COMPARISON OF GRANITE AND PRECAST CONCRETE CURBING
Cost and Technical Issues

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Executive Summary

This study was undertaken to determine the technical and economic feasibility of using granite curbing as an option within the normal practices of highway construction in Rhode Island. Previous studies have been carried out by various entities, including the RIDOT design section. These were reviewed and referenced where appropriate.

For this endeavor, the R&TD Section began with a literature search and surveys of states and vendors in their usage of highway curbing. A trip to the Fletcher Granite Quarries in Chelmsford was also undertaken to get a first hand look at the curbing operation and logistics involved in the supply of curbing. Through an interview with Mr. Robert Fruggiero, retired RIDOT Materials Engineer, we learned details about the inception of zero slump concrete curbing.

As the technical aspects of granite vs. concrete curbing had been studied and reported on previously, we decided just to overview these and focus our effort on the economics of initial and life cycle costs instead. Needed information was difficult to obtain. However, we did get the same from various sources, such as states, vendors, contractors, and RIDOT records. The life cycle costing was done using conventional formulae, but with three different interest rates. This would give the reader a sense of the life cycle cost over a spectrum of interest rates. Assumptions were made based on prevailing rates, current practices, and engineering judgment. The results indicate no significant difference in the life cycle costs of granite vs. concrete curbing. A major reason for this is that granite curbing shapes have been minimized and streamlined which in turn has led to efficacy in material savings, fabrication, transportation, handling, and installation costs.

The study shows that at lower interest rates the granite is slightly more favorable than concrete, whereas at high rates it is just the opposite. This is true for low, medium, and high volumes of bid quantities.

Socio-political factors were not considered in the analysis.

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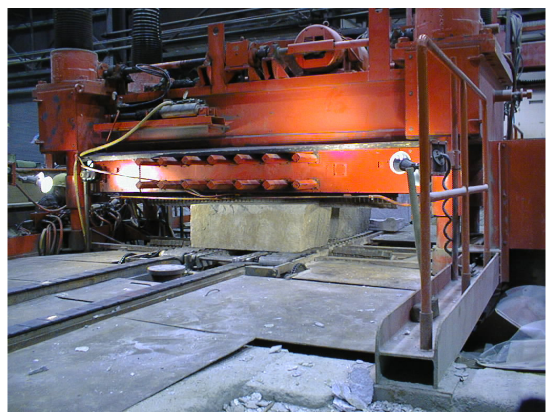
Objective: Comparison of costs and technical benefits of granite curbing versus zero slump precast concrete. The financial projections were based on estimated costs taken from contract bid items from two projects and General Construction List of Average Unit Prices, a range of interest rates and estimated lives for each material.

Background: Approximately twenty-five years ago, RIDOT stopped using granite curbing as a standard, with the exception of bridge projects. The primary motivation was cost, as precast concrete, the replacement, was cheaper to purchase and install. Granite had the advantage of long life and the capability of being reused, but it was very expensive and because of the massive size and irregular shape, very difficult to install. However, trimmed granite is still specified for bridges, due to its superior durability and the critical need for protection of the decks. At the current time, improved processes for quarrying and shaping the granite have both lowered the cost and made it possible to produce more dimensionally controlled pieces. This in turn lowers the installed cost of the granite curbing, to the point where it is nearly competitive with precast concrete. There are granite suppliers within 100 miles, but there has been interest shown from a supplier as far away as Canada. It is therefore believed that it is time to re-examine the use of granite as a standard for curbing.

Granite Quarrying and Shaping



Concrete Casting:

Procedure: The present worth of each system was taken using the installation cost per linear foot. Added to that was the remove and dispose cost for concrete (with the interest calculated over the expected useful life of the curbing) or the remove, stockpile and reset cost of the granite, also per linear foot. This was done over a sixty year time frame and only straight curbing was examined. The technical issues were reviewed by examining available literature and test reports and based on general knowledge of concrete and granite.

