing . Nustar Energy is the 3rd largest liquid asphalt producer in the United States.
[3] "Effect of Pavement Type on Fuel Consumption and Emissions in City Driving", Ardekani and Sumitsawan, University of Texas at Arlington, March 2010. Study performed for Dallas Metro area and PCA translated into national estimates.
[4] Methods, Impacts and Opportunities in Concrete Pavement Life Cycle, MIT, August 2011
[5] Urban Mobility Report: 2011, University Transportation Cement for Mobility, Texas Transportation Institute

- Wasted fuel, time and higher transportation costs resulted in a cumulative cost on the economy of roughly $21 billion (2010 dollars) in 1982 and increased to more than $100 billion in 2010.



During the next 25 years, demographics will place even more pressure on highway infrastructure. Consider the following by 2035:

- The United States is expected to add 54 million licensed drivers, an increase of 25% over 2010 levels.

- Vehicle registrations are expected to increase by 64 million vehicles over 2010 levels.

- Total vehicle miles travelled is expected to increase more than 50% over 2010 levels.

Lacking accelerated investment in highways, traffic congestion will worsen leading to increases in wasted fuel, CO2 emissions, wasted time, and to overall costs to the nation's economy. If the trends of the past 25 years are sustained, PCA estimates the following by 2035:

- Wasted fuel, time, and higher transportation costs are expected to result in a cumulative cost on the economy of roughly $150 billion annually.

- Peak traffic delays facing the average commuter is expected to increase from 34 hours per year currently to more than 50 hours per year in 2035.

- Wasted fuel accrued to congestion delays is expected to increase from more than 1.9 billion gallons currently to more than 6.5 billion gallons in 2035.

- Annual emissions attributed to congestion delays will increase from 22 million metric tons of CO_2 currently to nearly 60 million metric tons by 2035.

America appears unprepared for the coming changes in our nation's demographic profile and infrastructure needs. At best, current American policy toward infrastructure can be described as patchwork fixes rather than a coordinated policy that addresses the rapid demographic changes that lie ahead. Bringing our infrastructure up to speed is not something that can occur overnight. It takes time to plan, rebuild and expand these support systems. If the nation is to avoid the adverse economic consequences of further deterioration of our infrastructure, action must be undertaken quickly. Keep in mind, reinvestment in America's infrastructure will add jobs and lower logistics and commute costs over a prolonged period of time – boosting overall economic growth.

According to the American Society of Civil Engineers, $186 billion annually is needed to repair/and or rebuild the existing highway infrastructure to acceptable conditions.[6] Unfortunately, no financial commitment by the government comes close to providing this level of support at this time.

Point 2: A Comprehensive Understanding of Long-Term Paving Cost Dynamics Can Lead to Efficient Spending Solutions For Infrastructure.

A comprehensive understanding of all paving cost dynamics is essential for material specifiers to maximize taxpayer benefits. PCA believes this should include four key assessments of concrete and asphalt paved roads. These include: (1) road usage, durability and future maintenance costs, (2) factors that will drive relative paving costs in the context of a new world environment that is characterized by rising oil prices, (3) life-cycle cost analysis tools that recognize that the new world order will result in increasingly large changes in the relative prices of paving materials, and (4) the potential of paving materials' marginal impact on the environment.

These assessments must be considered in the context of "paving truisms" that may have been credible even five short years ago but no longer hold due to changes in the world economy. Furthermore, material specifiers and policymakers must recognize that procurement practices such as the use of escalators, non-use of alternative material bidding, and the lack of equivalent paving design could hinder the selection of the "optimal" paving solution. Finally, these assessments must be considered in the least cost long-term paving decisions which will occur in the context of urgency for efficiency in government spending since state budgetary pressures will likely worsen in the years ahead due to demographic changes and Medicaid spending requirements. In contrast to recent deficit reduction policy debates that focus on program cuts, this report focuses attention on government spending efficiency.

Point 3: The Dynamics of World Growth has Changed.

Increasingly, the emerging and lesser developed economies account for a greater proportion of global GDP growth, and as a result, are placing greater demand for all commodities. The Energy Information Agency (EIA) estimates that world GDP will grow at an average annual rate of 3.4% over the period of 2009-2035. Emerging countries are expected to contribute increasingly to world growth, with China's leading average annual rate during this period projected at 5.7% and all non-OECD countries at 4.6%, compared to OECD countries estimated at 2.1%[7].

The importance of growth among emerging and transitional economies should not be underestimated. The International Monetary Fund estimates that these countries' share in world GDP in terms of purchasing power parity will exceed that of developed economies by 2014. This suggests that a "new

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[6] ASCE, Report Card for America's Infrastructure, 2009.

[7] Energy Information Agency, International Energy Outlook 2011, September 2011

world economic order" is being ushered in. Global economic growth, once dominated by the United States, Europe and Japan, will increasingly be ruled by growth among the emerging and transitional economies.

The high rates of economic and population growth in many emerging economies will bring about significant changes in the global distribution of income and consumer markets. In Asia, a large number of households are positioned just below the global middle class threshold. As incomes rise in this region and other emerging economies, the global middle class will expand significantly and become concentrated in these countries. The World Bank has estimated that the global middle class will likely increase from 430 million in 2000 to 1.15 billion in 2030, with China contributing to 52% of the increase, and India 12%. These economic trends are expected to continue well into the future and will have a significant impact on global consumer demand and will lead to upward pressure on commodity prices, such as oil.

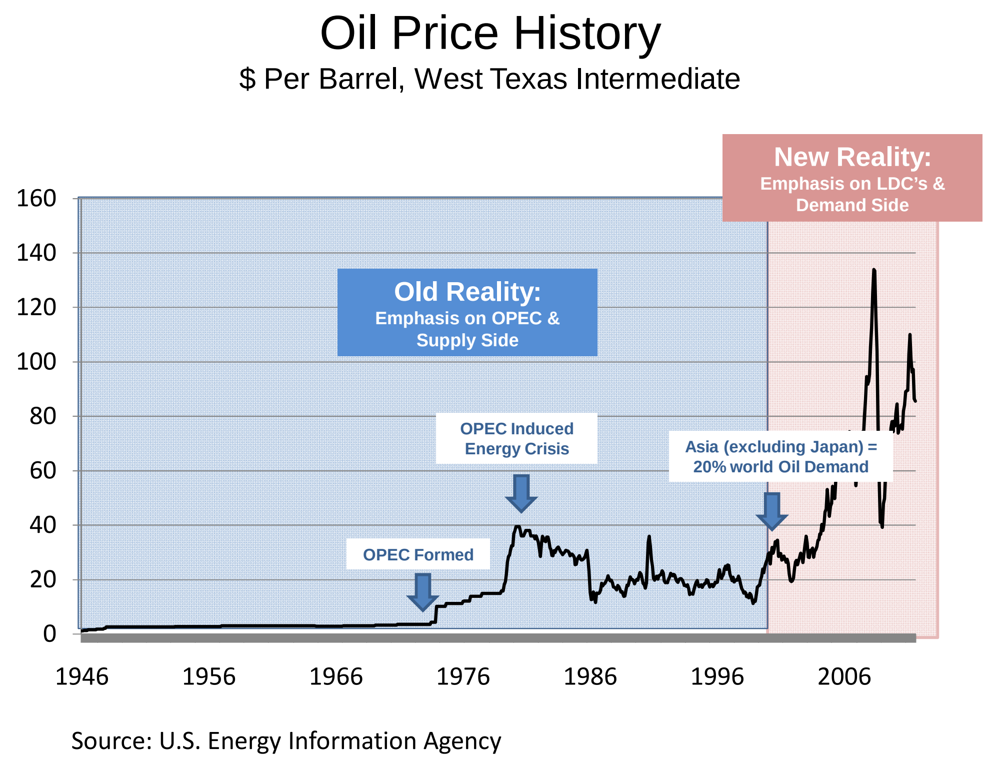
Structural Changes in Global Demand For Commodities: Oil Consumption Share (% of Total World Consumption)

