

An Industry Perspective on Elements Required to Create Competition in Alternate Pavement Type Selection: A Case Study for North Carolina

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Abstract

Alternate Pavement Bidding (APB) is a process in which both concrete and asphalt pavement designs are developed for a project and the contractor selects which material to submit with his bid. The bid and pavement type that wins is the one that has the lowest life cycle costs. The goal of APB is to increase competition and lower cost by bringing additional contractors and pavement options to the bidding table. In 2010, the North Carolina Department of Transportation (NCDOT) and the North Carolina Turnpike Authority (NCTA) started exploring the use of the APB. As part of development process, NCTA/NCDOT asked representatives from both the concrete and asphalt paving industries to participate. In reviewing the APB and LCCA models used by other Agencies, the concrete industry identified several reoccurring engineering and economic factors that they believed were correlated with successful implementation of an APB model. This paper presents the information given to the NCDOT / NCTA by the concrete paving industry in order to have a more comprehensive process that accurately reflects the risk, costs, and performance of the competing alternatives.

Introduction

In 2010, the North Carolina Department of Transportation (NCDOT) and the North Carolina Turnpike Authority (NCTA) started exploring the potential benefits of using Alternate Pavement Bidding (APB) for their Pavement Structures. In determining the best way to implement a program, NCTA/NCDOT invited both the concrete and asphalt industries to express the ideas as well as their concerns. In response to their request, the NC concrete paving industry developed a paper identifying the key Engineering, Economic, and Specification elements that the concrete industry felt needed to be included in APB and to show the impact each element has on the process.

Alternate Bid Process:

The Alternate Bid Process for pavement selection has been shown to lower cost by bringing additional contractors to the bidding table and increasing competition. It is also believed that APB will increase performance of the final pavement design by bringing innovation to design and construction. As an example, the use of APB by Missouri Department of Transportation MoDOT) has resulted in the number of bidders increasing from an average of 4.2 on non-APB projects to 5.5 on APB projects and the following decrease of pavement cost (Ahlvers, 2009).

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- The 3-year average asphalt price/ton for APB projects was 5.1% below the 3-year average of non-APB projects and 4.8% below the 3-year average for all projects.
- The 3-year average concrete price/CY for APB projects was 8.6% below of the price on non-APB projects and 2.8% below the 3-year average for all projects.”

However, in order to achieve these results, the APB process requires that the pavement design and rehabilitation strategies reflect how the pavement alternatives will perform; and the life cycle cost analysis (LCCA) reflects the most likely expenditures of the agency for each alternative over the analysis period. MoDOT’s success has been realized, in part, due to the participation of achieved success with their APB process. Specifically, they involved both the asphalt and concrete paving industries in the development of the process; used structurally equivalent concrete and asphalt sections in their designs; compared the bids objectively by using life cycle cost analysis; and adjusted their bidding / payment practices so that the material quantity risk between asphalt and concrete projects are treated similarly.

FHWA Recommendations

While there is not a considerable amount of information on what makes a good APB process, the Federal Highway Administration (FHWA) has a Technical Memorandum Dated Nov 13, 2008 titled “*Clarification of FHWA Policy for Bidding Alternate Pavement Type on the National Highway System*” (FHWA, 2008) that outlines the following nine engineering and economic aspects that need to be considered when doing APB:

1. Designs must be Equivalent
2. Realistic Discount Rate
3. Consideration of Uncertainty
4. Realistic Rehabilitation Strategy
5. Subjective Considerations
6. Appropriate Application
7. Commodity Price Adjustment Factors
8. Incentive/Disincentive Provisions
9. Material Quantity Specifications

While the NC concrete paving industry agreed with the FHWA on the elements, it also believed that the following, more comprehensive and thorough discussion on some of the elements was needed to ensure that the APB process was transparent, equitable and representative of the true costs of the pavement alternatives over their life, and also more reflective of the risk, costs, and performance of the competing alternatives.

Equivalent designs – According to the above FHWA Technical Memorandum, the pavement designs must be equivalent. Though not defined in this memorandum, or in FHWA’s “*Life-Cycle Cost Analysis in Pavement Design - In Search of Better Investment Decisions*” publication (FHWA, 1998), it is generally accepted that “Equivalent Sections” are designs that have the same Structural Capacity (e.g.

pavements that are designed with the same traffic, reliability, initial subgrade conditions and terminal condition for the pavement are equal).

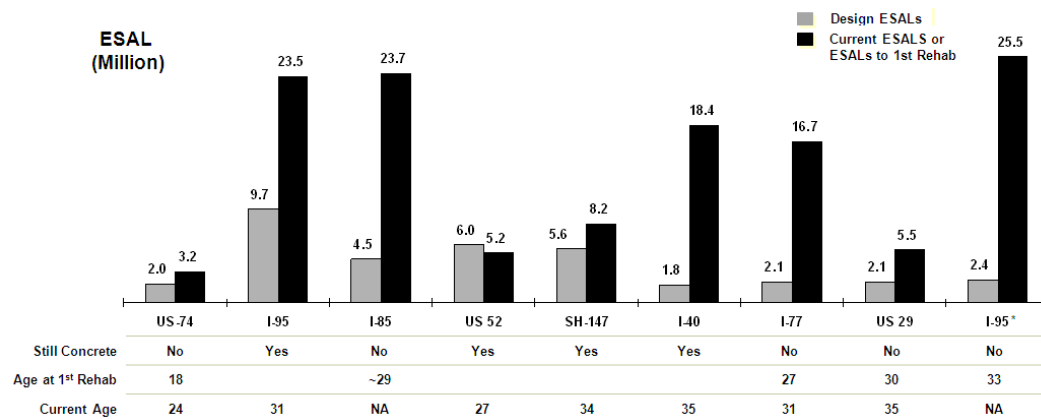
The reason that “Equivalent Sections” are required is that Life Cycle Cost Analysis (LCCA), which is used to evaluate the trade-offs between cost and performance, is a subset of a Cost/Benefit Analysis where the “Benefits” are assumed to be equal. Therefore, in order to determine which alternative is the best for the agency, the designs of the pavement sections must have common benefits – in the form of similar performance criteria – so that the comparative analysis can be based upon expected results.

