LifeCycle Cost Comparison

GRANITE AND PRECAST CURBING

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ECONOMIC COMPARISON

The physical comparison leaves no doubt that granite is the best curbing material available today. Its initial cost is higher than that of precast PCC curb but it has lower maintenance costs. Granite curb also lasts longer than precast PCC and offers other advantages because of its durability. The economical comparison presented in this report will consider this tradeoff between costs and durability. This report is an update and enhancement of a life cycle cost analysis on granite and concrete curbing performed in 1991 by Dr. John Collura and several other individuals

Life-Cycle Cost

Life-cycle cost analysis will be used to evaluate the economics of granite and precast PCC curbing. Life-cycle cost analysis is a procedure in which initial cost, maintenance requirements, and life span are jointly considered in the evaluation of alternative project designs (1, 2, 3). The present worth of the initial cost *and* future maintenance and replacement costs are considered rather than just the initial costs. The simplest way to think about present worth is to consider a trust fund in which the initial endowment would be just sufficient to maintain the project during its planned life. The logic of considering all costs, present and future, rather than just initial costs should be readily apparent. Life-cycle cost analysis is a valid means of accomplishing this task. In fact, the U.S. DOT agencies including FHWA requires all states to use life-cycle cost analysis as part of federally mandated pavement management programs (4).

Present worth (PW) is by definition dependent on the interest rate considered. This interest rate is also known as the discount rate, the rate at which future costs are discounted to current dollars. Discount rates are expressions for our time preferences. A discount rate of 7% implies an indifference between $1.00 today and $1.07 next year. Another way of looking at this time preference is to consider the common dilemma of choosing between two grades of a product, which have different life expectancies. Many people will pay a higher price for a product that lasts longer. The higher price is obviously paid now to avoid a future replacement expense. Implicit in this decision is a discount rate. Today's premium in price is weighted against a discounted future expense. If experiments were conducted, a range of these implied discount rates would surface. Public investment decisions, however, should be evaluated consistently. For this reason the time preference discount rate is made explicit.

High discount rates weight an expense which occurs in the future much less than the same expense occurring today. A 0% discount rate weights a future expense the same as a present expense. High discount rates favor the low initial cost, but high maintenance alternative because future expenses are weighted less. Low discount rates, on the other hand, favor the initially more expensive, but longer lasting, low maintenance alternative because future replacement expenses are given greater consideration.

This report will use a 7% discount rate consistent with guidelines provided by the U.S. Office of Management of Budget (OMB) and presented in FHWA Asset Management website (2). It should be noted that many individuals and organizations argue that a lower discount rate should be used. For example, the Portland Cement Association, for example, has historically concluded that real discount rates virtually always fall between 0% and 4.5% with typical values being between 1% and 2.5% (5). Moreover, some Federal agencies in their life cycle analyses currently use lower rates, based on inflation adjusted Federal borrowing costs. These lower rates, depending on the length of the life cycle, are on the order of 2.5 to 3.2 % (2).

Initial Costs

Determining initial costs is a difficult job. Material and labor expenses are usually combined. Lower material costs than those used in this research can be obtained but they are typically for large jobs or exclude overhead for the contractor. Contractors have expenses and these expenses must be included in their prices. It is a mistake to just consider material costs. The city or town is not purchasing a pile of curbing material. They are purchasing delivered, installed, functional curb.

A survey including information from local and state bid records as well as private contractors was conducted to determine the material and labor costs of installing granite and precast PCC curbing. Granite curb material and installation cost (VA 4) ranged from a low of $20 linear foot to a high of $33 per linear foot depending on the State location, type of roadway, size of job, and other factors. The average material and installation cost of precast PCC curb ranged from an average of $21 to $23.00 per linear foot. Representative values used in the analysis include $22 for PCC and $26.5 for granite

VA - 4 is a granite curb size specification. This standard designates top and bottom widths as well as tolerances. It is 6" wide at the top. VA - 4 was picked because it is the most commonly used type of granite curb and has dimensions similar to typical Precast PCC curb. It should be noted that because of granite's strength, thinner (and possibly less expensive) granite curb can be used in many situations. The use of thinner Precast PCC curb, however, is not practical.

Prices of both granite and Precast PCC curb were found to vary with respect to volume. Very large highway jobs cost less per linear foot than small repair jobs. Thus, there are economies of scale in curb construction.