	1970	1980	1990	2000	2009
Developed Countries	**72.9%**	**63.1%**	**57.8%**	**57.0%**	**48.9%**
Less Developed Countries	**27.1%**	**36.9%**	**42.2%**	**42.9%**	**51.1%**
North America	35.0%	31.3%	29.5%	30.1%	26.4%
South & Central America	4.6%	5.4%	5.3%	6.3%	6.6%
Euro zone	20.1%	17.8%	15.2%	15.0%	13.0%
Other Western Europe	7.7%	4.8%	4.2%	3.6%	3.1%
Other Eastern Europe and Eurasia	13.6%	17.6%	16.5%	7.5%	7.5%
Asia excluding Japan	4.7%	8.2%	12.0%	19.4%	24.7%
Japan	8.9%	8.0%	7.9%	7.2%	5.1%
Africa	1.6%	2.3%	3.0%	3.3%	3.7%
Middle East	2.6%	3.4%	5.4%	6.5%	8.7%
Source: United Nations					

Point 4: Oil Prices Face a Long-Term Structural Increase.

The trend of increasing demand by emerging economies can be seen in the distribution of world oil consumption during the past 40 years. Less developed countries currently account for 51% of total world oil consumption, as opposed to 27% in 1970. The most marked change has occurred in China, which accounted for approximately one third of the growth in the world's oil consumption in recent years, with its share increasing from 1.3% to 10.4% in the past 40 years.

The current cyclical downturn temporarily masks the longer term upward pressures facing oil prices. Once stronger world economic growth returns, oil prices are expected to ramp up quickly. The Energy Information Agency apparently agrees with this scenario for world growth and the resulting impact



on world oil prices. According to the EIA's base-case scenario for world economic growth, oil prices are expected to reach $155 per barrel by 2025 and nearly $200 per barrel by 2035[8]. The EIA's "high oil price" scenario suggests oil prices could reach $246 by 2025 and $322 by 2035. The scenarios differ based on assessments made regarding world growth and oil supply conditions.

Point 5: Rising Oil Prices Imply Higher Asphalt Paving Costs.

Asphalt paving materials represent a mix of aggregate (stone), sand or gravel, and crude refined bitumen, also called liquid asphalt. Liquid asphalt is a sticky, black residual material obtained from the refining of crude oil and acts as the binding agent for asphalt. Since liquid asphalt is a residual from crude oil refining, as oil prices rise, liquid asphalt prices increase.

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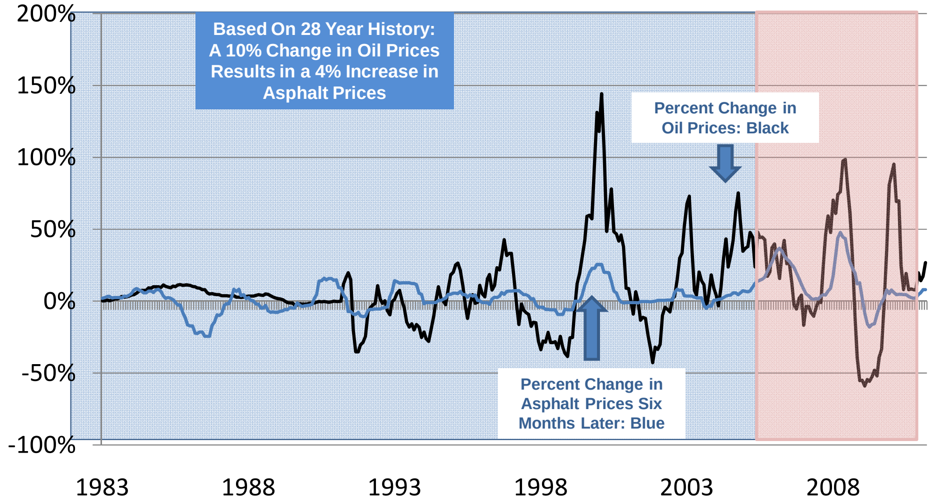
[8]The global oil market projections in the Energy Information Agency's " Reference" (or baseline) case are based on the assumption that current practices, politics, and levels of access will continue in the near to mid-term. The Reference case assumes that continued robust economic growth in the non-OECD nations, including China, India, and Brazil, will more than offset relatively tepid growth projected for many OECD nations. In the Reference case, non-OECD liquids consumption is about 25 million barrels per day higher in 2035 than it was in 2009, but OECD consumption grows by less than 3 million barrels per day over the same period. Total liquids consumption grows to 103 million barrels per day by 2030 and 111 million barrels per day by 2035.

The EIA assumes that limitations on economic access to resources in many areas restrain the growth of non-OPEC conventional liquids production over the projection period and that OPEC production meets a relatively constant share of about 40 percent of total world liquids supply. With those constraining factors, satisfying the growing world demand for liquids in coming decades requires production from higher cost resources, particularly for non-OPEC producers with technically challenging supply projects. In the Reference case, the increased cost of non-OPEC supplies and a constant OPEC market share combine to support average increases in real ("real" means inflation deflated. This report refers "nominal prices" which are not deflated for inflation) to world oil prices of about 5.2 percent per year from 2009 to 2020 and 1.0 percent from 2020 to 2035. In 2035, the average real price of crude oil in the Reference case is $125 per barrel in 2009 dollars.

Asphalt & Oil Price Correlation

Percent Change in Oil Prices Vs Percent Change in Asphalt PPI Lagged 6 months



Source: PCA Estimates

The EIA's oil price scenario suggests an improvement in concrete's competitive position against asphalt roads. Increases in oil prices and the resulting increases in asphalt prices are highly correlated. A simple regression correlation between annual percent changes in oil prices and the six month lagged annual percent change in asphalt prices suggest asphalt prices rose 4% for every 10% increase in oil prices during the past 28 years. The same analysis performed over the past ten years, however, shows that asphalt prices rose 7% for every 10% increase in oil prices. While other factors contribute to asphalt pricing, according to this analysis roughly 60% of long-term asphalt price increases are accounted for by oil price changes.

Based on the 28-year correlation between oil price changes and resulting asphalt price increases, the EIA's "Reference" case implies asphalt prices could be expected to rise roughly 4% by 2015, 27% by 2025 and 46% by 2035. Based on the 10 year correlation between oil price changes and resulting asphalt annual percentage price increases which suggests a 7% increase in asphalt prices given a 10% increase in oil prices, asphalt prices could be expected to rise roughly 8% by 2015, 48% by 2025 and 81% by 2035[9].