At the time the APB development process was underway, the NCDOT design procedures designed concrete pavements based on 30-year ESAL counts and asphalt pavements on 20-year ESAL counts (with the first overlay being placed between years 8 to 12). Because these designs were not based on similar performance criteria, they were not equivalent. The industry therefore recommended that all designs be based on 30-year ESAL counts in order to have equivalent designs that were close to the duration of NCTA bonds (40 years).

Rehabilitation Schedules – The current NCDOT LCCA process consists of 30 year analysis period. Included in the rehabilitation for concrete pavements is “joint resealing” at years 10 and 20. While not an unrealistic goal, the concrete industry argued that joint resealing was rarely performed in North Carolina (or any other state).

The NC concrete pavement industry therefore recommended that the frequency of pavement rehabilitation activities be matched to each specific pavement’s design and compared to historical and/or performance data of “like roadways” (e.g. interstates compared to interstates) using empirical databases, such as LTPP, and/or performance prediction data from the AASHTO Mechanistic Empirical Pavement Design Guide (MEPDG). The goal of this recommendation was to objectively match the rehabilitation schedules with the expected performance for a given design, rather than using the standard NCDOT rehabilitation schedule, which may or may not be accurate. For example, on a given roadway with a given traffic volume, an 8-inch concrete pavement will not have the same rehabilitation schedule as a 12-inch concrete pavement. Subsequently, they should not be evaluated using the same rehabilitation schedule.

The concrete industry also noted that North Carolina concrete pavements have carried many more loads than what they were designed to carry. Figure 1 shows the projected performance and actual performance of NC projects within the LTPP database (FHWA, 2010; Corely-Lay & Morrison, 2002). As can be seen, most concrete pavements have carried much more traffic than which they were designed. It is also important to note many of these concrete roads exceeded their design performance life even though they incorporated obsolete design features, such as long joint spacing. Current designs using improved design features, and the improved performance modeling available with the MEPDG show that new designs will provide better performance than achieved historically.



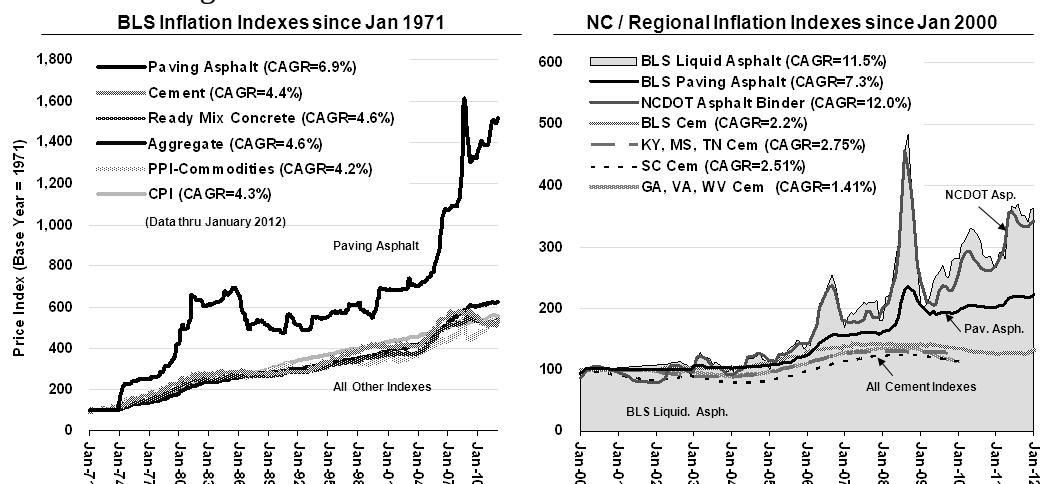
Note: Rehabilitation of US-74, I-77 and US 29 LTPP test sections consisted of patching and asphalt overlays. No information is available on I-85 and I-95 rehabilitation. I-95 Section is from (Corely-Lay & Morrison, 2002)

Figure 1: Performance of North Carolina LTPP/Other Concrete Test Sections

Discount Rates – The current NCDOT LCCA procedure uses a Real Discount Rate of 4%, which is consistent with the most recent FHWA recommendations (FHWA, 2008) that states: “Discount rates should be consistent with OMB Circular A-94. The trend over the past 10 years indicates a discount rate in the range on 2-4 percent is reasonable.”

The concrete industry argued a major assumption of the real rate is that inflation of the items being compared are similar to the general rate of inflation. By using data from industry recognized sources such as the Bureau of Labor Statistics (BLS), the US Geological Survey (USGS), and NCDOT, it can be shown that the inflation for asphalt is not only higher than concrete, it is also higher than the general rate of inflation.

Figure 2 shows two sets of inflation data. The graph on the left is the National Producer Price Indexes for Cement, Ready Mix Concrete, Asphalt Paving, the Producer Price Index for all Commodities; and the Consumer Price Index since 1971 (BLS, 2012). Though not equal, the inflation for the PPI, CPI, Cement and Ready Mix Concrete are generally increasing at the same rate (4.3% to 4.6%), while asphalt has been increasing at a much faster rate of 6.9%.