Assumptions: The three initial costs for the granite were taken to be: $11, $12 and $14[1] per linear foot and $6 per foot to install. The initial costs for concrete were taken to be: $13.50, $14 and $15[1] per linear foot. The costs are for large (over 5000 feet), medium (between 1000 and 5000 feet) and small (under 1000 feet) installations for each material, respectively. The cost is assumed to change only with inflation. The interest rates used were 3, 6 and 9 percent, to allow a reasonable range for comparison. The remove, stockpile and reset cost of granite was assumed to be $7 per linear foot and the remove and dispose cost for concrete was assumed to be $2 per linear foot. The life of granite curbing is projected to be over one hundred years and the life of concrete is assumed to be twenty years. The projection for this study is over sixty years. A loss of ten percent for breakage for the remove, stockpile and reset operations was allowed for the granite. It is possible that the concrete may still be usable after twenty years (in condition adequate for a remove and reset operation), but that is considered unlikely.[2]

Cost Analysis:

Case I (example):

Granite initial cost (GIC): $17 per linear foot (including installation)
Granite remove and reset cost (GRR): $7 per linear foot
Concrete initial cost (CIC): $13.50 per linear foot
Concrete remove and dispose cost (CRD): $2 per linear foot

Rate of return (i): 3%
Present worth factor over twenty years for given interest rate (PWF20i): 0.5537
Present worth factor over forty years for given interest rate (PWF40i): 0.3066

Granite:

Over sixty years, the cost of the granite will include the initial cost (once), replacement of broken pieces (two times at 10%) and remove and reset (twice, at 20 years and then 40 years hence). Therefore, the present worth cost for granite curbing (PWG) would be:

[$17, Initial cost]+[$0.94, present worth of 10% breakage replacement in 20 years]+[$0.52, present worth of 10% breakage replacement in 40 years]+[$3.87, remove and reset cost in 20 years]+[$2.15, remove and reset cost in 40 years]=***$24.48 per linear foot***

Concrete:

Over sixty years, the cost of the concrete will include the initial cost (three installations, at time zero, 20 years and 40 years), and remove and dispose (twice, at 20 years and then 40 years hence). Therefore, the present worth cost for concrete curbing (PWC) would be:

[$13.50, Initial cost]+[$7.47, present worth of the installation cost in 20 years]+[$4.14, present worth of the installation cost in 40 years]+[$ 1.11, present worth of remove and dispose cost in 20 years]+[$0.61, present worth of remove and dispose cost in 40 years]=***$26.83 per linear foot***

Similar analyses were performed for other rates and initial costs to obtain the costs shown in the table below.

Table 1 - Life Cycle Cost as a Function of Rate of Return and Quantity

	i=3%	i=6%	i=9%	i=3%	i=6%	i=9%	i=3%	i=6%	i=9%
GIC †	17.00			18.00			20.00		
GRRC †	7.00			7.00			7.00		
CIC †	13.50			14.00			15.00		
CRD †	2.00			2.00			2.00		
$PWF20_i$	0.5537	0.3118	0.1784	0.5537	0.3118	0.1784	0.5537	0.3118	0.1784
PWF40i	0.3066	0.0972	0.0318	0.3066	0.0972	0.0318	0.3066	0.0972	0.0318
PWG †	24.48	20.56	18.83	25.57	21.60	19.85	27.74	23.68	21.89
PWC †	26.83	19.84	16.76	27.76	20.54	17.36	29.62	21.95	18.57