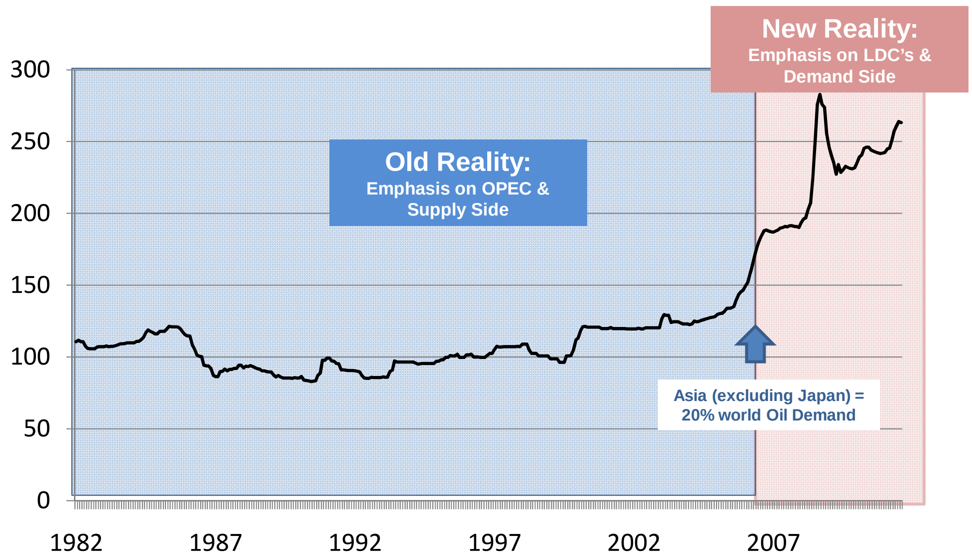
Point 6: New Refining Practices Imply Even Further Pressure on Asphalt Prices.

Oil price changes do not account for ***all*** of the movement in asphalt prices. Clearly, other factors also play important roles in determining the price outlook for asphalt. The current cyclical downturn, for example, has deeply depressed paving demand and temporarily masked the longer term upward pressures facing asphalt prices. Once stronger world economic growth returns, oil prices are expected ramp up quickly and asphalt prices are expected to follow. In addition, structural changes in asphalt

[9] Year-to-date (August 2011) asphalt prices are up 8.1% over 2010 levels based on calculations from the Bureau of Labor Statistics producer price indices.

Asphalt PPI Price History

1996 = 100



Source: Bureau of Labor Statistics, Producer Price Indices

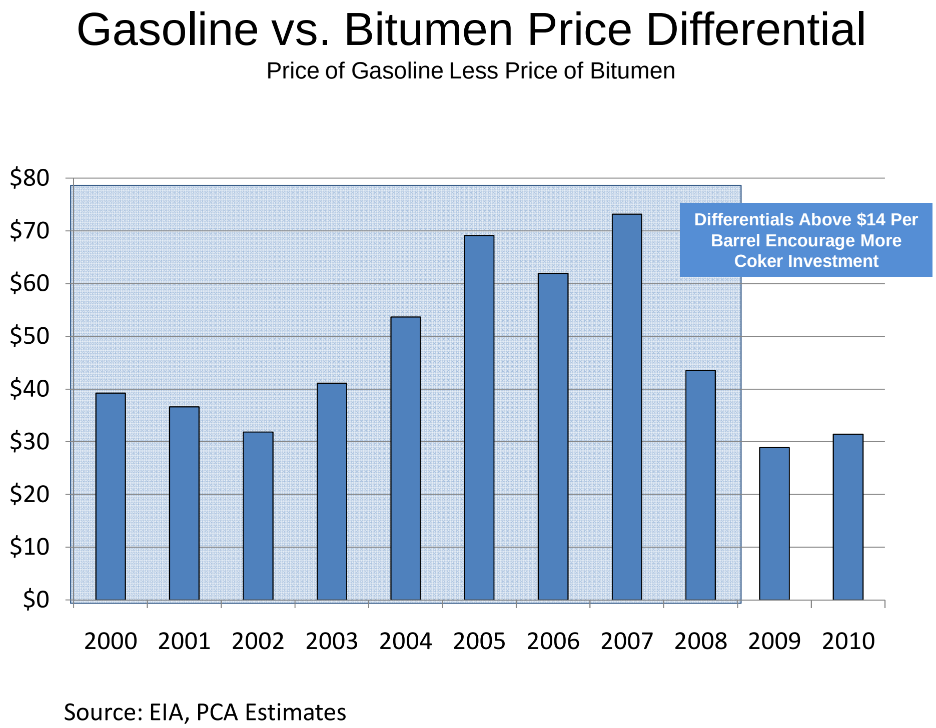
supply conditions have recently emerged – adding further to the long term upward pricing pressures facing asphalt.

Crude oil refineries in the United States have recently engaged in long-term decisions to shift production to light crude products and away from lower margin heavy crude products, such as liquid asphalt. This production shift is enabled by supplementing existing refining processes with equipment called cokers. Cokers increase the ability to refine additional higher margin light crude products, such as gasoline, per barrel of oil. Refineries with installed cokers produce fewer lower-margin residual products such as liquid asphalt – reducing the market supply of asphalt.

Based on a ten-year investment payback to make installing cokers a viable investment, PCA estimates the threshold margin differential between light and heavy crudes is roughly $14-$15 per barrel. The margin differential steadily increased above the threshold beginning in 2004 and reached more than a $90 per barrel spread in 2008. As a result of these margin incentives, 21 new coker projects at refineries that currently produce liquid asphalt are expected to come on-line during 2008-2014.

The light-heavy crude differential declined during the height of the recession and led to a pause in even more new coker installation announcements. Since then, the differential has since increased to levels well above investment thresholds. In the context of sustained, high margin differentials between light and heavy crude products, as well as government mandated ultra-low sulfur diesel requirements, the incentive for crude refiners remains to add even more cokers in the years ahead.

The impact of coker investment on asphalt prices has been muted by the recession's impact on paving demand. Longer term, cokers reduce asphalt supply. The recession has reduced demand well below the supply impact of cokers – thereby masking cokers' impact on prices. The bulk of the new coker investments, however, will come on line during 2012-2014. According to reports by Nustar, the third largest liquid asphalt producer, the United States was short of asphalt supply by 24 thousand barrels per day during 2007. Once the economic recovery gains traction, and paving activity increases, the



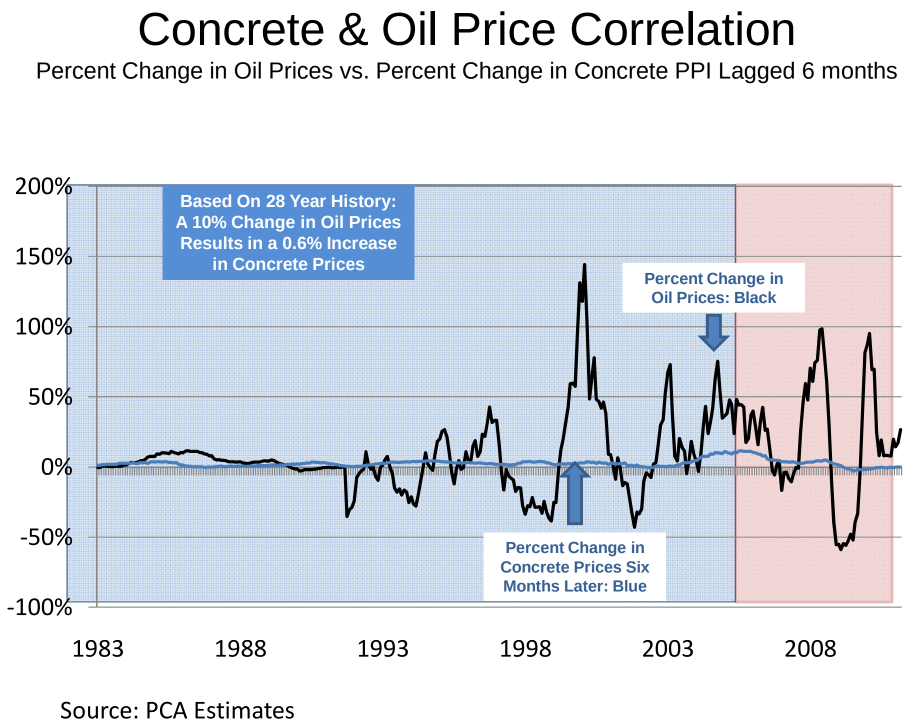
magnitude of asphalt shortages are likely to become more severe than those that materialized in 2007-2008. Given the realities facing the economic recovery, it may take a bit longer for such shortfalls to materialize – but it remains in the cards and this structural change in oil refining practices and resulting asphalt supply conditions suggests further upside longer term pressure on asphalt prices

Point 7: Concrete is not Vulnerable to the New World Growth Dynamics.