Recurring Costs

There are three recurring costs which can be examined with some degree of certainty. They are preventive maintenance, replacement, and disposal of worn out curb. Other recurring costs, such as curb damage, are random and prove difficult to quantify. Costs of this nature will be addressed later.

Properly installed granite curbing requires no maintenance. Concrete curbing, after proper installation, requires periodic sealing to extend its life. However, this maintenance is seldom, if ever, performed. Consequently, cost figures are unavailable. It is realistic to assume no maintenance will be performed on concrete curbing. This lack of maintenance will be reflected in shorter life expectancy than attainable with ideal care.

At the end of its life, the concrete curbing will have to be removed, discarded, and replaced. Recycling of Precast PCC curb is not economically feasible at this time because of the labor required to remove reinforced rod. The cost to dispose of deteriorated curb has risen dramatically in recent years. In 1988 the Massachusetts DPW paid, on average $1.96 a linear foot to remove and discard curb (6). Current prices to remove and discard are approximately $4.86 a linear foot (7). Disposal prices will continue to rise faster than other prices as remaining landfill space becomes more valuable.

Life Expectancy

Granite has an "indefinite" life expectancy. Granite curb can be removed and reset when curb reveal is diminished due to road resurfacing. Granite's structural properties also allow it to be left in-place during road milling operations, a popular highway maintenance treatment presently being employed in New England. Road milling is an especially attractive alternative to reconstruction in urban areas. In these locations road height is limited by the height of building sills and bridges. At some point additional overlays become impossible. When there is a good base present, road milling is less expensive than tearing up the old pavement and reconstructing the roadway. It is also quicker and permits continued use of the road during resurfacing. This factor is especially important for major arterials and collectors.

Concrete curbing has no salvage value. It is subject to breakage during removal operations which are very common today given that many state and local highway agencies are implementing large scale pavement management and maintenance programs. It is typically removed, discarded and replaced when its reveal is lost. By this time, it has usually deteriorated to a point where it cannot be reinstalled even if some life remains and if it could be removed intact economically. Concrete is prone to damage during milling operations because of its low strength and abrasion resistance. Extreme care must be taken to avoid damaging it. This extra care means greater milling expenses.

In actual application, a Precast PCC curb's useful life is often dictated not by its own life but rather by the life span of the road. It makes sense to replace deteriorating Precast PCC curb while the road is being rehabilitated. If Precast PCC does not last as long as the road, curb replacement requires tearing up part of the road. This necessitates patching, which in practice, seldom yields quality comparable to original construction. In fact, patching often leads to premature deterioration of the roadway.

Two life expectancies of Precast PCC will be examined, ten and twenty years. The twenty-year life expectancy is based on a study by the Rhode Island Department of Transportation (8). This study examined twelve to fourteen year old samples of Precast PCC curb and concluded that they should last six to eight more years. This would result in an effective service life of twenty years. It is not known whether this curbing received any preventative maintenance. The twenty-year life span is consistent with the design life of many urban roads. Precast PCC curb is normally replaced in conjunction with reconstruction.

The ten year life span was included to show what the life cycle cost would be if the Precast PCC curb did not last twenty years. Lab testing indicates this possibility should not be ruled out, especially if Precast PCC curb is being considered for installation in a region, which experiences harsher winters than Rhode Island.

Analysis

This analysis will consider typical curbing expenses over the life of a newly (re)constructed road. A forty-year planning horizon will be used. Curbing expenses will be examined on a linear foot basis.

Assuming Precast PCC curb lasts twenty years and a 7% discount rate, expenses will consist of $22 immediately (year 0) and $26.86 ($4.86 to remove and discard + $22. to replace) in year twenty. A total of $46.86 will be spent over twenty years. Curb replacement at the end of year forty is not considered. The net present value (NPV) of these expenses is $28.92. The granite curbing can be left in place during projected road milling and rehabilitation in year 20 or so there will be no other expenses during the forty year planning horizon. The NPV of granite is therefore $26.50. It is this NPV of present and future expenses that should be considered by public officials- not initial cost. When the inevitable future expense of replacing deteriorated precast PCC curb is considered granite curb is clearly the less expensive curb material. If precast curb lasted only 10 years, its NPV would be $46.20 compared to granite's $26.50. Below is a sample calculation of New Present Value (NPV) using a twenty-year life expectancy of Precast PCC curb, 7% discount rate and a forty-year planning horizon. All dollar values are per linear foot.

