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Effects of Highways On Urban Environments

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ABSTRACT

This article describes a study performed to identify the impacts of an urban highway on the communities through which it passes. Air pollution, noise pollution, access disruption, loss of job opportunities, and loss of housing are analyzed. Considerable additional work in these areas has been performed by the author and others since this paper was written two years ago. This additional work represents significant extensions to the material presented here, and will be reported in a subsequent paper.

From 1966 to 1970, Parsons, Brinckerhoff was involved as a co-venturer in the Urban Design Concepts Associates (UDCA), a consulting group consisting of Skidmore Owings and Merrill, architects/planners; the J. E. Greiner Company, consulting engineers; Wilbur Smith Associates, transportation consultants, and Parsons, Brinckerhoff, Quade & Douglas, consulting engineers. The team was formed to help resolve a fifteen year stalemate over the placement of a portion of the interstate highway system through urban Baltimore. This design concept team was charged with the location and preliminary design of the road and with the planning of projects to be associated with the highway. These so-called "joint development" projects were intended to insure that the highway was an acceptable addition to the fabric of the city. It was even hoped that by encouraging such projects, the highway would become a positive, rather than a negative influence on the neighborhoods through which it passed. In some areas where the highway was passing through an already deteriorated neighborhood there were possibilities that the presence of all the Federal financial and administrative muscle

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associated with the interstate program would act as a catalyst and turn around those neighborhoods toward a brighter future.

The UDCA worked closely with local planners as well as local pressure groups which ranged in interest and style from the Black Panthers to the B'Nai Brith. The team studied housing, transportation, education, social services, health services, industry, commerce, population, employment, race relations, crime, and every other socio-economic parameter that a very large team of planners and other consultants could think of.

For each community through which the highway was to pass, a comprehensive picture was developed, describing that neighborhood in terms of all of these parameters and in terms of some intuitive measures such as–is this a stable neighborhood?; is this a transition neighborhood?; or, is this a neighborhood at all?

The next step in the overall procedure was to examine these profiles and decide what were the needs of the communities in terms of social and economic parameters–more housing, schools, health facilities, shopping, industry, jobs, better transportation, day care centers, recreation facilities, and so on.

The community needs were then translated into the need for physical facilities–so many new housing units, classrooms, parks, stores, etc. The team then looked at the proposed highway location and attempted to design simultaneously the exact alignment and grade of the highway and the associated joint development structures. It was at this point that environmental considerations came to light. Given projected joint development uses and the immediate presence of an interstate highway, was there any mismatch or incompatibility?

It was decided that two essential elements had to be studied–pollution and disruption. Highway vehicles generate both air and noise pollution which is inflicted on any urban neighborhood through which they travel. The highway itself can be a disruptive element when placed through a community, because it interrupts the existing street system, and often eliminates a certain amount of housing, commerce, industry and, consequently, employment from the neighborhood. The studies made by the concept team are described below.

Air Pollution

In order to measure the cost to a community of the pollution generated by motor vehicles it is first necessary to consider the extent of the pollution. Portions of a community located close to a highway will usually experience greater concentrations of gaseous and particulate pollution and more noise than will those areas farther from the road. Under certain circumstances, however, concentrations of pollutants may gather at distant points. In general, the diffusion and resultant concentration of pollutants is a function of traffic volume, meteorological conditions, roadway geometry, and the geometry of the surrounding terrain or physical facilities. Very few analytical studies have been made which take all of these factors into consideration. It is mathematically difficult to do so and most investigations have been limited to empirical formulations of the probable diffusion. No work was found which attempts to solve the differential equation of diffusion with general boundary conditions and takes into account the effects of buildings, walls, roadway geometry and meteorology. The writer and his colleagues performed such an analysis and developed a computer program for the numerical solution of the problem under a wide variety of meteorological and roadway conditions.[1] This "exact" solution has not yet been tested with experimental data. Approximate solutions to the diffusion problem have been presented in the literature for those cases where the roadway is in open terrain.[2] These solutions have been extended to the urban terrain problem and applied to the prediction of pollution concentrations in specific neighborhoods by the writer and colleagues.[3]

Noise Pollution

An excellent summary of currently developed models of traffic noise may be found in the unpublished report by Bolt, Beranek and Newman for the Highway Research Board, submitted in January, 1970. Four models are described—an empirically derived model, two analytical models including the line source and discrete source models, and a simulation model. Their report also discusses the effects of road width and observation distance.