Concrete is not as vulnerable to the unfolding changes in world growth dynamics as asphalt. Asphalt's key factor input is oil, which is subject to ***international*** changes in demand. Concrete's key factor input is limestone, which is harvested ***locally*** and not subject to the new world growth dynamics[10]. Various industry surveys indicate that cement kilns are largely fueled by coal and coke, with oil based products accounting for slightly more than 1% of kiln fuel requirements. Arguably, coal and coke prices will follow oil's lead in price escalation. At this point, it is important to recognize that even though some characterize cement production as "energy intensive," this is not reflected in the industry's cost structure. According to industry surveys, energy costs account for roughly 10% of total cement costs[11]. Oil price changes, therefore, are unlikely to cause as significant an impact on concrete production costs as it does for asphalt.

Increases in oil prices and resulting increases in concrete prices are not highly correlated. The same simple regression correlation performed for asphalt, but run between annual percent changes in oil prices and the six month lagged annual percent change in concrete prices, suggests concrete prices rose only 0.6% for every 10% increase in oil prices during the past 28 years. The same analysis performed over the past ten years of data reflect similar results. The bottom line is concrete prices are much less

[10] Locally versus foreign (oil) produced factor inputs may also have marginal implications on job creation, the nation's trade balance, the value of the dollar, inflation and long term interest rates – all favoring concrete.
[11] PCA Financial Benchmarking Report, 2011



exposed tochanges in world growth than asphalt and it further suggests sustained improvement in concrete's competitive paving advantage over asphalt, as world growth dynamics take hold.

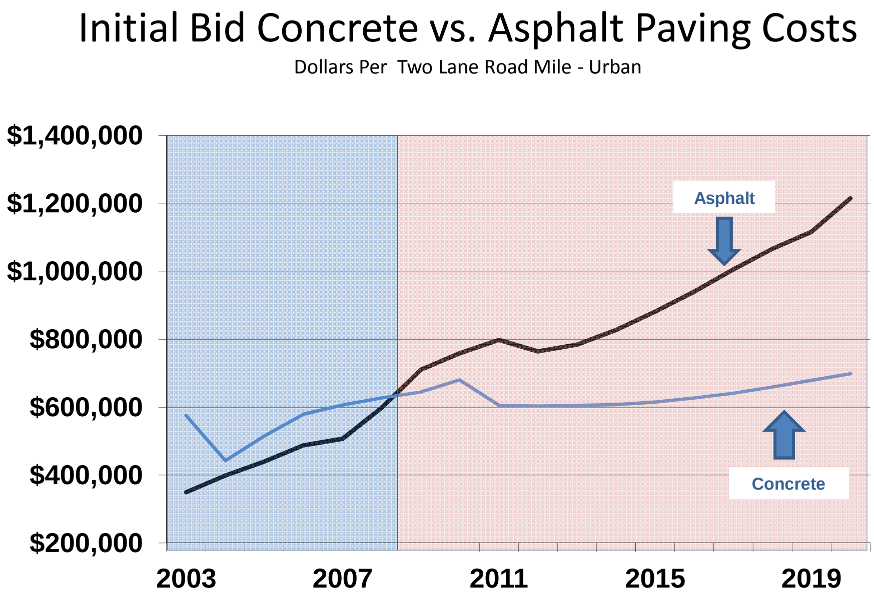
Point 8: Concrete Holds an Initial Outlay Paving Cost Advantage Over Asphalt.

Faced with the strain to meet short-term state budget objectives, state DOT executives sometimes place more emphasis on the initial paving cost rather than the life cycle cost of a road. Until recently, initial bid costs favored asphalt paved roads. Using Wisconsin DOT WisPAV software to calculate initial bid costs for a one-mile "standard" two-lane roadway, PCA calculates asphalt enjoyed a $225,000 cost advantage over a concrete paved road in 2003 – roughly a 39% advantage[12]. Given the "old" realities, it is understandable asphalt paved roads accounted for 94% of all state and local roads.

Past comparisons of asphalt versus concrete initial bid costs, however, are irrelevant. The environment and dynamics of world economic growth that resulted in asphalt's paving cost advantage no longer exists. The new paving realities have taken hold. Since 2003, oil prices have increased more than 200%, coker capacity has increased 33%, and asphalt prices have increased 120%. Concrete prices during the same period increased a comparatively modest 37%.

Initial bid costs now favor concrete paved roads. Based on DOT software, near parity in initial bid paving costs between asphalt and concrete was reached in fiscal 2008 (August 2007). In FY 2009, concrete paved roads enjoyed an $65,000 cost advantage over asphalt paved roads. This reversal in initial bid

[12] Estimates based of Wisconsin Department of Transportation's WisPAV software. A standard road as designed in WisPAV for this analysis consists of an average daily traffic of 7512 vehicles with 15% of all traffic being heavy truck. Soil specifications consist of a design group index (DGI) of 12, Frost Index of F-3, Soil Support Value (SSV) of 4.2, and a Modulus of Subgrade Reaction (k) of 150pci. The pavements were then designed according to these parameters with an asphalt pavement depth of 6.5 inches and 15.5 inches of crushed aggregate base, and an 8 inch concrete road with 6 inches of aggregate subbase.



Source: PCA estimates using WisPAV (Wisconsin DOT paving cost software)

paving costs was due largely to the $60 per barrel increase in oil prices since 2003. During 2010-2011 concrete's initial cost advantage over asphalt increased to $78,500 in FY 2010 and $192,700 in FY 2011 per one mile "standard" two lane roadway.

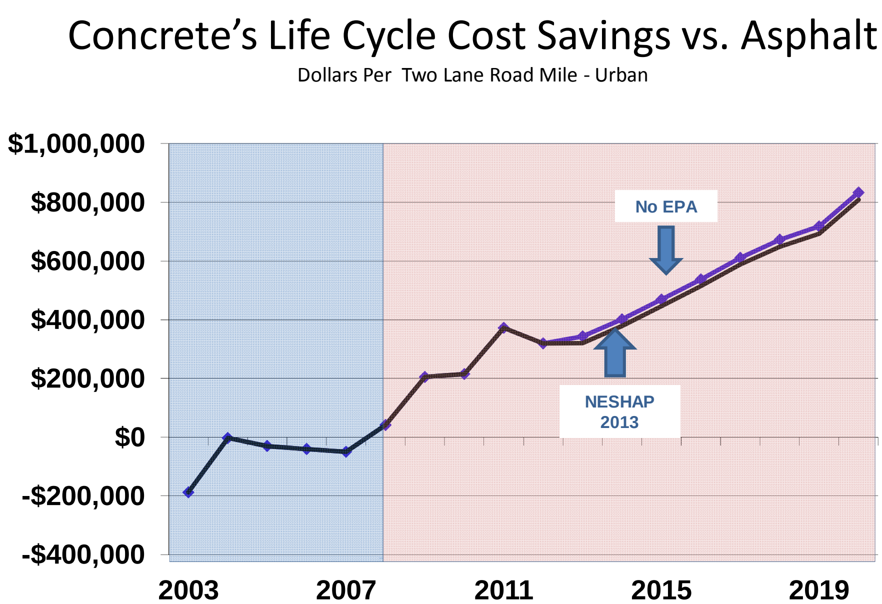
The changes in the composition of world economic growth that have ushered in the new paving cost realities are just beginning. Increasingly, longer term global economic trends suggest concrete will enjoy an even more substantial paving cost advantage compared to asphalt. PCA's initial bid estimates take into consideration key factors that will likely drive costs for both asphalt and concrete prices. This includes projections for oil prices, coker installations, and EPA regulations targeting concrete. PCA uses the EIA's "Reference" case for its oil price projections. Light and heavy crude projected differentials drive coker installations. Combining these two key elements yield the basis for asphalt price projections. For concrete, prices during the past 50 years have risen roughly in-sync with inflation. PCA uses EIA projected inflation rates as a proxy for the rate of concrete price increases. EPA regulations could force a one-time step increase in environmental compliance costs. These estimates are integrated into our EPA compliance scenarios.

