# Summary of Highway Noise Barrier Construction in the United States

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**More than 450 mi of noise barriers have been constructed in the United States at a cost of more than $300 million (in 1986 dollars). About one third of these were constructed after the highway had originally been built, and about one third are adjacent to Interstate highways. The average barrier is ~12 ft high and costs about $12/ft^2 in 1986 dollars. More than 30 percent of all highway noise barriers are in California, and about ~10 percent are in Minnesota. It is reasonable to expect that in the future, noise barrier construction will be of the order of tens of miles annually.**

Estimates of past highway noise barrier construction in the United States have been found to be useful to both governmental and nongovernmental institutions and individuals. This paper is the third such estimate and the second by FHWA (*1, 2*). The estimate is based on physical data that are current through 1986 and on price adjustment. The bulletin *Price Trends for Federal-Aid Highway Construction* (*3*) was used to convert actual construction costs to 1986 dollars. The estimate includes noise barriers constructed with highway funds, according to data from state highway agencies (SHAs).

## SUMMARY

By the end of 1986, more than 450 mi (aggregate) of noise barriers had been built in the United States at a cost of more than $300 million in 1986 dollars. About one third of all barriers, by length, were constructed along existing highways. (Henceforth these will be called Type II barriers.) About one third of all barriers, by length, were adjacent to highways other than Interstates. The average barrier is ~12 ft high. Block, concrete, earth, metal, wood, and combinations of these materials have all been used in barrier construction, and there is no indication that any given material dominates the market.

## DATA UNIFORMITY

The word "estimate" has been used intentionally in the preceding material. It is important that the meaning of this word be clearly understood. The data are not uniform because they were gathered by individual SHAs. Each of these agencies had nearly full discretion in choosing what would be defined as a barrier and what would be counted as barrier costs. The following are examples of potential nonuniformity:

- Some states consider certain safety barriers to be noise barriers, whereas others do not.
- A long, continuous barrier of variable height and material may be considered to be a single barrier in one state. In another state, however, it may be considered to be two, three, or more individual barriers.
- A short barrier over a structure that is made of a different material than the adjacent barriers on each side may be considered a separate barrier in some states. Other states may consider the entire system to be a single barrier.
- A barrier that is built over the course of three construction seasons in conjunction with other highway work may be considered to have been constructed in the first year in one state or in the third year in another state. About 1 percent of barriers (by length) could not be identified by any year.
- The height of many barriers is variable. In a number of cases, barriers were tabulated under the assumption that the average height was the mean of the maximum and minimum heights.
- In some states, noise barrier costs may represent little more than the cost of barrier material. In other states, costs may include ground preparation of the entire area from the shoulder to the edge of the right of way, drainage of this same area, engineering, and administration. Still other states may have no line item in the bidding papers for the noise barrier and thus may have no way to estimate the cost. A cost could not be assigned to ~3 percent of the barriers (by length). This nonuniformity is both regrettable and unavoidable. The data on barrier length are much less affected by nonuniformity than are the data on barrier cost. Although the cost data are not uniform, they are useful for determining trends and approximate costs.

## TRENDS

Of special interest to those performing, reviewing, or implementing highway traffic noise analysis or highway noise barrier design are estimates of

- trends in quantity and cost of barriers,
- construction adjacent to Interstate highways versus adjacent to non-Interstate highways,
- construction of Type I projects (new location, significant realignment, or through lane addition) versus construction of Type II projects, and
- noise barrier material and height.

Table 1 presents the overall trends in quantity and cost for total barrier construction. As can be determined from the table, 5.5 mi of barrier could not be assigned either a year of

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TABLE 1 NOISE BARRIER CONSTRUCTION BY YEAR

| Year Constructed | Noise Barriers (linear mi) | Cost (1986 $ millions) |
|---|---|---|
| Unknown | 5.5 | Unknown |
| Pre-1974 | 3.8 | 2.3 |
| 1974 | 15.2 | 10.0 |
| 1975 | 20.2 | 9.8 |
| 1976 | 5.4 | 2.3 |
| 1977 | 14.4 | 11.9 |
| 1978 | 59.8 | 40.4 |
| 1979 | 58.2 | 33.1 |
| 1980 | 44.4 | 23.5 |
| 1981 | 38.4 | 29.4 |
| 1982 | 24.6 | 19.9 |
| 1983 | 39.3 | 35.2 |
| 1984 | 50.8 | 43.6 |
| 1985 | 41.1 | 34.7 |
| 1986 | 46.0 | 42.7 |
| Total | 467.1 | 338.8 |

NOTE: Costs are approximate.

construction or a cost. In addition, ~8.9 mi was assigned a year but could not be assigned a cost. Finally, one state that had substantial barrier construction was unable to provide data for barriers constructed after 1983.