Note: The original data presented to NCDOT was through March 2010. This updated data is through January 2012.

Figure 2: Price Indexes for Pavement Materials
(CAGR = Compound Annual Growth Rate)

While the graph on the left is based on national data, the same trend holds true for state data. The right graph shows the NCDOT Asphalt Binder Index (NCDOT, 2012); a cement index developed from the USGS data for cement shipments into NC (USGS, 2011); and the BLS data for cement, paving asphalt and liquid asphalt since January 2000 (note that the BLS liquid asphalt data starts June 1985, which is why it was not included in the left graph). As can be seen, the cement data follows the BLS data reasonably well, showing that the national BLS data provides reasonable results. The NC Asphalt Binder Index reveals much higher inflation and greater variability than the BLS paving asphalt index, but matches the BLS liquid asphalt reasonably well. The reason that paving asphalt is lower is because it is combination of liquid asphalt and aggregate, and aggregate's lower inflation rate pulls down the paving asphalt's inflation.

As an agencies future expenditures are highly impacted by differing inflation rates, it is important to identify and incorporate measurable economic variables that reflect the actual inflation rate of each product. Therefore, in order to get a more accurate estimate of future expenditures and each pavement's Net Present Value (NPV), the concrete industry recommended that NCDOT/NCTA follow the LCCA procedures outlined in the Department of Army's publication "*Economic Analysis: Description and Methods*" (Army, 1992) and the Department of Commerce's publication "*Life Cycle Costing Manual for the Federal Energy Management Program*" (NIST, 1996). These publications deal with the inflation rates that differ from the general inflation rate in one of two ways:

1. Estimate future costs (termed current dollars in these publications) to the year of activity by inflating today's costs using the appropriate rate of inflation and then discount back using "nominal" discount rates.
2. Escalate the today's constant dollar by the difference of the general inflation rate and the commodities inflation rate to the year of activity and then discount back using "real" discount rates.

While both procedures can produce the same results, economists prefer procedure 2 because it allows the analyst to take into account the difference in each commodity's specific inflation rate with the general rate of inflation, without having to estimate the actual agency return on investment and inflation rates for labor, equipment, and all the other commodities such as steel, wood, aggregate, fuel, etc. That is, one of the advantages of using "real rates" is that it is not the absolute values that matters, but it is the difference that matters and escalation allows one to account for that difference.

For guidance, the following paragraph from Section 3-6 (e) of Department of Army publication "*Economic Analysis: Description and Methods*," was provided as it succinctly describes the process for taking into account inflation rates that grow faster than the general inflation rate.

Section 3-6(e). When OMB A-94 guidance is followed, and some costs are increasing faster than the general rate of inflation, the value of those costs must be inflated before discounting. Suppose one of the costs is maintenance of a complex electronics station and the cost of labor is increasing 3 percent per year faster than the overall inflation rate. The cost at the beginning of the second year would be the cost at the start of the first year increased by 3 percent, the cost in the third year would be the cost in the second year

increased by 3 percent (cost at the end of third year = first-year cost x 1.03 x 1.03 x 1.03), and so on. Once all inflated values are computed for this cost, they are discounted along with the other costs in the Economic Analysis.

In providing this recommendation, it was recognized that while no state takes inflation rates into account, it was pointed out that such a recommendation is in line with the FHWA recommendations in their Life-Cycle Cost Analysis Primer (FHWA, 2003), which states:

“In a few cases, the analyst may believe that a resource’s cost has grown or will grow much more rapidly than the rate of inflation. For instance, right-of-way costs may soar due to real estate speculation in anticipation of a new road. In such cases, the analyst should work with experts to determine how much the real price of the resource will change over time and include this adjusted price in the economic analysis.” (p 10-11)

Since the time this information was provided to NCDOT/NCTA, other publications have been found or developed that address this issue in much greater detail. The first is ASTM standard E 917 “Standard Practice for Measuring Life-Cycle Costs of Buildings and Building Systems” (ASTM International, 2005), which recommends approaching the issue of inflation rates that differ from the general rate of inflation in the same manner as the above publications.

The second is a paper entitled *The Effects of Inflation and Its Volatility on the Choice of Construction Alternatives* (Lindsey, Schmalensee, & Sacher, 2011) that investigated inflation and its volatility on the choice for construction materials. This study found that concrete and asphalt had very different inflation rates and that ignoring that experience greatly underestimates future cost expenditures. Specifically, it found that concrete’s real price change declined on average 0.17% real terms while asphalt has risen 1.25% per year on average. In addition, it found that concrete’s real price volatility, at 2.9%, was substantially less than that of asphalt at 6.3%. This study then used the past distribution of inflation rates to determine material-specific statistical distributions of “mean real price” and found that over a 50 year period, the mean real price of concrete decreases by 20%, while the mean real price of asphalt increases by 95%. (Lindsey, Schmalensee, & Sacher, 2011)

The final paper titled *Accounting for Material Specific Inflation Rates in Life Cycle Cost Analysis for Pavement Type Selection* confirmed similar trends as the Lindsay study and expanded on the results; addressed several concerns for not accounting for inflation in a LCCA; and finally presented how to perform a LCCA using escalation rates. (Mack, 2012)

Analysis Period – The current NCDOT LCCA process uses a 30 year analysis period. The problem with the 30 year analysis period is that it is the same length as the design period and it did not take into account any continued service after 30 years. As a result, the full economic benefit of the investment is not captured. The general recommendation is the analysis period should be long enough to capture the full life of each pavement, which typically is considered to be the pavement design life plus at least 1 full rehabilitation cycle of each alternative. For example, the current FHWA publication on LCCA (FHWA, 1998) states:

“The LCCA analysis period should be sufficiently long to reflect long-term cost differences associated with reasonable design strategies. The analysis period should generally always be longer than the pavement design period, except in the case of extremely long-lived pavements. As a rule of thumb, the analysis period should be long enough to incorporate at least one rehabilitation activity.”