Using Wisconsin DOT software, PCA estimates that by 2015 concrete paved roads will enjoy a $266,185 initial bid cost advantage over asphalt for a one mile "standard" two lane roadway – roughly a 30% savings. By 2025 concrete paved roads will enjoy a $634,489 initial bid cost advantage over asphalt for a one mile "standard" two lane roadway – roughly a 44% savings. By 2035, concrete paved roads will enjoy a $916,732 initial bid cost advantage over asphalt for a one mile "standard" two lane roadway – roughly a 46% savings. Given the magnitude of concrete's cost advantage over asphalt, it is likely that other state paving cost software will lead to similar conclusions regarding comparative initial bid estimates.

Point 9: EPA Regulations Aimed at Cement Do Not Alter the Paving Cost Advantages of Concrete.

Cement plant compliance to proposed EPA emission standards could add to the costs of concrete paved roads – but not enough to change the expected cost advantages of concrete paved roads over asphalt paved roads. Compliance to EPA emission standards by 2013 could add as much as $23 per ton to domestic cement production costs by 2020. PCA conducted a rigorous plant-by-plant study using EPA emission estimates, combining them against compliance standards, and integrating these estimates with likely reduction technologies. A detailed assessment regarding capital and operating costs of these technologies was also undertaken. This cost assessment includes capital compliance investments and includes annual operating costs associated with the emission capture systems.

Increased cement costs account for only 20%-22% of concrete material paving costs, with coarse and fine aggregates accounting for the bulk of the remaining costs. PCA assumes a 95% pass through of these costs – representing a one year step increase in resulting concrete paving costs materializing in 2013. Even with these EPA compliance costs added, concrete maintains its initial bid and life cycle paving cost advantage over asphalt.



Source: PCA estimates using WisPAV (Wisconsin DOT paving cost software)

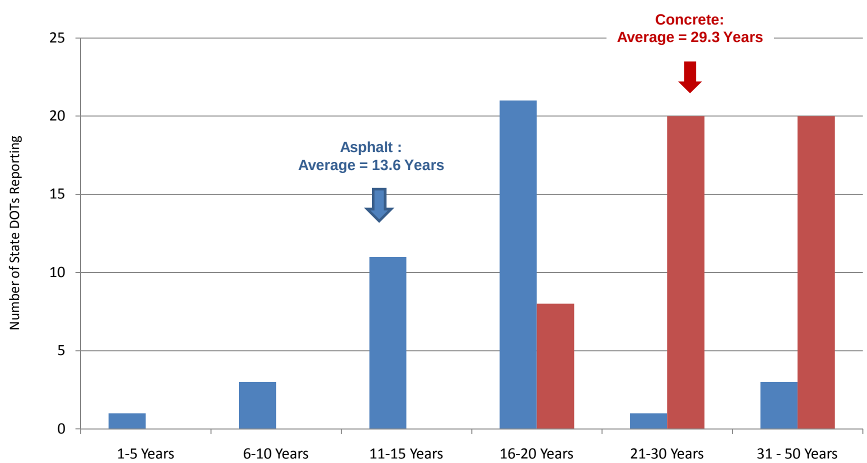
It should be noted that it remains unclear when these EPA costs will materialize. In October 2011, H.R. 2681, the "Cement Sector Regulatory Relief Act of 2011," cleared the House by a bipartisan vote of 262-161. The bill addresses the National Emission Standards for Hazardous Air Pollutants (NESHAP) rule for the portland cement industry, the commercial and industrial solid waste incinerator rule and associated definition of "solid waste," and, lastly, the new source performance standards rule. The legislation requires the EPA to put a hold on its NESHAP compliance date of 2013 and within fifteen months develop new requirements and compliance dates using more realistically achievable technologies over a longer period of time. The bill now goes to a Senate vote. If Senate passage occurs, it must then receive White House approval. The latter steps represent a substantial challenge. In terms of the cost assessments used in this report, PCA includes ***all*** potential EPA regulation costs in its compliance scenario estimates.

Point 10: Procurement Procedures That Emphasize Durability Can Hedge Against the Risks of Volatile Material Price Changes on Highway Maintenance Costs.

No prudent investor would place all their eggs in one basket. A financial portfolio approach that disperses risk and returns is typically recommended. America, however, has bet heavily on asphalt paved roads. Asphalt paved roads represent 94% of the portfolio of all paved roadways. These roadways are highly vulnerable to high maintenance cost risks in the future due to volatile asphalt prices and relatively short life span before a major repaving is required. Asphalt roads are not durable. According to a survey of DOT officials[13], asphalt roads face repaving every 13.6 years. According to the same survey of DOT officials, a concrete paved road lasts nearly 30 years and therefore requires less maintenance costs. Based on a recent MIT study[14], nearly 40% of the lifetime (30-year) cost of a road paved with asphalt is tied up in maintenance, repair, and repaving costs. In contrast, due to concrete's durability, maintenance and repair accounts for only 11% of the lifetime road costs.

Pavement Life Expectancy: Asphalt vs. Concrete

Years Before a Major Reconstruction is Required



Source: PCA 2008 Highway Report

Roadways whereby maintenance costs represent a high proportion of total lifetime cost, imply that high spending risk should be attached to the total lifetime assessed cost of the roadway. Committing to roadways with low durability and requiring frequent repaving equates to betting on future commodity prices (oil) – a risky business particularly when taxpayer dollars are at stake. The bet is substantial. According to the Federal Highway Administration, roughly 58% of SAFTEA-LU dollars spent were dedicated to "system preservation" or maintenance.

During the past ten years, the price of asphalt has fluctuated greatly and is much more volatile than concrete. This volatility hinders the ability of decision makers to accurately estimate contract values, increasing the financial risk of construction contracts. DOTs can hedge against the risk of future increases in paving materials by minimizing their portfolio of non-durable roadways. Quite simply, increased reliance on more durable concrete paved roads with less reliance on future maintenance costs equates to a paving material price hedging strategy for DOTs.

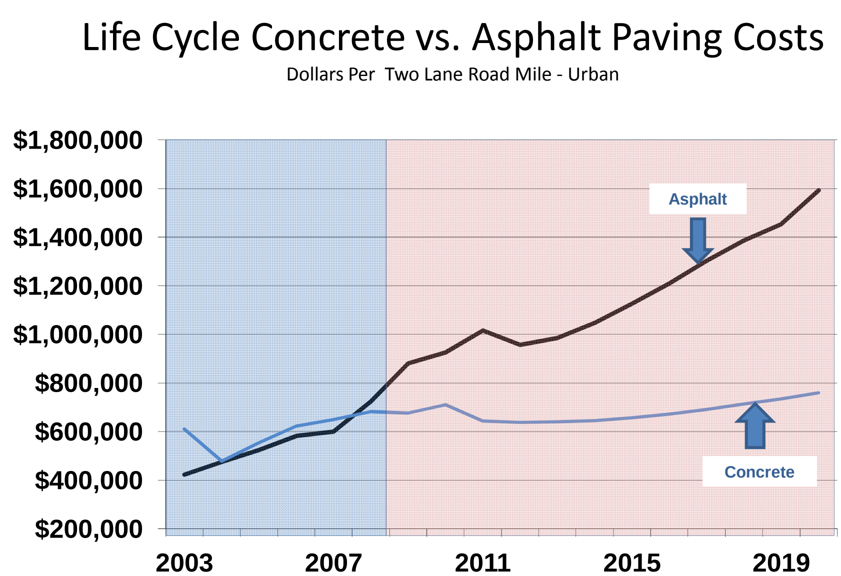
[13] PCA Highway Report 2008

[14] Accounting for Inflation in LCCA, MIT Concrete Sustainability Hub, July 2011

Point 11: Concrete's life cycle paving cost advantages over asphalt are likely to improve considerably in the future.

