

Granite and Concrete Curbing: A Comparison of Performance and Costs

**MOHAMED ELKORDY
FAIZAL S. ENU**



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**Mohamed Elkordy, Engineering Research Specialist I
Faizal S. Enu, Civil Engineer I**

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New York State Department of Transportation
State Campus, Albany, New York 12232-0869**

ABSTRACT

In New York State, concrete and granite are the most commonly used materials for curbing. This report compares performance and life-cycle costs for these materials, based on a survey of NYSDOT resident maintenance engineers and the city engineers of Albany and Schenectady. Although concrete curbs are initially less expensive, comparison of full life-cycle costs indicates that in the long run these costs are similar, allowing for potential granite recycling and re-use and taking into account removal and disposal of deteriorated concrete. Also, considering other, less easily quantifiable aesthetic and environmental factors, granite curbing may be the preferable alternative.

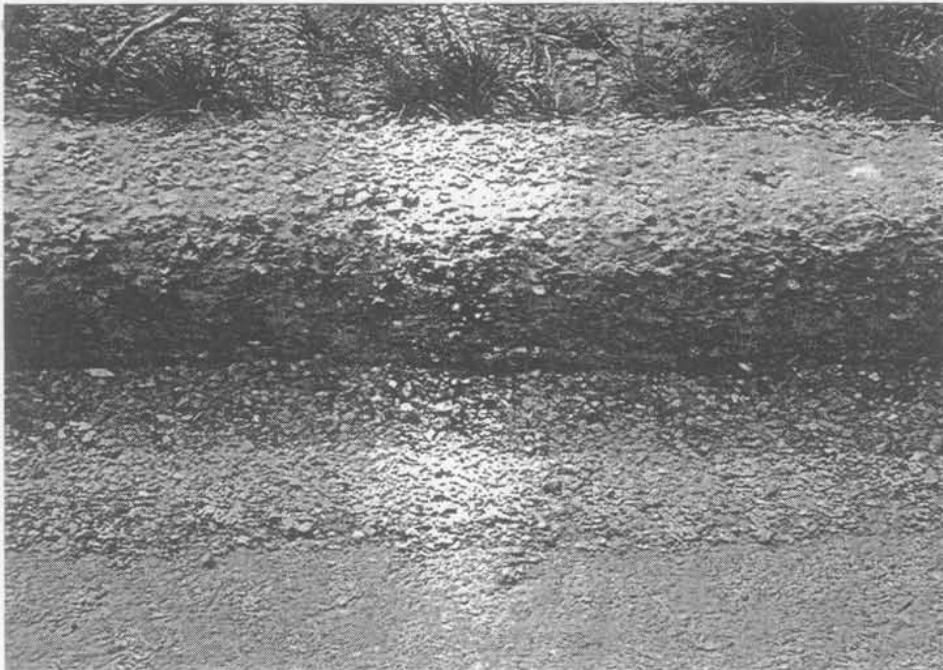
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Table 1. Summary of survey responses.

Response	Estimated Life Span, yr		% of Granite Curbing Recycled	Other Comments
	Concrete	Granite		
1	20	60	50	Prefer granite for aesthetics and life-cycle cost
2	--	--	--	Most curbs are within city jurisdiction
3	20	60	50-100	No curb maintenance
4	35	35	100	--
5	10-20	--	--	Granite does not deteriorate because it is a rock
6	--	--	--	No curb repair or maintenance
7	--	--	--	Not much curbing activity
8	10	20	0	--
9	30	100	90	Prefer granite, although more costly
10	20	25+	80	--
11	20	30	--	No curb repair or maintenance
12	10-20	30-50	--	Prefer granite, concrete deteriorates
13	--	--	--	Granite curbs last longer
14	--	--	--	No relative experience
15	40	100+	100	Granite is maintenance-free, lasts forever
16	40	100	60	Granite is more durable under de-icing chemicals
17	--	60+	100	Granite is almost always re-usable

Figure 1. Prematurely deteriorated 3-year-old concrete curb.