The idea of the empirical model is to predict from actual field measurements the relation between traffic volume and noise levels. Such models are limited to the range of data that have been collected and to the uncertainty of separation of outside sources from traffic sources by the measuring instrumentation.

The simplest analytical model is sufficiently accurate to estimate the average traffic noise level if the flow rate is of the order of 1000 vehicles per hour or more.

In the discrete source model, the acoustic intensity observed in the summation of an infinite series of terms, each of which is proportional to the inverse square of the distance of the individual sources from the observation point.

The analytical models do not account for sound absorption as a function of frequency and distance, do not account for non-uniform traffic flow, do not properly handle multi-lane highways, do not allow for a mixture of vehicle types and do not account for the statistical distribution of noise levels as a function of time, but a simulation model may be used to account for these effects. Such a model assumes a random distribution of vehicles distributed along a highway of any number of lanes. The noise characteristics of each vehicle class are described in terms of pressure levels at a given reference distance. The simulation consists of summing the noise levels produced at specific observation points by Poisson distribution of vehicles. By repeating the process a number of times, each time randomly selecting the vehicle distribution, but maintaining the average flow rate constant, histograms of the noise level as a function of time are generated for a particular set of average flow rates, lanes, and vehicle mixes. The model truncates the roadway at some distance beyond which the individual noise sources are insignificant with regard to the total effect of all closer vehicles.

Very good agreement is obtained between the simulation model and the line source model over the intermediate range of traffic densities and for fixed observation distance. At lower traffic densities, the simulated levels are accurately described by the discrete source analytical model.

Access Disruption

When a highway is placed through an existing neighborhood, access between points in the neighborhood must be disrupted unless the highway is completely underground and the surface street system remains unaffected. This disruption may be measured by a cost analysis similar to that performed for determining the feasibility of highway projects.

In simple form, the sequence of measurements is as follows:

a. Define the existing (pre-highway) neighborhood network. This would include streets, sidewalks, pedestrian malls, pedestrian overpasses, etc.
b. Perform an origin-destination study for trips wholly within the neighborhood boundaries and for trips between the neighborhood and outside points.
c. Assign all trips to the existing neighborhood network on a least cost (i.e., least time) basis and measure the total time and distance for all trips.
d. Define the post-highway neighborhood transportation network.
e. Assign all trips to the post-highway network, and measure the total time and distance for all trips.

If the total time and distance for all trips on the post-highway network is greater than the total time and distance of the existing network, the highway has caused disruption. The disruption may be measured by assigning a dollar value to the time lost and extra distance traveled in the total trips.

The techniques described above have all been used for highway projects in the past and may be easily applied to neighborhood movement analysis. Computer programs exist for assigning the traffic to the network after the origins and destinations have been developed. Origins and destinations may be developed by home interview survey, cordon line interviews, or neighborhood street interviews. Again, these techniques have all been used before, and are easily transferred from highway analysis to neighborhood movement analysis. It should be emphasized that this movement may involve pedestrians moving between home and work or home and stores, or automobiles on similar trips, or trucks moving from industry to stores, or service vehicles moving from house to house, and so on. Costs may be segregated by type of trip and separated by user type so that industrial, commercial, and private costs can be clearly identified.

In Baltimore, a neighborhood containing 6000 families was analyzed for highway disruption costs. Disruption was divided into two types, (a) extra distance traveled due to linkage changes to origins and destinations not condemned; and (b) extra trips due to destinations relocated by the highway. The total number of trips involving the neighborhood population was 44 million per day. The extra distance traveled due to linkage relocation after the highway would be completed was estimated at 250,000 miles per year. The cost to the neighborhood for these trips was estimated as $62,500 per year. The extra trip distance due to relocated origins were 467,000 miles per year at a yearly cost of $117,000. The total distance added to trips of local origin or destination was 717,000 miles per year at an annual cost of $179,500.