In Table 2, noise barrier construction is disaggregated by Type I and Type II construction and by location adjacent to an Interstate versus location along other highways. The Type I and Type II percentages do not always add to 100 percent because some records indicate that barriers were built by SHAs without federal funds or by tollway authorities, or because the SHA was unable to identify the barriers as Type I or Type II. It can be observed that there are almost 2 mi of Type I barrier for every mile of Type II barrier, and there are more than 2 mi of barrier adjacent to an Interstate for every mile of barrier adjacent to another highway. The data also indicate that in the previous 9 yr, the percentage of constructed barriers located adjacent to Interstate highways has remained more or less steady. The percentage of Type I barriers has remained more or less steady for ~5 yr.

TABLE 2 PERCENT OF NOISE BARRIER LENGTH BY TYPE AND FACILITY LOCATION

| Year | Type I (%) | Type II (%) | Interstate (%) | Other (%) |
|---|---|---|---|---|
| Unknown | 100 | 0 | 100 | 0 |
| Pre-1974 | 61 | 39 | 84 | 16 |
| 1974 | 41 | 59 | 57 | 43 |
| 1975 | 70 | 30 | 66 | 34 |
| 1976 | 94 | 6 | 44 | 56 |
| 1977 | 25 | 75 | 91 | 9 |
| 1978 | 62 | 38 | 71 | 29 |
| 1979 | 60 | 36 | 66 | 34 |
| 1980 | 79 | 21 | 63 | 37 |
| 1981 | 46 | 54 | 66 | 34 |
| 1982 | 72 | 25 | 74 | 26 |
| 1983 | 71 | 23 | 66 | 34 |
| 1984 | 72 | 28 | 74 | 26 |
| 1985 | 65 | 35 | 69 | 31 |
| 1986 | 74 | 26 | 67 | 33 |
| Overall | 65 | 34 | 70 | 30 |

In Table 3, the total noise barrier construction is disaggregated for the SHAs that have the largest investment in barriers. As can be observed in both Table 3 and Table 1, more than 75 percent of noise barrier construction (in miles and in dollars) was within the 10 leading states. Total costs for Virginia and Oregon are understated because more than 5 mi of Virginia and 6 mi of Oregon barriers could not be assigned a cost. Furthermore, an additional few miles and million dollars are not counted in Table 3, even though these barriers are physically located in Virginia. This is because they are on federal land and were built directly with federal funds.

TABLE 3 NOISE BARRIER CONSTRUCTION BY STATE

| Construction by Length | | Construction by Cost | |
|---|---|---|---|
| State | Length (linear mi) | State | Cost (1986 $ millions) |
| California | 148.1 | California | 116.5 |
| Minnesota | 47.6 | Minnesota | 41.6 |
| Colorado | 31.2 | Virginia | 26.6 |
| Virginia | 26.1 | New Jersey | 21.5 |
| Oregon | 20.8 | Michigan | 16.3 |
| Michigan | 18.6 | Tennessee | 13.2 |
| Arizona | 17.1 | New York | 13.0 |
| New York | 17.1 | Illinois | 10.1 |
| New Jersey | 15.8 | Pennsylvania | 8.9 |
| Washington | 14.5 | Oregon | 8.7 |
| 10-state total | 356.9 | 10-state total | 276.4 |

NOTE: Costs are approximate. Virginia and Oregon costs are understated. Virginia totals do not count direct federal construction.

In all, 15 states have constructed Type II noise barriers. Table 4 presents these states, along with the length of constructed barriers. From Table 3 and Table 4, it can be seen that three states (California, Minnesota, and Colorado) each have more than 50 percent of their barriers classified as Type II. Colorado has ~30 percent of its barriers so classified. All other states have, at most, a modest Type II program.

TABLE 4 TYPE II NOISE BARRIER CONSTRUCTION

| State | Total Barrier Length (mi) |
|---|---|
| California | 94.9 |
| Minnesota | 26.5 |
| Colorado | 11.8 |
| Michigan | 11.5 |
| Connecticut | 3.1 |
| New York | 2.7 |
| New Jersey | 1.3 |
| Wisconsin | 1.0 |
| Louisiana | 1.0 |
| Iowa | 0.7 |
| Maryland | 0.7 |
| Oregon | 0.6 |
| Georgia | 0.6 |
| Massachusetts | 0.5 |
| Washington | 0.3 |
| Total | 157.0 |

NOTE: Maryland total is through 1983; others through 1986.