The need to accelerate highway investment, coupled with new budgetary pressures, suggest that states must re-assess how to best stretch scarce infrastructure investment dollars. When roadways are viewed as a long-term public investment, life-cycle cost analysis (LCCA) is used to provide cost estimates over the useful life of the road (roughly 35 years). LCCA is an engineering and economic analysis tool useful in comparing the relative merit of competing project implementation paving alternatives. By considering all of the costs incurred during the service life of an asset, this analytical process helps transportation officials to select the lowest cost paving option. All of the relevant costs that occur throughout the life of a road, not simply the initial paving expenditures, are included. Based on an informal PCA survey of state DOTs, only 13 states have accepted the use of LCCAs as part of their cost assessments.

Most DOT LCCA assessments are flawed because they use the same discount rate for expected future concrete and asphalt cost increases – even though concrete costs have risen significantly slower than asphalt. This assumption tends to underestimate asphalt's long term costs – and, thereby, such LCCA's are often biased in favor of asphalt. The DOT software used in this section of the analysis ***includes this bias***.



Source: PCA estimates using WisPAV (Wisconsin DOT paving cost software)

Given these potential biases using the Wisconsin DOT software, PCA estimates concrete paved roads currently enjoy a $372,466 life-cycle cost advantage over asphalt for a one-mile "standard" two-lane roadway – or roughly a 37% savings. By 2015, concrete paved roads will enjoy a $468,802 LCCA bid cost advantage over asphalt for a one-mile "standard" two-lane roadway – roughly a 42% savings. By 2025, concrete paved roads will enjoy a $998,682 life-cycle cost advantage over asphalt for a one-mile "standard" two-lane roadway – roughly a 53% savings. By 2035, concrete paved roads will enjoy a $1,376,782 life-cycle cost advantage over asphalt for a one mile "standard" two lane roadway – roughly a 54% savings. Given the magnitude of concrete's cost advantage over asphalt, it is likely that other state paving cost software will lead to similar conclusions regarding comparative life-cycle estimates.

Point 12: Proper Use of LCCA Suggests Concrete's Life Cycle Cost Advantage is Underestimated.

Some estimates of paving life-cycle cost calculations underestimate concrete's advantage compared to asphalt. These underestimations may materialize due to protocols contained in the software used by DOTs. DOTs that use LCCA assessments typically use the same discount rate for expected future concrete and asphalt cost increases – even though concrete costs have risen significantly slower than asphalt. This assumption tends to underestimate asphalt long-term costs – and, thereby, such LCCAs are often biased in favor of asphalt.

According to the Federal Highway Administration, "LCCA's value as a decision-support tool is contingent upon its proper use". The LCCA process begins with the development of alternatives to accomplish the structural and performance objectives for a project. The analyst then defines the schedule of initial and future paving activities involved in implementing each project design alternative. Next, the costs of these activities are estimated. The predicted schedule of paving activities form the projected life-cycle cost stream for each design alternative.

Using an economic technique known as "discounting," these costs are converted into present dollars and summed for each alternative. The analyst can then determine which alternative is the most cost-effective. By using the same discount rate for all materials, LCCAs have traditionally ignored the possibility of future changes in relative prices by assuming that future price increases for asphalt will be identical to those of concrete. However, significant differences exist in the historical and expected future increases in the price of paving materials.

MIT recently released a study finding that not using material specific deflators or discount rates will greatly underestimate the total cost of asphalt roads and overestimate concrete roads. MIT found that asphalt prices will increase an inflation adjusted 95% while concrete will drop 20% over a 50 year timeline. MIT stated that not using material specific cost adjustment factors can cause budget overruns of up to 4% specifically due to higher than expected asphalt prices.[15] MIT's analysis, which points to the need to use material specific discount rates, are critically important.

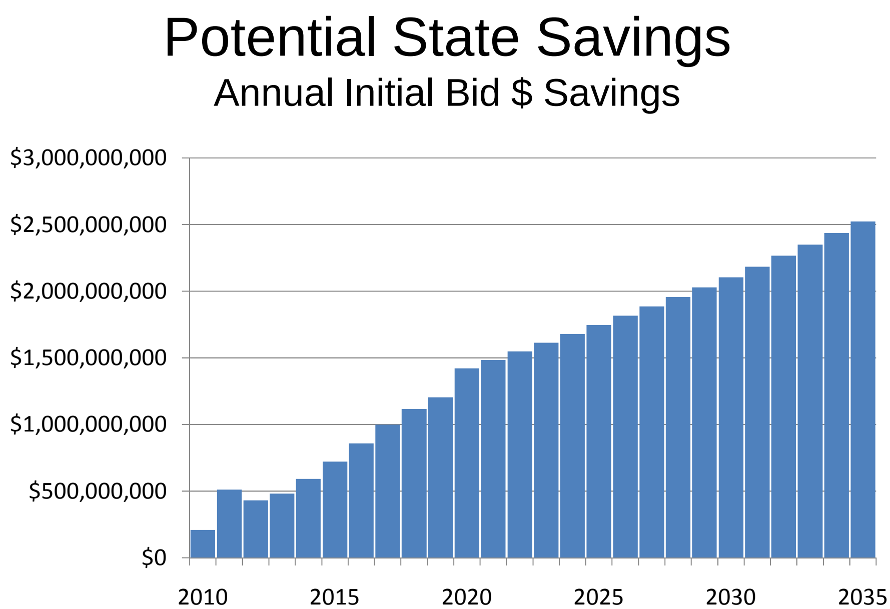
This is not an academic exercise. MIT's findings could save state DOTs billions of paving dollars over the long run by more correctly assessing the discount rates that should be attached to each material cost. A recent study calculated the potential savings to state DOTs by integrating MIT's recommendations regarding the use of separate discount rates for each material[16]. By not accurately accounting for inflation rates, the study estimates material inflation could cost state DOT budgets $14 billion over the next 30 years. The study was based on a small subset of roads. Adjusted for all interstates, major and minor arterials, this translates into nearly $120 billion of additional costs.

The MIT analysis focuses on historical precedents as the basis of their conclusions. If the ***structural changes*** of new global growth realities and its impact on oil prices are correct, then an even greater divergence in material price growth rates is likely to materialize – adding to the bias contained in most DOT LCCA calculations. This implies the MIT analysis may underestimate the size of future budget overruns due to higher than expected asphalt prices. Furthermore, it emphasizes the researcher's conclusion that the use of material specific discount rates should be required if LCCA's value as a decision-support tool leading to the most cost effective paving solution can be achieved.

[15] Concrete Sustainability Hub@MIT Life Cycle Cost Analysis Research Brief July, 2011
[16] Not Accounting for Inflation Rate has a Large Impact on Future System Expenditures, James Mack, CEMEX, Houston, TX.

Point 13: Concrete Paved Roads Could Save States Billions of Scarce Dollars.