The assignment of a dollar value travel time is a key point in the above analysis. Two concepts must be considered as alternatives to computing a value for time. First, is the so-called "willingness-to-pay" concept. This is the most common idea and is defined as the maximum number of dollars that the potential traveler is willing to pay for an hour's saving in time. This concept is similar to that of opportunity cost of capital in economics since both concepts depend on alternative opportunities for the use of that time. For example, if it takes a commuter an extra half hour to travel home in the evening, he loses that half hour of leisure. What he is willing to pay to regain that half hour of leisure is a measure of time value for that trip. In this sense, a home to work trip may have the value of leisure time and not work time. That distinction is not clearly made in many existing studies, but is more important in computing time value.

Second, is the so-called "cost of time" concept. This is defined as the actual cost of providing time savings on a specific job. For example, in a neighborhood analysis, the cost of providing savings in time for certain trips might be the cost of a bridge to shorten those trip times.

Present knowledge about the value that should be given to time is undeveloped, and much work must still be done to improve understanding of this important concept.

Loss of Job Opportunities

The construction of a highway changes the employment picture in the communities through which it passes. The following changes can be quantified:

- loss of jobs as a direct result of the highway condemnation.
- loss of jobs through the "industrial multiplier" effect. That is, jobs outside the condemnation lost in the neighborhood due to their dependence on the jobs inside the condemnation area (inside and outside the neighborhood). These can be found through questionnaires.
- loss of jobs through the "residential multiplier" effect. The loss of residential population in the area will result in a direct loss of neighborhood purchasing power. This will result in a corresponding loss of jobs in the businesses serving these residents (residential service jobs).

The total of jobs lost is equal to the condemnation loss plus the industrial multiplier loss plus the residential multiplier loss. The total annual dollar value of these losses may be computed by multiplying the average wage by the industrial multiplier loss, the average residential service wage by the residential multiplier loss and adding these to the condemnation loss. In Baltimore the loss of job opportunities was measured for the neighborhood of 6000 families. The total number of jobs displaced by condemnation was 490. The industrial multiplier effect displaced an additional 735 jobs. These two accounted for a yearly loss of $7,105,000 in job opportunities. The residential multiplier effect accounted for $288,000 per year in lost purchasing power and an additional $144,000 in lost dependent business. The total value of lost job opportunities amounted to $7,537,000, or $145,000 per week. If the average period of unemployment were 14 weeks, $2,030,000 would be lost due to job displacement.

Loss of Housing

The change in housing inventory caused by a highway condemnation will affect rents in a neighborhood. Since most people of low income or cultural minorities tend to relocate in the same neighborhood, most affected will be those housing units in the immediate area of the highway route. A relationship between per cent vacancy in the neighborhood, net loss in the neighborhood housing inventory, and the concomitant change in rents can be established through a supply and demand economic analysis.

The object of the economic analysis is the development of supply and demand curves for the pre-highway and post highway conditions. These are shown schematically in Figure 1. Generally, the supply, V, increases slowly as the potential rents increase and the demand, D, decreases quickly as the rents increase. The decrease in housing inventory caused by the highway condemnation has a two pronged effect: The demand curve jumps to a significantly higher level due to the displaced families and the supply curve decreases by the number of vacant units which were within the highway taking. The consequence is a higher equilibrium rent imposed on the relocated residents seeking housing. As leases of the remaining housing units in the neighborhood come due, those rents will also assume the equilibrium value. The final results, therefore, will be an increase in the average rent for the area equal to the difference between R2 and R1 as shown on Figure 1.

The supply and demand curves could be developed through a survey of past and present trends in the housing market in each neighborhood and in analagous neighborhoods. Included in such a survey would be a compilation of the number of units available at each price range in past years as determined from real estate data, and the rents paid by relocated families on similar projects.