Along similar lines, in the report *Alternate Pavement Type Selection: Literature Search and Data Collection* developed for NCTA (The Transtec Group, 2010), The Transtec Group stated that a common analysis period is two times the initial design life. Though not detailed in that report, a potential reasoning behind the longer requirement was that The Transtec Group recognized that pavements can be rehabilitated two, three or more times. The inherent assumption of only using 1 rehabilitation cycle is that at the end of the rehabilitation the pavement will be removed and replaced. This is rarely, if ever, done. Consequently, an analysis period of two times the design life more accurately reflects the pavement’s service life. The Transtec Group also pointed out that the longer requirement is typically long enough so that activities beyond this point have minimal impact on the NPV due to the discounting, and any longer analysis periods would have little impact.

Finally, the industry argued that from an economics perspective, a primary requirement was that the analysis period be at least as long as the maturity of the bond used to purchase the asset in order to ensure a positive return on the investment. The concept here is that one does not want to borrow money and then have to repay for the asset over a longer period than for which it lasts. For the NCTA, 40-year bonds were going to be used to pay for the asset and it was argued that a 30-year analysis did not account the final 10 years of additional bond payments.

Price Adjustment Clauses (Indexing) – Indexing of material prices are used to limit a contractors’ exposure to raw material price fluctuations and is considered especially beneficial for contracts that extend over several years. Indexing of asphalt price materials was started in the 1970’s to address price volatility of oil based products such as fuel and asphalt. Conceptually, indexing was implemented to reduce the impact of price escalation premiums contractors would place on their bids to protect themselves from raw material price fluctuations. It was assumed that if an agency permitted indexing, the contractor would eliminate the premium and their bids would come in lower.

The industry argued that “indexing” does not eliminate price fluctuation risk; rather, it transfers risks from the contractor to the owner agency. That is, the price fluctuation risk remains but it is now being carried by the owner. The industry also argued that when one group is given an index and another is not; the net result is the group that is indexed is given a bidding advantage that is artificially subsidized by the owner. This interferes with the market process and creates an unfair advantage for the select group. The result is that the owner perceives cost savings because of lower bids; but in reality ends up paying more than the bid price.

Figure 3 shows the historical trends for Asphalt Binder Prices (solid dark line), the bi-monthly percent change (dark column)^d, and yearly percent change (light column) in North Carolina from January 2000 through May 2010 (NCDOT, 2012).

^d Bi-monthly change was chosen because in the “North Carolina Department of Transportation Price Adjustment Procedures For Asphalt Binder For Plant Mix” – August 2006, the base asphalt price index is set at the monthly Price Index in effect two months prior to the month in which the contract is let.

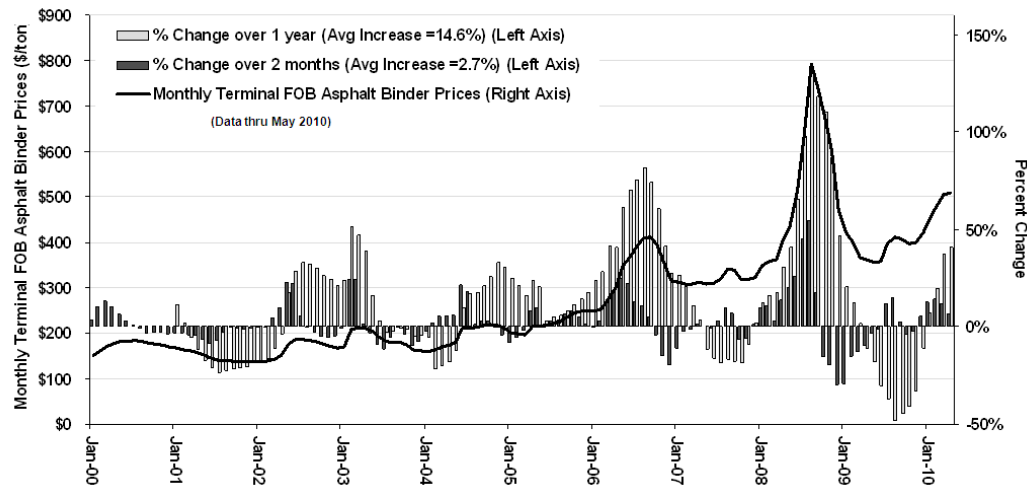


Figure 3: NCDOT Monthly Terminal FOB Asphalt Binder Prices and Percent Change since Jan 2000

Overall, since 2000 the Asphalt binder price has increased by 234%. Also note that while NCDOT has benefited from both “up” and “down” fluctuations, the majority of the bi-monthly and yearly changes are in the “up” direction and the percentage change with the “ups” is greater than the percentage change with the “downs.” Overall, the average bi-monthly change is a 2.7% increase and the average yearly change is a 14.8% increase.

As an indication of the effect indexing can have on the cost paid by the agency, Figure 4 was developed to show the potential cost impact for the Monroe Bypass project, which is described further below. On the right side of this graph is the average monthly bid price for asphalt binder since January 2000, adjusted to account for the index using the procedures described in the “*North Carolina Department of Transportation Price Adjustment Procedures For Asphalt Binder For Plant Mix*” (NCDOT, 2006) and assuming all paving occurred between 1 and 15 months after the bid. The average monthly bid price for asphalt binder is the light grey column, the line shows the range of Adjusted Bid Price over the 15 month period, and the circle shows the average Adjusted Bid Price over the 15 month period. Overall, the average Adjusted Bid Price increased by 10.7% over the actual bid price for asphalt binder. The left side shows the impact that this adjustment would have on the overall initial cost difference between pavement types. In this example, indexing biased the results by 2.5% and because most states do not adjust for this increase in their historical bid prices, these increases are left out of the LCCA.