The recent economic downturn has forced states to prioritize their spending – shifting highway maintenance dollars to entitlement spending. Road quality, as a result, has deteriorated according to the Federal Highway Administration's international roughness index (IRI). States face both the need to expand, repair, and improve roadways. Concrete paved roads could save states billions of dollars annually in initial paving costs and over the life-cycle of their roads. How much concrete paving could save a state depends on the amount of paving activity undertaken by a state and how quickly DOTs recognize and react to the new paving realities and turn to the concrete alternative. Urban interstates, major arterials and minor arterials are typically characterized by high daily traffic use – requiring durable pavements. These roads represent only 615,000 lane miles out of the nation's 8.3 million total lane miles, or roughly 7.5% of all roadways. If ***only*** these major high traffic roads in urban areas rated in "poor" condition by the IRI were repaved in concrete, states and localities would have saved more and $500 million in initial paving costs and nearly $1 billion in life cycle costs ***this year.*** [17] As time wears on, and concrete's paving advantage widens, the potential annual savings grow. During a 25-year horizon, states could save $61.8 billion in lifetime paving costs. Keep in mind, PCA believes these estimates are conservative and the savings could be even larger.



Source: PCA Based on WisPAV Data, For Urban High Volume Roads Only

The need to accelerate highway investment, coupled with new budgetary pressures, suggests that states must re-assess how to best stretch scarce infrastructure investment dollars. The possibility of increased future federal funding, at least for now, seems remote. Much of the responsibility to maintain and expand the nation's infrastructure will inevitably fall on the shoulders of state and local governments. Updating and increasing existing highway infrastructure may be compromised by competing state entitlement responsibilities and diminished federal support. Nearly 23% of total state spending is directed at Medicaid. As the population ages, Medicaid spending will increase. Medicaid spending is expected to account for 34% of total state spending by 2030 – potentially at the expense of highway and infrastructure spending.

[17] Federal Highway Administration defines these roads as interstates, major arterials and minor arterials. Geographically, urban areas include all roadways of these type in metropolitan areas.

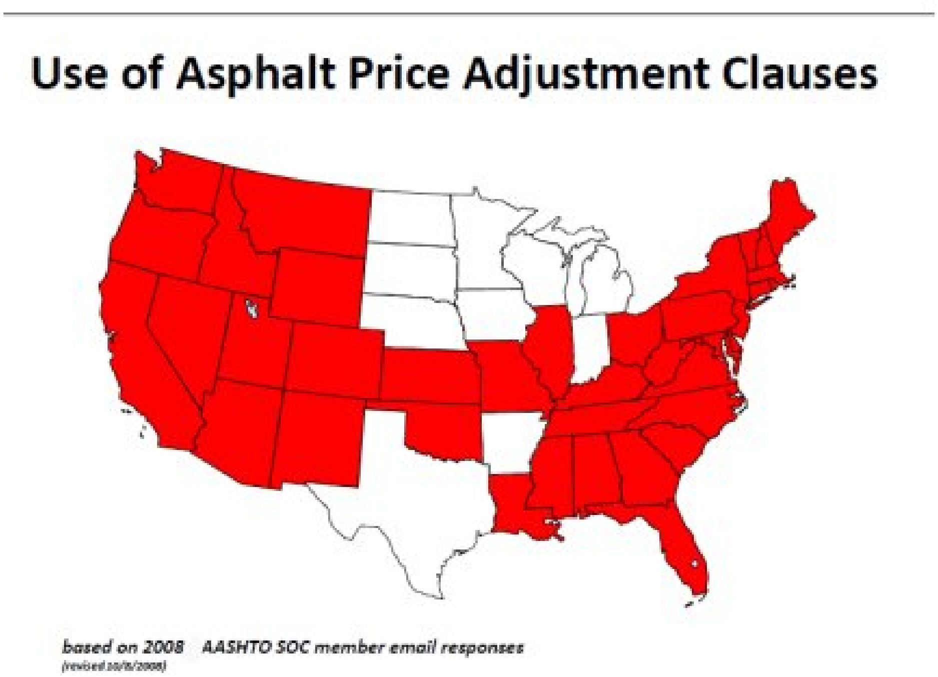
Given the context of increased budgetary oversight, the discussion of fiscal responsibility should not be solely centered on cuts in programs and services. Fiscal responsibility should also center around efficiencies in government spending. The new paving cost dynamics are just beginning and could usher in new potential for government spending efficiencies.

Point 14: Outdated State DOT Procurement Concepts May Hinder States from Capturing These Cost Saving Benefits.

"Free market" dynamics suggest that the growing use of concrete paved roads could save potentially billions of dollars annually in road maintenance costs – enabling states to spend scarce dollars on higher priorities. Unfortunately, the dynamics of "free market" economics favoring concrete are hindered by some states' DOT procurement practices that include escalators, non-use of alternative material bidding, flawed LCCA calculations, and the lack of equivalent paving design. These practices could slow concrete's penetration of the paving market and at the same time cost states and taxpayers billions of dollars in unnecessary paving initiatives.

Asphalt Cost Escalator Clauses

Asphalt cost escalator clauses are a price adjustment provision that allow for asphalt paving contractors to adjust their construction price based on a fluctuation in liquid asphalt cost. Asphalt escalator adjustments occur after the contractor has won the bid. In the context of rising oil and asphalt prices, taxpayers actually pay more to a contractor at the time of construction than the price quoted to win the project. This practice can result in DOTs choosing a more expensive paving option and result in significant cost overruns. Most state DOT paving material procurement policies allow for the use of asphalt escalators.



Asphalt cost escalators were first introduced to support the asphalt industry during the oil embargo of the 1970s which resulted in volatile swings in liquid asphalt costs. These DOT procurement policies may have had some merit at the time they were introduced. At the time escalators were introduced, with oil prices averaging $30 per barrel, concrete paved roads were not usually competitive on either an initial bid or life-cycle cost basis according to DOT paving software calculations. In essence, DOTs had no cost competitive alternatives to asphalt paved roads. DOTs were forced to implement escalators, and absorb the risk of material price volatility, to ensue paving bids. Because the paving cost dynamics have changed so radically during the past ten years, DOTs now enjoy the advantage of another cost competitive paving alternative – concrete roads, therefore, are no longer bound to be the risk insurer for asphalt paving contractors.

While escalators may have been a prudent policy for the 1970s, they have no place in the context of the new paving realities. Escalators now serve only to potentially enhance asphalt's contract bid position versus concrete paved roads and mask unneeded cost overruns caused by asphalt's price volatility. Based on Oman systems data, PCA estimates that escalators have cost states roughly $70 million annually on state roads in cost overruns since 2008.[18] Keep in mind, Oman data represents only a small subset of all roads. This implies the actual annual cost of these escalators to taxpayers could be much larger.

Often, Road Design Processes are Outdated and Based on 50 Year Old Research.

The paving material performance characteristics of concrete and asphalt are vastly different. Existing road design processes often do not have the required resources to conduct equivalent design methods and, hence, performance comparisons are not frequently performed. Most existing design methods used by DOTs are based on the two-year American Association of State Highway and Transportation Officials (AASHTO) road test in the late 1950s and used only one asphalt and one concrete mixture. This dated information does not reflect the present realities of today's road requirements. Heavy truck traffic, for example, has increased 10 to 20 fold since the 1960s. At the same time, the expected design life of a road has doubled from 20 years to 40 years. Mixture designs for both asphalt and concrete have changed. Repair and maintenance cycles along with many other important design considerations are also not adequately accounted for in current design guides.