Given supply and demand information for various housing market conditions, a curve relating per cent change in housing inventory to per cent change in rent could be developed. This working curve is shown in Figure 2.

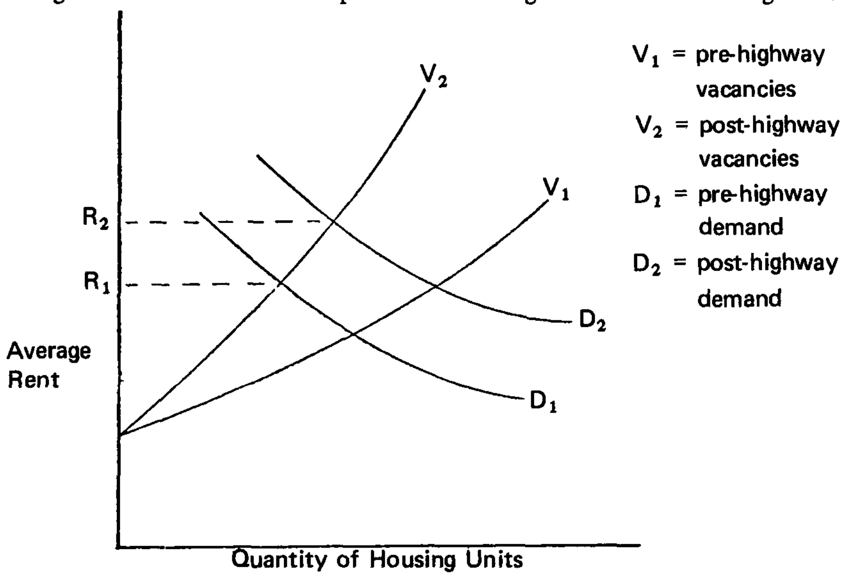

Figure 1. Vacancy-demand relationship for pre- and post-highway conditions.

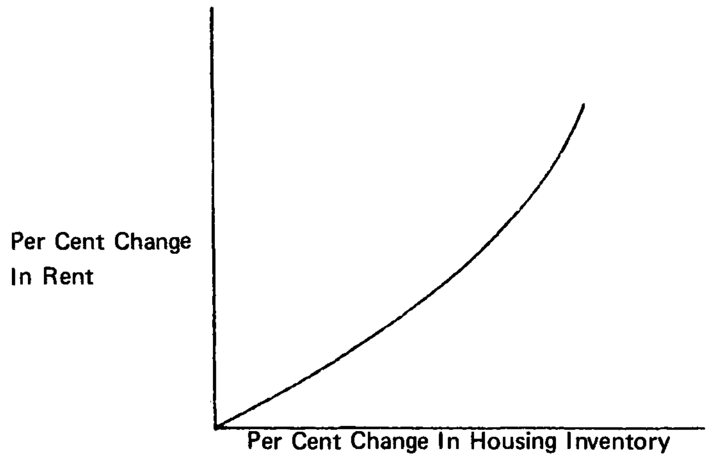

Figure 2. Variation of change in rent with change in housing inventory.

The change in housing inventory is the number of housing units replaced through new construction minus the number of units removed through condemnation. The percentage change in the housing inventory is the net increase or decrease in units divided by the total number of units before the highway is built.

The percentage change in the housing inventory would be used to find the percentage change in rent from the working curve for each particular neighborhood. By multiplying the total number of occupied dwellings in the post-highway condition by the per cent change in rent, the yearly cost or benefit to the neighborhood is determined. This calculation should be done separately for the construction period between the demolition of the original housing units and the replacement of these units through new construction. The yearly costs found through these methods could then be converted to capitalized values giving a total cost or benefit to the neighborhood resulting from the change in the housing inventory.

Conclusion

The effects of the automobile on the environment are real, they are costing communities money and they are measurable. If a cost/benefit analysis is performed when a highway is planned, it is possible to perform realistic studies of environmental effects and include them in the cost side of the equation. These effects are no longer soft or qualitative or nebulous. It is hoped that these facts will contribute to a change of thinking at the Federal level about the expenditure of highway dollars.

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