INTRODUCTION

Rural and urban highway curbing serves many functions, including drainage control and protecting drivers from accidentally leaving the roadway. It should also resist high-speed impacts and freeze-thaw cycles, withstand de-icing chemicals used in snow-and-ice control operations, and be aesthetically acceptable. The most commonly used curbing materials in New York State are granite and precast or formed concrete. Granite is notable for its strength, durability, and appearance. Concrete has lower initial costs, easier workability, and is used extensively in many other structural applications.

The study reported here resulted from a "research suggestion" originating under this Bureau's program to solicit researchable ideas from state transportation personnel, academics, industry, and the public who use New York State's transportation systems. A proposal to examine the "problem of life cycle cost of curbing" was received from Edwin Williams, Vice President of the American Granite Curb Producers Association of East Otis, Massachusetts, and was endorsed (after review by research staff) as "needed and warranted" by Larry W. Brown of the Design Quality Assurance Bureau.

This report compares relevant properties and life-cycle costs of concrete and granite curbing, based on a survey of NYSDOT county resident maintenance engineers and the city engineers of Albany and Schenectady. After summarizing survey responses, relative physical properties and resulting variations in service life are compared. During the study, wide differences in curb bidding prices were noted, and cost factors are presented that explain these variations.

SURVEY OF FIELD AND MUNICIPAL ENGINEERS

This survey was designed to obtain evaluations and insights from respondents concerning actual performance, life expectancy, and any hidden costs associated with these curbing materials. In all, 17 responses were received and are summarized in Table 1. Although most respondents did not specify costs associated with curbing, many noted that granite remained in good condition and retained its desirable properties longer than concrete, and typically could be recycled. One respondent said that although concrete is used more often because it is cheaper, he preferred granite for its appearance and longer maintenance-free life. Median life spans calculated from the responses were 20 years for concrete and 60 years for granite. Three respondents estimated lives of 100 years or more for granite curbing. Three others said that concrete curbs often deteriorate long before the 20 years of service expected for most concrete pavements. They said that by the time 20 years have

passed, concrete curbs usually need major work when adjoining pavements are repaired, resurfaced, or replaced. Figure 1 shows a prematurely deteriorated 3-year-old concrete curb on Rte 20 in Buffalo.

LIFE-CYCLE-COST ANALYSIS

Dollar values used in the analysis (initial, re-setting, and disposal costs) were taken from NYSDOT's 1993-94 and 1995 "Average Weighted Bid Price" books. It was assumed that average pavement life span is 20 years, after which paving and curbing are rehabilitated. As the results showed, granite curbs can be re-set and re-used, but concrete curbs must be removed and replaced. NYSDOT guidelines for life-cycle-cost analyses specify the present-worth method with a 4-percent discount rate for all costs, as used in this study. The following factors were not included in the analysis:

1. Costs reflecting environmental concerns that concrete curbs must be replaced and disposed of, but granite can be recycled. These are difficult to quantify and were beyond the scope of this study.
2. Although concrete curbs typically break down before the expected 20-year normal service of the adjoining pavement and normally receive little maintenance, a 20-year curb life span was nevertheless assumed in calculating life-cycle costs.
3. Aesthetic values associated with granite and concrete curbing could not be quantified.

Cashflow diagrams using average costs to achieve 60 years of useful curbing life are shown in Figure 2. The basic equations for calculating curbing present worth P are

$$P = IC + (RC)(1 + I)^{-20} + (RC)(1 + I)^{-40} + (DC)(1 + I)^{-60} \text{ for granite, and}$$

$$P = IC + (IC + DC)(1 + I)^{-20} + (IC + DC)(1 + I)^{-40} + (DC)(1 + I)^{-60} \text{ for concrete}$$

where I = discount rate,

IC = initial cost per linear foot,

RC = replacement/recycling cost per linear foot, and

DC = disposal cost per linear foot.