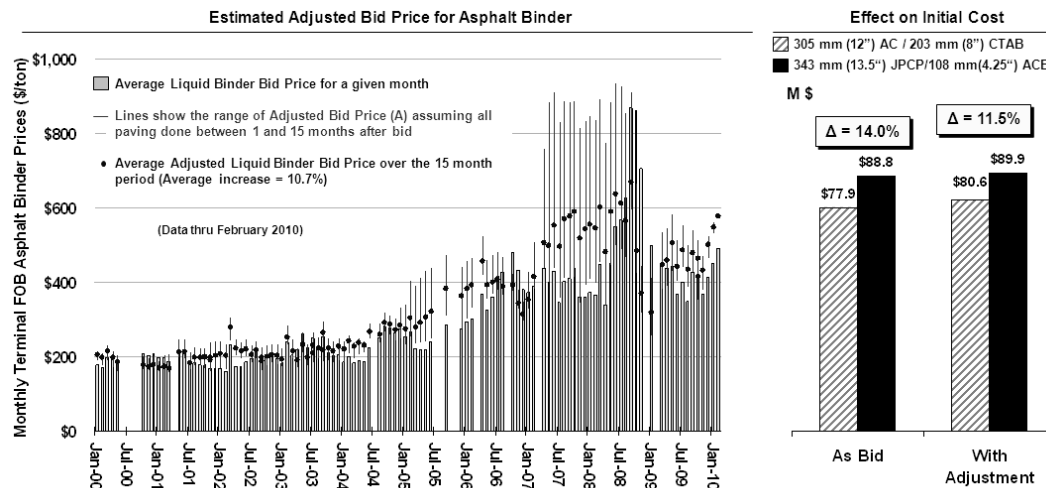


Figure 4: Effect of Asphalt Indexing on Asphalt Binder Price assuming all Paving done between 1 and 15 months after Bid

Based on this, the concrete industry argued that NCTA/NCDOT carries substantial material price cost risk, and the prices that NCTA/NCDOT could be paying are much higher than what is in the bid and used for comparison (i.e. because these costs are not reflected in the bid, they are not in the LCCA). As the Alternate Bid Process is designed to account for the actual cost difference between asphalt and concrete pavements, the concrete industry stated that the costs analysis must account for the most likely cost for all materials and recommend either:

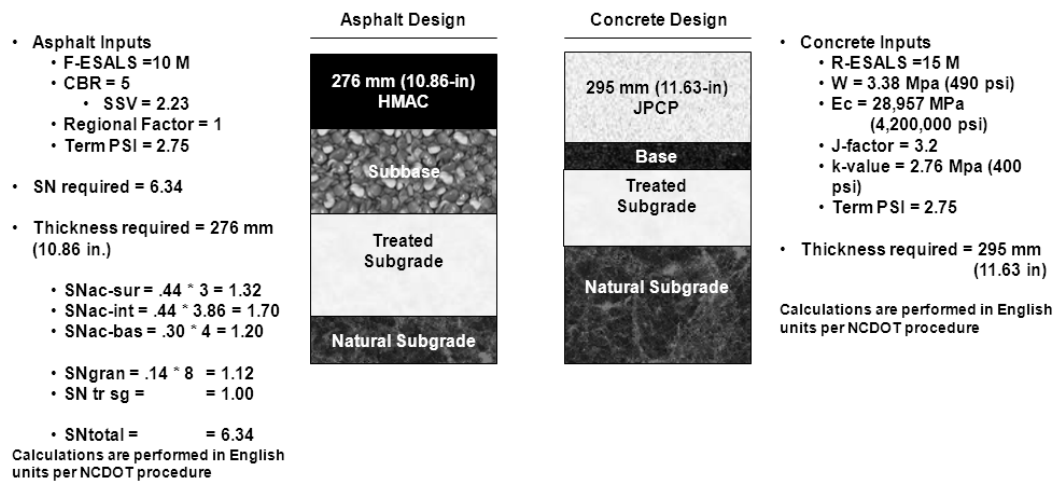
- Remove the asphalt index for all APB projects
- Adjust the asphalt pavement price based on historical 10-year trend for indexing adjustments prior to comparing initial costs and calculating Life Cycle Costs

The industry also pointed out while they understood that the asphalt's price inflation and volatility are the reasons that "price adjustment clauses" were introduced; the use of a "price adjustment clause" to compensate for the volatility of liquid asphalt, while at the same time using a "real" discount rate to account for future costs was inconsistent and contradictory.

Material Quantity Specifications– There are two specific differences in how concrete and asphalt pavements are bid and paid for that impact the bid results and how they are compared. The first is the NCDOT/NCTA specifications that address thickness. For concrete pavements, the current NCDOT/NCTA specifications require that thickness be checked for each lot; and if thickness is low, there is a substantial penalty. To avoid this penalty, concrete paving contractors place approximately an extra 12.5 mm (0.5-in) of concrete. Conversely, asphalt pavements are placed in "*reasonably close conformity with the lines, grades, thickness, and typical sections shown on the plans*" and do not have depth checks or penalties for thin sections. (NCDOT, 2006).

This difference also results in the base / subgrade grades, cross slopes and width requirements becoming more stringent for concrete pavements requiring the use of an auto grade for the base and making the concrete more expensive. While the owner agency benefits from increased concrete thickness (the additional concrete depth placed to avoid penalty adds pavement life), and the increased attention paid to

the base and subgrade construction; a thickness deficiency on an asphalt pavement will have a similar reduction in “load carrying capacity” and should be treated similarly.