AASHTO has responded to the need for a better road design process by adopting a mechanistic-empirical pavement design guide (MEPDG) referred to as DARWin-ME. The guide acknowledges the deficiencies of previous pavement design processes that have traditionally kept road building agencies from exploring equivalent paving alternatives in their current design practices. The MEDPG empowers a road designer to create equivalent designs for asphalt and concrete. Much like material specific inflation factors, the MEPDG will assist concrete paving by creating a level playing field in which side by side comparisons of pavement material designs are possible.

The absence of a MEPDG road design process that incorporates multiple design possibilities can reduce or completely eliminate competition between asphalt and concrete roads. Unless specially called for, most current road design processes do not compare the designs of asphalt and concrete roads for the same project.[19] Often times, tradition drives paving material choices rather than comparative cost benefit analysis.

Research performed at MIT and AASHTO indicate the need to put concrete on level ground with asphalt in order to effectively engage in meaningful material considerations. The use of AASHTO's recommended MEPDG approach toward road design could increase paving competition and result in reduced costs for state DOTs. In a time where funding is scarce, DOTs must use the most cost efficient strategies at their disposal. Based on an informal PCA survey of state DOTs only nine states have accepted the use of MEPDG as a design protocol.

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[18] Using Oman initial bid data, PCA assumes a six month lag between bid and project completion. Overlaying asphalt price increases based on Bureau of Labor Statistics PPI indices, the asphalt price increase can be calculated. These increases are compared against the national average for asphalt price escalator's threshold increase/decrease.

[19] Guide for Mechanistic-Empirical Design of New and Rehabilitated Pavement Structures, ARA, Inc ERES Division for the National Cooperative Highway Research Program Transportation Research Board

Lack of Alternative Design-Alternative Bid (ADAB)

Frequently, DOTs strictly specify the paving material to be used in a road's construction, excluding a concrete paving solution from being considered in the bidding process. Such practices work against free market competition and exclude states from the potentially lower costs associated with the new paving realities. Under increasing fiscal pressure, some state DOTs are beginning to recognize the costs associated with these procurement practices and have begun adopting new procurement protocols called Alternative Design – Alternative Bid (ADAB).

Alternative Design-Alternative Bid is a contracting process used in an increasing number of state DOTs. The process gives the contractor a choice to bid on either a concrete or asphalt option, thereby increasing the number of bidders on each job and enhancing competition. ADAB allows the bidding contractors to select the pavement type to be constructed, rather than a DOT. This not only eliminates any bias in the selection process, but also increases competition between paving industries. The end result is greater choice, lower costs, and enhanced innovation.

Alternative Design-Alternative Bid fosters competition. The beneficiary of enhanced competition is the state. The Indiana DOT, for example, recently employed ADAB for the reconstruction of a 52 mile stretch of roadway largely related to Route 69. Compared to conventional bidding processes, the Indiana DOT estimates it saved $51 million[20]. One state, one project, huge spending efficiencies and state savings. Based on an informal PCA survey of state DOTs only 13 states have accepted the use of ADAB as a procurement protocol.

Point 15: Concrete Paved Roads May Result in Fuel Savings.

Pavement systems have significant impacts on the environment and economy due to large material consumption, energy input, and capital investment. As a result, state DOT material specifiers are increasing taking into consideration life cycle assessment (LCA) of asphalt versus concrete paved roads. The goal of LCA is to compare the full range of environmental effects assignable to products and services in order to improve processes, support policy, and provide a sound basis for informed decisions.

To this end, the University of Texas conducted a study[21] to investigate differences that might exist in fuel consumption and CO2 emissions when operating a motor vehicle on asphalt versus concrete under city driving conditions. The study was performed using passenger cars driving in city conditions in the Dallas area. Every attempt was made to carefully control all other factors that could impact fuel economy.

The study concluded that small differences in fuel consumption and emissions over the design life of a road could result in substantial user cost differences. These differences favor concrete paved roads. PCA translated the conclusions of the University of Texas' test results into national estimates based on total urban roadways in the United States. While the potential miles per gallon improvement is small, it could conceivably be multiplied by billions of vehicle miles travelled annually. Based on the University of

[20] INDOT, SEP 14 Report, March 11, 2011. INDOT compared the average difference in percentage below the engineer's estimate for all eleven (11) alternate bid contracts versus the conventional bid contracts, then the savings would be a much greater amount. INDOT received winning bid amounts that averaged nine (9) percent more below the engineer's estimate for the alternate bidding process than the conventional bidding process. Reference the table in section B Analysis above. The winning bid amounts for all eleven (11) alternate bids were $422,698,033.04 and the engineer's estimate amounts were $574,204,558.37; therefore a nine (9) % difference between alternate and conventional bid for all items, INDOT saved the tax payers approximately **$51,000,000.00**. This shows that INDOT not only saved on pavement pay items, but saved on all other pay items in the contracts also. INDOT believes that this greater percentage below the engineer's estimate phenomenon for Alternate Bidding versus Conventional Bidding was because INDOT does not publish the PW cost before the bids are opened. INDOT believes that this Alternate Bid process for Pavement Type Selection may affect all the bid items in the contract based on the percentage below the engineer's estimate phenomenon.

[21] Effect of Pavement Type on Fuel Consumption and Emissions in City Driving, University of Texas Arlington, March 2010.

Texas' conclusions, if all urban roadways were paved with concrete it could result in billions of dollars in fuel cost savings and reduce CO_2 emissions by hundreds of million tons annually.

Another study by the National Research Council (NRC)[22] Canada concluded similar findings. When comparing concrete to asphalt roads fuel consumption savings ranged from 0.8 to as much as 4.1 percent in favor of concrete. The highest savings occurred for fully loaded trailer trucks.

MIT is engaged in preliminary research regarding pavement-vehicle interaction (PVI) which describes the effect of pavement structural and surface properties on vehicle fuel consumption. The analysis on pavement deflection seems to support the findings of the University of Texas and the Canadian NRC.[23]. While these results remain preliminary, initial research indicates favorable MPG savings for concrete paved roads and should be considered when performing comparative pavement life cycle environmental analysis.

Point 16: The Timing of Concrete Share Gains May Be Slow.

Given PCA's foregoing assessments, free market dynamics unleashed by the new paving realities will eventually reshape DOT attitudes and procurement protocols regarding paving material choices. Concrete paved roads will gain share – eventually. It would be a mistake to assume that since concrete holds an initial and life-cycle cost advantage all roads going forward will be paved with concrete.

Several institutional factors will slow this process. First, there is a recognition lag. The new paving realities are a recent phenomenon and it will take time for some DOTs to recognize that the old world in which asphalt paved roads made economic sense no longer exists. Second, there is a convenience lag. State DOT road designers have long used asphalt for paving and are comfortable in its use. Material specification for pavements may favor asphalt due to its habitual or traditional use as well as the paving material's ability to be consistent with existing roads. Third, there are policy lags. Policy procurement protocols such as escalators, non-use of alternative material bidding, flawed LCCA calculations, and the lack of equivalent paving design will slow concrete's paving gains. Each of these factors represents resistance to the economics of the new paving realities and slows the process of concrete paving gains.

Initiatives undertaken to educate DOTs and policymakers regarding the new paving realities will likely meet resistance. This resistance will likely vary by state. It is quite possible that resistance to the new paving realities may be least among the most heavily travelled and congested routes whereby durability carries a high premium. High home prices during the early-mid 2000's resulted in urban sprawl and a geographic redistribution of driving population. Urban, major and minor arterials witnessed rapid increases in congestion. IRI indices suggest road conditions among these roads have deteriorated most. Furthermore, these roads account for more than 500,000 lane miles.

[22] Effects of Pavement Structure on Vehicle Fuel Consumption-Phase III, National Research Council of Canada, January 27, 2006.
[23] Methods, Impacts and Opportunity in Concrete Pavement Life Cycle, MIT, August 2011