Results of the analysis showed similar life-cycle costs for both curb types. Table 2 summarizes costs per linear foot and results of the cost analysis. Because of large fluctuations in bidding prices, however, the analysis was extended to include the full range of these bidding prices, with the results shown in Figure 3. In addition to the life-cycle assumptions made for the analysis presented in Table 2, it was assumed that disposal cost DC is constant at \$5 regardless of initial bidding price, and that resetting costs are \$9, \$12, or \$15, also regardless of initial bidding prices. The X and Y coordinates in Figure 3 respectively represent initial bid prices for concrete and granite curbing. The envelope

Figure 2. Cashflow diagram using average costs.

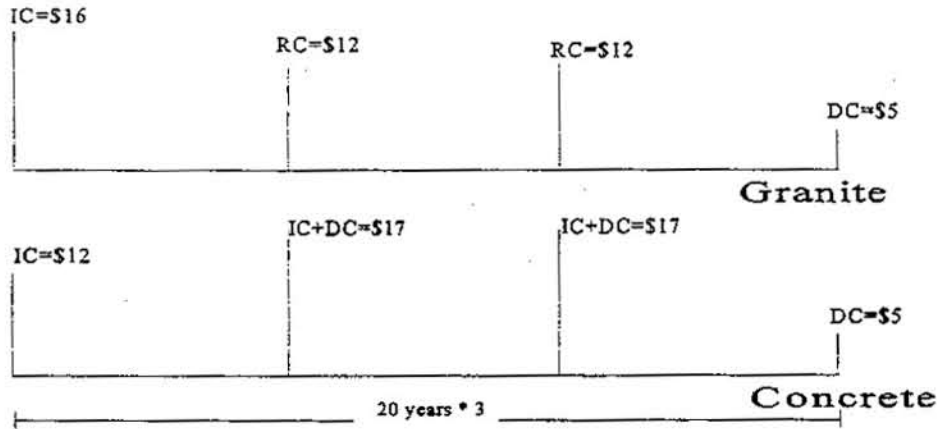


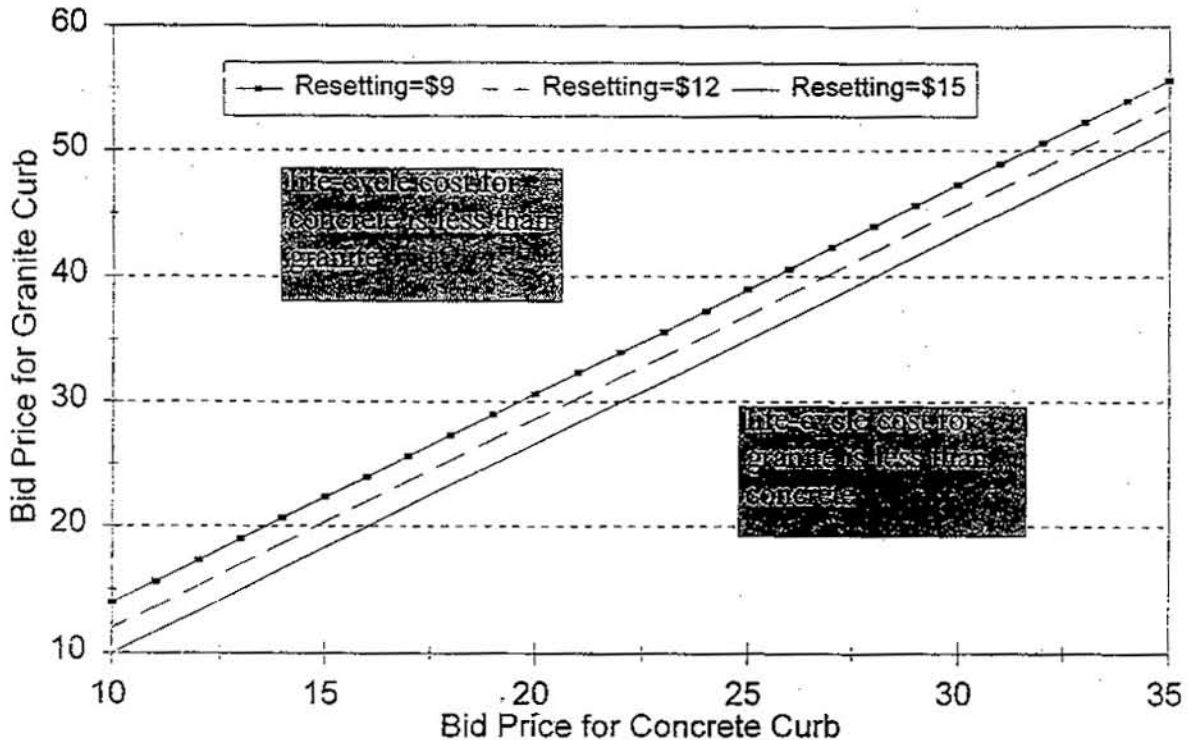
Table 2. Life-cycle-cost factors and analysis.