	<u>Asphalt</u>		<u>Concrete</u>	
<u>Thickness Reduction</u>	<u>Allowable ESALS</u>	<u>% reduction</u>	<u>Allowable ESALS</u>	<u>% reduction</u>
6.35 mm (0.25-in.)	8,966,576	10.3%	12,920,613	13.9%
12.7 mm (0.5-in.)	7,961,812	20.4%	11,095,734	26.0%
25.4 mm (1.0-in.)	6,256,657	37.4%	8,105,129	46.0%
38.1 mm (1.5-in.)	4,895,059	51.0%	5,841,602	61.1%

Figure 5: Effect of Thickness on Load Carrying Capacity for NCDOT Example Pavement Designs

As an example, Figure 5 shows the impact of thickness deficiencies for equivalent asphalt and concrete pavements designed to carry 10 M Flexible ESALs and 15 M Rigid ESALs respectively^e based on the NCDOT design procedure (NCDOT, 2007). As can be seen, both pavements have a large reduction in load carrying capacity as thickness decreases and that the reduction is in the same relative magnitude. For this reason, the concrete industry argued that both pavements need be held to the same thickness requirements.

One item to point out is that NCDOT typically rounds the specified thickness on concrete projects up to the nearest 12.7 mm (0.5-in.) to avoid odd thickness requirements (e.g. the 295 mm (11.63-in.) requirement here would be rounded to 305 mm (12.0-in.). This rounding increases the load carrying capacity at approximately the same percentage as the decrease and as such the actual load carrying capacity of the pavement is much higher than the design. These means that there are times when a thickness deduction penalty could be assessed to a pavement that is still thicker than the required design thickness (eg thickness increased to 305 mm (12.0-in.) and then the contractor gets penalized for a 298 mm (11.75-in.) lot).

The second material quantity issue deals with the differences in pay for concrete and asphalt pavements (Bid / Pay Items). The Current NCDOT/NCTA policy is to pay for concrete by the “Square Yard” while asphalt is paid for by all “tons delivered and placed.” This issue is created because the placement

^e Rigid and Flexible ESALS are not the same. For equivalent designs, Flexible ESALS ~ 2/3 Rigid ESALS. Design thickness where kept at exact values (eg 10.9 inches of HMAC and 11.63 inches of JPCP) so that thickness impact can be evaluated.

requirements for asphalt and concrete are different. Asphalt is “*reasonably close conformity with the lines, grades, thickness, and typical sections shown on the plans*” while concrete is “*meeting the lines, grades, and cross sections required by the plans.*” (NCDOT, 2006)

The impact is that concrete paving contractors receive no pay adjustments for excess material and must add 2 to 4% to their volumes to cover thickness, width, and placement requirements. However, because asphalt is paid for all “tons delivered and placed,” the contractors do not need to account for this contingency in their bid because the material risk quantities are covered by the agency. The net result is payment system that covers material quantity risks for asphalt (but not for concrete) combined with a bidding process that favors asphalt because the contingency excess material volumes are not included in the bid (note this is not an issue on fixed contract projects).

Figure 6 shows how these material quantity specifications issues affect a bid and the perception of the price differential between pavement types. Using same designs shown in Figure 5 (but rounded to common paving thicknesses and looking at top layer materials only), Figure 6 shows how the thickness requirements and payment items for a 1.61 km (1 mile) of Interstate, 2 lanes, 2 directions plus shoulders (3.05 m (10-ft) outside and 1.22 m (4-ft) inside shoulder). As can be seen, the concrete materials are higher in initial costs by \$41,000 (2.6% higher). However this includes a 7.17% additional volume of concrete materials that concrete contractor has added to his bid to cover the placement requirements and additional thickness to avoid penalty. Once the costs of any additional asphalt material that may be needed are included, the material costs difference quickly closes and becomes more favorable for concrete.

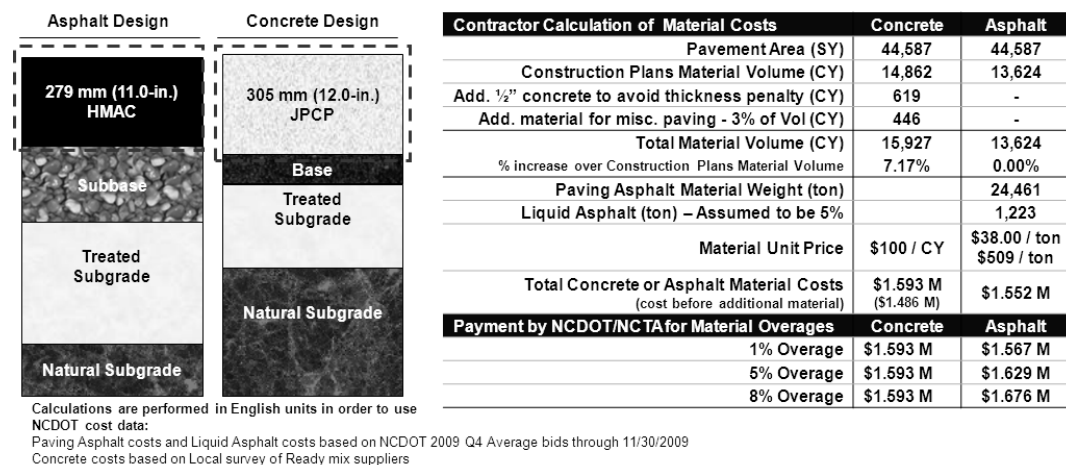


Figure 6: Effect of Pay Item Specifications on NCDOT Example Pavement Costs

Based on this information, the concrete paving industry recommended that both pavement types need to be held to the same thickness standards and that concrete materials be paid for all “Cubic Yards (CY) delivered” and placement for both materials be paid for separately on a square yard basis. Similar methods have been used by other states. For example, Illinois and Missouri pay by the “Square Yards” for all pavements and California and Oklahoma pay for materials by the cubic yards for concrete and tons for asphalt.