Like other highway projects, Type II noise barrier programs have periods of activity and inactivity that vary by state. For example, Colorado's previous Type II barrier was completed in 1984, and Minnesota's was completed in 1980. On the other hand, Wisconsin's first Type II barrier was completed in 1984, Massachusetts' in 1985, and New York's in 1986.

Tables 5 and 6 illustrate the trend in barrier height and the ranges of barrier heights, respectively. As can be observed in Table 5, average noise barrier heights have changed little. Before 1977, however, they were a bit lower than they have been since. Table 6 indicates that barrier height is more or less Gaussian in distribution. In general, barriers adjacent to Interstates tended to be a bit higher than other barriers (12.4 ft versus 11.2 ft), and Type II barriers were a bit higher than Type I barriers (12.4 ft versus 11.7 ft). As noted previously, the barrier height data sometimes represent an adjustment from the raw data provided by the data sources and are probably less accurate than the data on barrier length (although more accurate than those on barrier cost).

TABLE 5 AVERAGE BARRIER HEIGHT

| Year | Average Height (ft) |
|---|---|
| Unknown | 14.9 |
| Pre-1974 | 9.1 |
| 1974 | 10.8 |
| 1975 | 11.7 |
| 1976 | 10.4 |
| 1977 | 13.3 |
| 1978 | 12.6 |
| 1979 | 11.9 |
| 1980 | 12.6 |
| 1981 | 11.1 |
| 1982 | 12.7 |
| 1983 | 12.5 |
| 1984 | 11.4 |
| 1985 | 11.9 |
| 1986 | 11.8 |
| Average | 12.0 |

TABLE 6 NOISE BARRIER LENGTH BY HEIGHT

| Height Range (ft) | Miles |
|---|---|
| Under 5 | 4.7 |
| 5–8 | 76.2 |
| 9–12 | 194.5 |
| 13–16 | 139.5 |
| 17–20 | 41.8 |
| 21–24 | 6.5 |
| 24+ | 4.0 |

Tables 7 and 8 provide information on materials used for barrier construction and on trends in the use of material. Because of the nonuniformity in the cost data and the potential for misuse, only barrier lengths are provided in these tables. The totals in Table 8 are not equal to those in Table 7 because of the length of certain barriers, most of which were concrete or metal, that could not be assigned to a specific year.

Table 8 does not indicate that any specific material is clearly preferred on a national basis. There are, however, some preferences on a statewide basis. California, for example, uses block for more than 75 percent of its barrier length. This factor, in combination with the large number of barriers in California, accounts for the large national total for block barrier length. Minnesota and Colorado use wood for more than 50 percent of their combined barrier length. Of the combined barrier length for Arizona and Washington, more than 66 percent is made up of simple berms, and much of that consists of excess highway excavation material. Oregon uses a combination berm and concrete wall for ~33 percent of its barrier length. The only obvious national trend is a decreasing use of berms as a single material.

TABLE 7 TOTAL NOISE BARRIER LENGTH BY MATERIAL TYPE

| Single-Material Barriers | | Combination Barriers | |
|---|---|---|---|
| Material | Length (mi) | Material | Length (mi) |
| Block | 144.2 | Berm/concrete | 18.0 |
| Concrete (precast) | 63.8 | Wood/concrete | 15.7 |
| Berm only | 47.4 | Berm/wood | 9.8 |
| Wood (unspecified) | 32.2 | Concrete/brick | 7.3 |
| Concrete (unspecified) | 27.4 | Wood/metal | 6.7 |
| Wood (post & plank) | 23.8 | Berm/block | 6.5 |
| Metal (unspecified) | 22.6 | Metal/concrete | 4.8 |
| Wood (glue laminated) | 12.9 | Berm/metal | 3.5 |
| Brick | 3.9 | Wood/block | 2.5 |
| Other | 2.2 | Other | 12.1 |
| Total | 380.4 | Total | 86.9 |