	Granite	Concrete
Useful Life	60 yr	20 yr
Initial Costs, IC	\$16	\$12
Disposal Costs, DC	\$5	\$5
Recycling/Replacement Costs (20-yr avg), RC	\$12*	\$12**
Salvage Value, S	\$0	\$0
Discount Rate, I	4%	4%
Net Present Cost	\$24	\$24

*Recycling/re-setting.

**Replacement.

Figure 3. Decision zones based on life-cycle costs.



representing equal life-cycle costs of granite and concrete curbing divides this chart into two decision zones based on life-cycle costs. For example, if initial bid prices were \$13 and \$15/lin ft for concrete and granite, respectively, then it can be inferred from this chart that 1) granite life-cycle cost is less than that for concrete when re-setting cost is estimated as \$9 or \$12/lin ft, and 2) costs for both materials are equivalent when re-setting is estimated as \$15/lin ft. It should be noted that disposal cost higher than \$5 would favor granite. Along with other survey findings and design engineering experience, this chart can be used as an aid in choosing between concrete and granite curbing.

During analysis of 1995 bidding prices, wide fluctuations were noticed -- for example, bids for initial granite curbing on different Long Island contracts ranged from \$10 to \$36/lin ft. It was also noted that contract costs depended primarily on contract quantities. Two nonlinear relationships were developed to correlate bidding price with contract quantities for both concrete and granite, as plotted in Figure 4. To explain other variations, cost factors both granite and concrete are now discussed.

Granite Cost Factors

Large granite quarries are widely accessible (1), and granite materials actually contribute less to the cost of curbing than the costs resulting from requirements for its cutting and finishing, and from contract-specific and specification-related expenses.

Cutting and Finishing Costs

In curb production, the quarryer removes roughly rectangular blocks and sends them to the stonecutter for dimensioning. Granite planes (Fig. 5) and their roles in curb production are as follows:

The Hardway: This plane offers most resistance to splitting. Using diamond saws, the quarry block is initially divided into slabs as thick as the curb depth, parallel to the hardway, providing smooth bottom and top faces.

The Rift: This plane offers least resistance to splitting. After the blocks are cut into slabs, they are guillotined parallel to the rift (opposing blades are used to split the stone). Because the rift plane is easily split, it needs not be sawed but simply split apart. The force applied is sufficient to split the granite along planes parallel to the front and back of the finished curb.

The Grain: This plane runs perpendicular to both hardway and rift. The curb is cut so that this plane is parallel to curb "joints."

Directions and points of development of splitting planes determine how readily granite can be quarried and cut, and also directly affect curb cost. Grain size is also an important cost factor. Granite has a wide range of natural grain sizes -- 0.04 to 1.0 in. (2). Finer textures are better suited

Figure 4. Cost analyses.