Impact of Changes on Initial and Life Cycle Cost:

As a demonstration of the impact these changes could have on the initial and life cycle cost of a pavement, an analysis was conducted looking at the cost impact of each of these items on potential preliminary pavement designs for the Monroe Bypass project (near Charlotte NC) that was being developed as this process was underway. This project consisted of approximately 71.7 km (19.7 miles) of 6-lanes plus shoulders interstate type paving.

The concrete and asphalt sections and anticipated 30-year rehabilitation strategies per NCDOT procedures were:

- 343 mm (13.5-in.) of jointed concrete pavement (JPCP) on 76 mm (3.0-in.) of Permeable Asphalt Treated Base on 32 mm (1.25-in.) of Dense AC Base over 178 mm (7-in.) of treated subgrade.
Rehabilitation – saw and seal joints at years 10 and 20
- 305 (12.0-in.) of SuperPave AC (Surface, intermediate and base mixes) over 203 mm (8.0-in.) Cement Treated Aggregate Base (CTAB) over 178 mm (7-in.) of treated subgrade.
Rehabilitation – 76 mm (3-in.) Mill / 76 mm (3-in.) AC Overlay in years 10 and 20

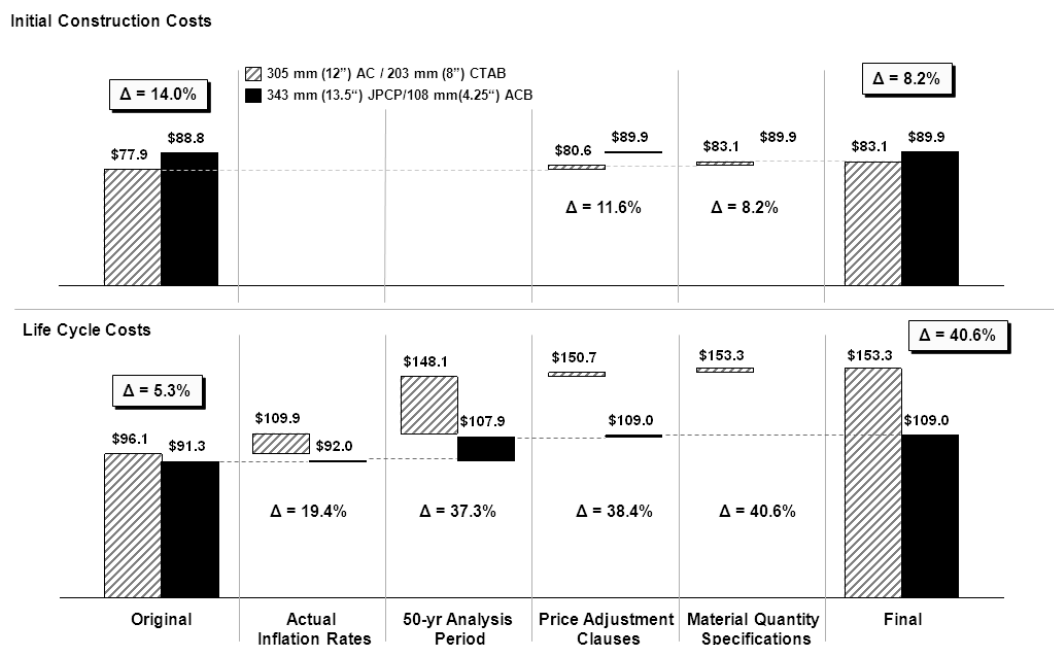


Figure 7: Cumulative Impact due to Changes on Initial and Life Cycle Cost

Using these designs and typical unit costs the time of the evaluation, the initial and life cycle costs were developed using the NCDOT LCCA procedures. The asphalt pavement's initial cost was estimated to be \$77.9 M and the concrete pavement's initial cost was estimated at \$88.8 M, or 14.0% higher. While the life cycle cost analysis had the concrete 5.3% lower than the asphalt (\$91.3 M for concrete vs. \$96.1 M for asphalt), based upon this data, it is difficult to argue that the agency should forgo an immediate savings of 14.0% today for a 5.3% savings over 30 years.

However, once the initial and life cycle costs were developed, the impacts of inflation rates, analysis period, price adjustment clauses (indexing) and differences in material quantity specifications on initial and life cycle costs were estimated and are shown in Figure 7. The specific items changed consisted of:

- **Actual Inflation rates:** Specific Commodity inflation rates were taken into account using the escalation procedure outlined by the Department of Army and Department of Commerce's Federal Energy Management Program (Escalation rate = commodity inflation – CPI: concrete escalation = 0.3% and asphalt escalation = 2.5%). Note this only affects the LCCA results.
- **Analysis Period:** As the concrete design was 30-year design, the analysis period was increased to 50 years in order to be long enough to capture the full life of each pavement. Added to this was a set of estimated additional rehabilitation activities to get both pavements through the 50 year period. For concrete patching and grinding were added at years 30 and 40 and for asphalt, the same standard mill and fill AC overlays used at year 10 and 20 were again used in years 30 and 40. This only affects the LCCA results.
- **Price Adjustment Clauses:** The asphalt binder prices for both designs were adjusted by the historical 10-year trend for indexing as shown in Figure 4. This affects both the initial costs and the LCCA results.
- **Material Quantity Specifications:** The additional quantity of concrete materials needed to account for differences in thickness requirements and pay items was accounted for as described in Figure 6. This affects both the initial costs and the LCCA results.