Precast PCC

Year	Expense	x	PWF	=	PW
0	$22.00		1.0		$22.00
20	$26.86		0.258	=	6.92
					$28.92 NPV

Granite

Year	Expense	x	PWF	=	PW
0	$26.50		1.0		$26.50 NPV

Notes:

PWF = Present Worth Factor = $\frac{1}{(1+r)^t}$

PW = PWF x expense,
where r = discount rate
t= time period (year)

When this analysis is conducted at a lower discount rate, such as 5%, the NPV of Precast PCC and granite would be $32.12 and $26.50, respectively, for the twenty-year life of Precast PCC. The NPV of Precast PCC would be $54.82 if it lasted only 10 years. The 5% discount rate could be considered a "social discount rate". This rate considers future citizens more than the 7% discount rate will. Many economists argue that a public official, entrusted with public welfare, should use the lower rate (9).

When the 2.5% real, inflation adjusted, discount rate advocated by the Portland Cement Association is used the NPV's of Precast PCC and granite are $36.30 and $26.50, respectively, for a twenty year life span of Precast PCC. Precast PCC would cost about 40% more than granite. If Precast PCC lasted only 10 years its NPV would be $72.17, more than two and a half times more expensive than granite! This extremely low discount rate is probably idealistic, however. It neglects the financial realities of budgetary constraints.

It should be stressed again that this analysis neglects some costs, which are extremely hard to quantify. These costs are curb damage, construction delays to road users and aesthetics.

Curb damage is typically inflicted on Precast PCC curb by rollers, snowplows, and heavy trucks. Granite curb, however, has a legendary resistance to this kind of damage.

A very important value, which has been ignored by the economic analysis, is the salvage value of granite. Granite curb was assumed to be worth nothing at the end of the forty-year planning horizon. Granite curb, which was laid at the turn of the century, however, is routinely salvaged and reused. Granite curb laid today will be around for generations. The fact that granite curb is reusable, rather than disposable commodity, will undoubtedly become more important in the future. The days of plentiful, inexpensive, landfill space are over. Recycling is rapidly becoming a necessity. In western Massachusetts 85 cities and towns who joined a regional recycling facility, rather than constructing expensive new landfills, were required to adopt mandatory recycling laws (10). Similar arrangements are being adopted across the country. Environmental concern had become a pressing national issue and a structural switch from disposable to reusable commodities is an integral part of the solution.

In summary, the analysis clearly shows how basing expenditure decisions on initial cost without regard to future expenses can lead to high costs over the long run. Public officials cannot afford to ignore the effects today's investment decisions will have on our children. The infrastructure of N.E. states, like most of the country, has been burdened by a backlog of deferred maintenance (11,12). The situation will not improve if future expenses are ignored during the public works investment decision making process.

CONCLUSION

The physical comparison clearly indicated that granite is a superior curb material in New England where winters, road salt, and plowing are tough on Portland cement concrete. The economic analysis indicated that when the inevitable replacement of Precast PCC is considered, granite curb is less expensive curb material. The only advantage of using Precast PCC curb is its lower initial cost. This advantage is negated, however, by granite's durability, longevity, and reusability.

It should be expressed that many advantages of granite curb did not need to be considered in order to reach this conclusion. The fact that granite curb needs substantially fewer repairs was ignored. The costs of construction delays to motorists where Precast PCC curb is torn out and replaced, and savings when using road milling, were also ignored. Additionally, no effort was made to value the eyesore posed by deteriorating PCC curb. These uncounted costs only serve to reinforce the conclusions of this report. They also indicate that the installation of granite curb is most desirable where these costs will be greatest- along major urban roads.

The conclusions of this report area also strengthened by a continued rise in costs to dispose of deteriorated curb. The disposal crisis is a disturbing, expensive reality, which cannot be ignored. Part of its solution seems to be a general trend toward reusable versus disposable commodities. Granite curb is a reusable commodity.

The salvage value of granite curb was excluded in the economic analysis. It is their decision, which determines whether future generations will be left with continual curb replacement expenses or a stock of durable, reusable curb.

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