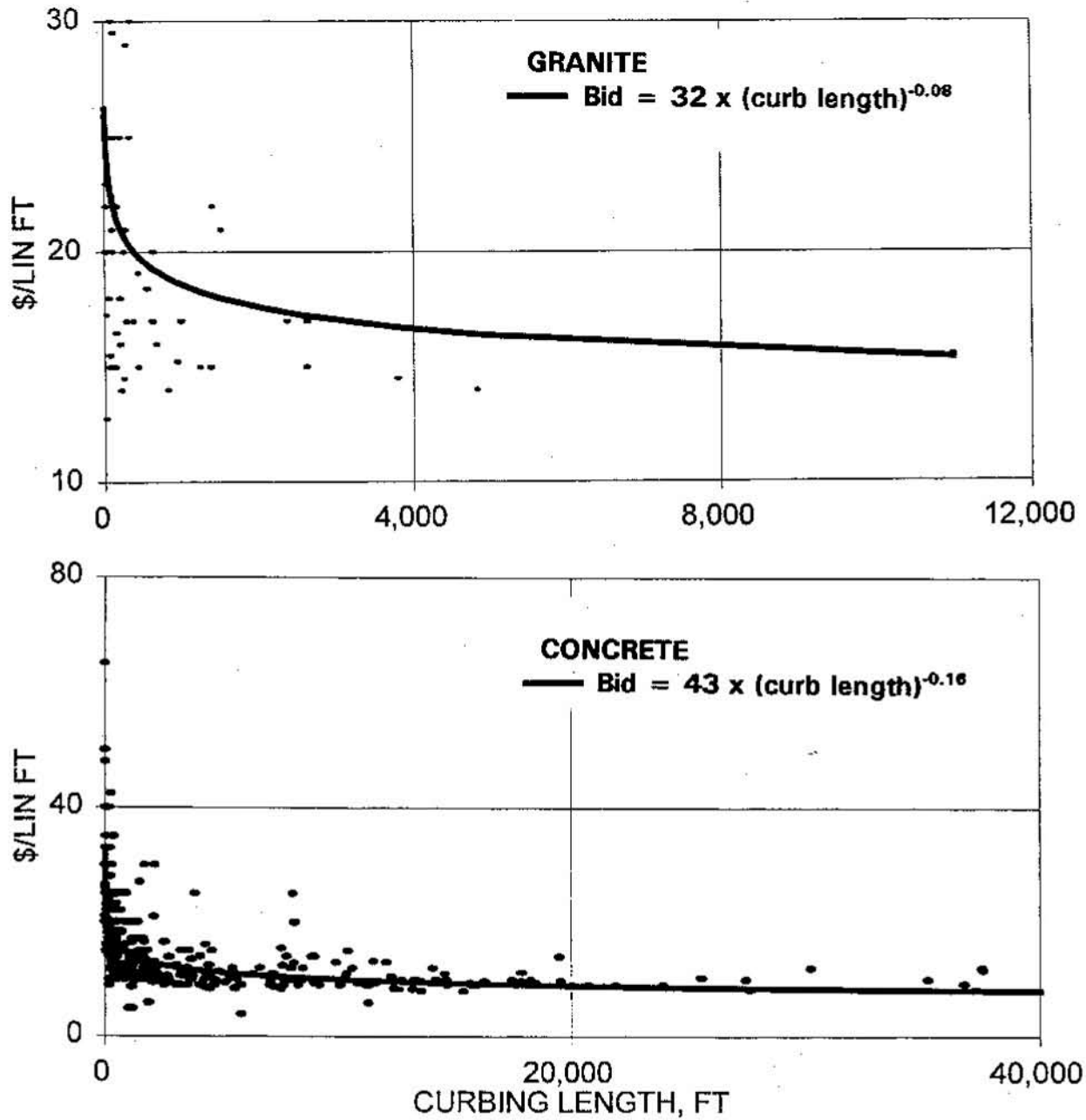
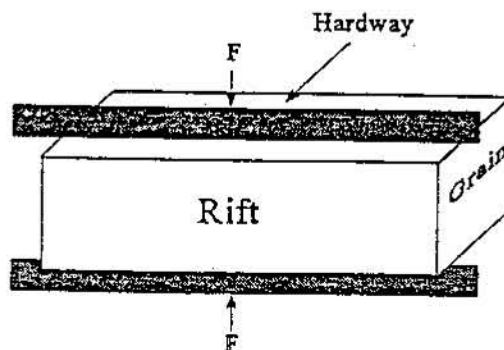