As can be seen, as each item is adjusted, the initial costs difference decreases and the life cycle cost difference increases so that at the end, the difference in initial costs had drop to 8.2% and the difference in life cycle costs had increased to 40.6%. While this analysis is a theoretical exercise, the comprehensive, objective impact is profound and can be equated to lost opportunity cost.

Summary:

Alternate Bid Process for pavement selection is a proven way is to increase competition and bring additional contractors to the bidding table. However, in order to realize the full impact, the APB process must treat both the asphalt and concrete paving industries equally and be based on the following engineering and economic principles that are transparent, equitable and representative of the true costs of different pavement alternates over their life.

1. **Equivalent designs** – Designs need to be based on the same traffic and subgrade conditions over the same period of time (eg. 30 years)
2. **Rehabilitation Schedules** – Specific rehabilitation schedules need to be match to each design with the expected performance.
3. **Discount Rates** – The actual inflation rate of each product needs to be account for by using material specific escalation rates for each product.
4. **Analysis Period** – Use an analysis period that accounts for the full expected life of the alternatives, including rehabilitation activities.
5. **Indexing of Material Prices** – Either remove the asphalt index for all APB projects or adjust the asphalt pavement bid price based on the historical 10-

year trend for indexing adjustments prior to comparing initial costs and calculating Life Cycle Costs.

6. **Material Quantity Specification** – Hold both pavement types to the same thickness standards and grade-control requirements. On concrete pavement projects, pay for the concrete materials on “Cubic Yards (CY) delivered” and pay for placement of both materials on a square yard basis.

References

- Ahlvers, D. (2009). MODOT Alternate Pavement Approach,. *Presentation to the 2009 AASHTO Subcommittee on Construction*,. Chicago, IL.
- Army. (1992, August 10). *Economic Analysis: Description and Methods*, Army Pamphlet 415-3. Retrieved from http://www.army.mil/usapa/epubs/xml_pubs/p415_3/head.xml
- ASTM International. (2005, November). Standard Practice for Measuring Life-Cycle Costs of Buildings and Building Systems. *ASTM E 917 – 05*. West Conshohocken, PA.
- BLS. (2012). Producer Price Indexes for Paving Materials. Washington, DC: U.S. Department of Labor, Bureau of Labor Statistics. Retrieved February 23, 2012, from <http://www.bls.gov/ppi/home.htm> (thru April 2011)
- Corely-Lay, J., & Morrison, C. S. (2002). 33-year Performance Study of Jointed Concrete Test Sections in North Carolina. *TRB Annual Meeting*.
- FHWA. (1998). *Life-Cycle Cost Analysis in Pavement Design, Pavement Division Interim Technical Bulletin*, (Vols. FHWA Publication No. FHWA-SA-98-079). Washington, DC: U.S. Department of Transportation, Federal Highway Administration,.
- FHWA. (2003, August). Economic Analysis Primer. (FHWA Publication No. FHWA-IF-03-032). U.S. Department of Transportation, Federal Highway Administration .
- FHWA. (2008, November 13). *Clarification of FHWA Policy for Bidding Alternate Pavement Type on the National Highway System*, U.S. Department of Transportation, Federal Highway Administration. Retrieved May 28, 2010, from <http://www.fhwa.dot.gov/pavement/081113.cfm>
- FHWA. (2010, January). Long Term Pavement Performance, Standard Data Release 24. Wahsington, DC.
- Lindsey, L., Schmalensee, R., & Sacher, A. (2011, July). *L. Lindsey, R. Schmalensee and A. Sacher, The Effects of Inflation and Its Volatility on the Choice of Construction Alternatives*. Boston: Massachusetts Institute of Technology, Concrete Sustaianbility Hub.
- Mack, J. (2012). Accounting for Material Specific Inflation Rates in Life Cycle Cost Analysis. *91st Transportation Research Board Annual Meeing*, (pp. Paper 12-2686, accepted for Publication in Transporation Reserarch Record). Washington, DC.
- NCDOT. (2006). North Carolina Deparment of Transporation 2006 Construction Manual. Raleigh, NC: North Carolina Deparment of Transporation.
- NCDOT. (2006). *Price Adjustment Procedures for Asphalt Binder Plant Mix*. Retrieved May 18, 2010, from http://www.ncdot.org/doh/operations/dp_chief_eng/constructionunit/paveconst/Asphalt_Mgmt/acprices/

- NCDOT. (2007). NC Department of Transportation 2000 Interim Pavement Design Procedure (with November 2007 modifications). Raleigh, NC: Pavement Management Unit.
- NCDOT. (2012). *NCDOT Monthly Terminal Asphalt Binder FOB Prices*. (NC Department of Transportation, Producer) Retrieved February 23, 2012, from http://www.ncdot.org/doh/operations/dp_chief_eng/constructionunit/paveconst/Asphalt_Mgmt/acprices/
- NIST. (1996). *Life-Cycle Costing Manual for the Federal Energy Management Program, NIST Handbook 135*,. Retrieved from http://www.nist.gov/manuscript-publication-search.cfm?pub_id=907459
- The Transtec Group. (2010, March 4). Alternate Pavement Type Selection: Literature Search and Data Collection. *Reported for North Carolina Turnpike Authority*.
- USGS. (2011). Cement Prices. *Minerals Yearbook*. US Geological Survey. Retrieved November 15, 2011, from <http://minerals.usgs.gov/minerals/pubs/commodity/cement/>