TABLE 8 TRENDS IN GENERAL MATERIALS USED IN NOISE BARRIERS

| Length (mi) | Pre-1977 | 1977–1981 | Post-1981 |
|---|---|---|---|
| Combination | 8.4 | 45.0 | 32.6 |
| Block | 4.5 | 69.7 | 70.1 |
| Concrete | 6.3 | 37.0 | 45.2 |
| Berm | 7.9 | 27.4 | 12.2 |
| Metal | 0.5 | 11.1 | 9.1 |
| Wood | 16.8 | 22.9 | 29.1 |
| Other | 0.2 | 2.2 | 3.6 |

Barrier unit cost (dollars per square foot) is one of the more important but less easily inferred values. Its importance is the result of the need, during location and design, to judge the reasonableness of an expenditure for noise abatement. The difficulty in inferring a value is caused, in part, by the previously described nonuniformities in determining total barrier cost and average barrier height. In addition, Leo Defrain of the Michigan Department of Transportation recently noted that (*4*) "noise walls of similar design, material, topographic and soil environment, and height can vary by a factor of 2 in cost per square foot due solely to unanticipatable local wages/work load/union conditions."

As an example of the problem with inferring unit costs, Table 9 provides a disaggregation by height of unit costs of berms. The square footage of a berm is calculated as if the berm were a wall of equal height. These costs were computed from those barriers whose costs were known. To say that these values violate intuition would be an understatement. No doubt this deviation is partially due to the existence of a relatively small number of berms. A special case in one barrier can thus have substantial influence. For this reason, Tables 10 and 11,

TABLE 9 UNIT COST OF BERMS BY BERM HEIGHT

| Height Range (ft) | Cost (1986 $/ft$^2$) |
|---|---|
| Under 5 | 16.2 |
| 5–8 | 3.3 |
| 9–12 | 2.9 |
| 13–16 | 5.0 |
| 16+ | 2.0 |

which provide additional information on barrier unit costs, are not finely disaggregated.

The first row in the body of Table 10 indicates that more than 15 percent of barriers with assigned costs were no more than $5/ft$^2$. Of these, about 7 mi of barriers were constructed for essentially no cost (or even negative cost) because they were made of excess excavation material. The second column of Table 11 demonstrates the effect of inflation on noise barrier unit costs. The last column indicates that even without inflation, noise barrier costs appear to be increasing.

Barriers along Interstates tended to have higher unit costs than those along other highways ($12.4/ft$^2$ versus $10.1/ft$^2$, 1986 dollars). Also, as expected, Type II barriers tended to have higher unit costs than Type I barriers ($13.5/ft$^2$ versus $10.7/ft$^2$, 1986 dollars).

## FUTURE NOISE BARRIER CONSTRUCTION

FHWA regulations provide a good deal of flexibility to SHAs in the administration of their own highway programs. Given this flexibility, SHAs can and do change emphasis and priorities from one year to the next. The previously noted differences in the amount of barrier construction from one state to another and from one year to another are manifestations of this flexibility. Thus it is difficult to predict the extent of future noise barrier construction.

TABLE 10 NOISE BARRIER LENGTH BY UNIT COST

| Cost (1986 $/ft$^2$) | Length (mi) |
|---|---|
| Up to 5 | 79.5 |
| 5+–10 | 140.9 |
| 10+–15 | 110.6 |
| 15+–20 | 60.1 |
| 20+–25 | 40.0 |
| 25+–30 | 11.3 |
| 30+ | 10.2 |

TABLE 11 TREND IN UNIT COSTS

| Years | Actual Cost ($/ft$^2$) | Relative Cost (1986 $/ft$^2$) |
|---|---|---|
| Pre-1977 | 5.3 | 9.6 |
| 1977–1981 | 8.3 | 10.1 |
| Post-1981 | 13.2 | 14.0 |
| Total (barriers with assigned costs) | | 12.0 |

FHWA does biennially update an estimate of the cost to complete the Interstate system on the basis of data provided by SHAs (*5*). Included in the estimate are noise barrier costs. The 1987 Interstate cost estimate for noise barriers was approximately $142 million (1986 dollars). This estimate is only for those barriers built as part of construction projects that close gaps in the Interstate system or add lanes with Interstate construction funding. Other construction projects on the Interstate system that use primary funds (i.e., funds for improvement of the primary system), 4R funds (funds for reconstruction), and so on are excluded, as is all construction on non-Interstate projects.

If past history is considered, a reasonable assumption is that the future will be somewhat like the past. This means that for the immediate future, annual noise barrier construction will be of the order of tens of miles. Annual expenditures will be of the order of tens of millions of dollars.

## REFERENCES


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