Figure 5. Granite planes for cutting and finishing.



to construction applications, and larger grains decrease crystal interlock and strength (3,4). Finer-textured granite cuts more easily, producing a smoother, more uniform appearance that adds aesthetically as well as reducing production costs (4). Rectangularity of granite formations also affects production costs -- because curbing is generally cut from rectangular blocks, less stone is wasted. Additional costs stem from quantity of wasted material, extra cutting effort, and more manual work, which may result during both quarrying and cutting-plant operations (1).

Contract-Specific Cost Factors

Material is not the only factor affecting granite-curb costs -- other factors are inherent in each highway contract. Project location considerably affects price, because granite must be transported to widely distributed construction sites, making freight expense a major cost component. Profitable granite formations are often distant from project sites -- none on the NYSDOT Materials Bureau Approved List are located in New York State. For a specific contract, shipping thus may account for a significant part of curb price.

According to Means Heavy Construction Cost Manual (5), city-street curbing is more expensive than general-use highway curbing. A standard curbing crew can install 300 lin ft daily in the country, but only 75 lin ft in the city. Labor comprises about half the urban curb installation cost, but only one-quarter of rural curbing construction costs. Also, M&PT (maintenance and protection of traffic) tends to be more expensive on city streets. Urban unit costs may also be increased by smaller contract quantities and more frequent installation of curb end-sections.

Conformance to Specifications

Stone curbing installation is governed by Standard Specifications Item 714-01 (6), which has the following special language:

1. Material Requirements: "Stone curb shall be either bluestone, sandstone or granite. The stone shall be sound and durable, free from seams which impair its structural integrity and of a smooth splitting and machining character."
2. Curbs on Curved Sections: "With exception of Economy and Sloped curbs, segments on curves with radii of 30 meters or less shall be shaped to the required curvature and the ends cut on radial lines."
3. Surface Finishing (details are specified for top and back surfaces, arris lines, front exposed faces, and drill holes).

Conformance to these requirements increases curbing costs. Specifications become more stringent for sharper curves, thus additionally raising costs. Curb faces are of two types: rough texture

(quarry-split or "QS") and smooth (sawed, hammered, or thermal "SH&T" finishes). QS finish is usually produced by guillotining, wedging, burning, or presplitting the rock apart. SH&T finishes are directly diamond-sawcut, or a previously rough-split surface is hand-hammered or burned. As mentioned earlier, top and bottom faces are already smooth from slab sawing, but other SH&T faces need special finishing, adding to work required and cost.

Concrete Cost Factors

Concrete is more readily available than granite, and can be delivered to the project site on relatively short notice. Its cost does not vary greatly from location to location. Useful lifespan is the main cost factor. Premature failure of concrete curbs is typically caused by chemical reactions with de-icing chemicals or by freeze-thaw cycles.

CONCLUSION

Granite curbs cost almost the same as concrete curbs, when life-cycle costs are compared. The higher initial cost of granite curbing should not overshadow such environmental concerns as disposal of removed concrete, or the probable additional expense of maintaining concrete curbing in satisfactory condition -- granite curbing for both reasons is an attractive alternative to concrete curbing, particularly where aesthetics are important, as in tourist areas. Granite also is clearly preferable as a natural rather than a manufactured material.

ACKNOWLEDGMENTS

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