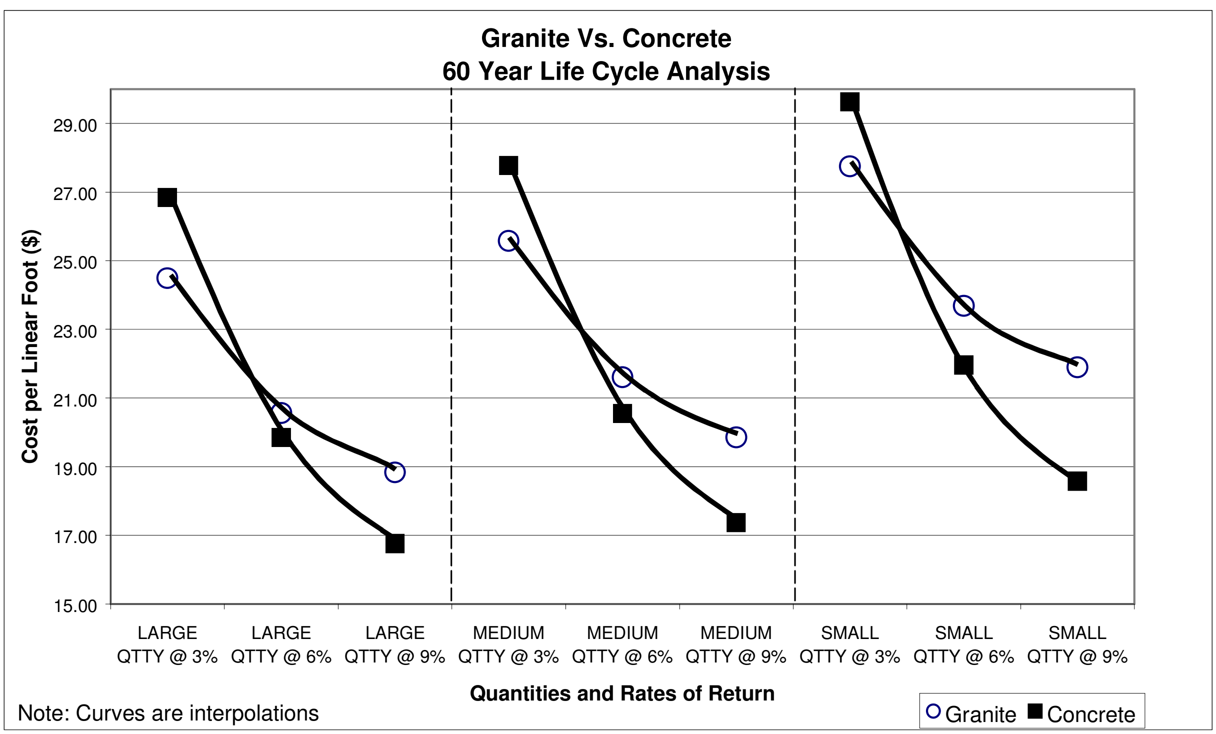
† dollars per linear foot

Material Properties - Technical Analysis:

The durability of the granite in comparison to the concrete is the main issue in terms of performance. It is generally accepted (and testing bears out) that although low w/c concrete is resistant to freeze/thaw deterioration, granite is virtually unaffected. Erosion and wear can be an issue over the long term, but again, the properties of granite in this regard are far superior to that of concrete. Since it is assumed that the granite will be reset after removal and the concrete will be disposed of, breakage of the granite can affect costs. But care in handling the granite will minimize any losses and it is a very strong material, capable of being subjected to a certain degree of rough treatment without fracturing. Placement of the granite is not the consideration that it was, since current means of production produce pieces that have consistent geometric shapes with dimensions that are sufficiently controllable to provide adequate ease in setting. However, since precast concrete curbing is a manufactured product, its tolerances can be determined very precisely, with great repeatability.

Summary:

From the present worth analysis, it can be seen that the granite is less expensive when interest rates are low. Since it is assumed that the precast will be replaced every twenty years, the longer the period of the analysis, the greater life span of the granite will improve its competitiveness. Granite weathers better than concrete, although a good mix will generally show only moderate scaling over a twenty year period and will resist freeze/thaw. Finally, granite is considered aesthetically more



pleasing than concrete, although the value of that is less tangible. Note that it would be necessary to perform another analysis for a case where a significant amount of radius curb is used.

Commentary – Francis Manning:

One consideration that could affect the type of curb is the concept of the permanent roadbed. Alterations in alignment and grade have necessitated, every twenty years or so, rebuilding most entire pavement structures. For several reasons, we are now reconstructing more roads in place. This could make feasible a permanent roadbed, i.e., a strong, permeable, well-drained, subsurface capable of lasting scores of decades. Riding surfaces would still have to be maintained, resurfaced, and replaced at appropriate intervals, but the granular structure below the metaled asphalt or portland cement concrete surface would not have to be touched. It would make sense to consider the curb, embedded in the subbase, part of the permanent roadbed. But only indefinitely durable granite could with assurance be expected to last at least two pavement replacement cycles.

References:

1. Rhode Island Contract Nos. 9730 and 9822 , Proposal Items and General Construction List of Average Unit Prices
2. Mohamed Elkordy and Faizal S. Enu, Granite and Concrete Curbing: A Comparison of Performance and Costs, Client Report 81, Transportation Research and Development Bureau, New York State Department of Transportation, September 1998