and for the redevelopment and conservation of central residential areas. Adequately landscaped and planted, the expressway will serve as attractive and logical boundaries for communities and good location for certain recreational facilities. They are viewed as an essential measure in the checking of wasteful decentralization and the restoration of older areas to economic health.

Several theories have been advanced relative to the best location for an expressway. Each has its advantages and disadvantages. The authorities who prefer between-block locations claim a cheaper right-of-way cost on the basis that this method, in the majority of cases: (1) will preserve the buildings facing the street by using the back yards of the property required; (2) through preservation of the houses and small retail neighborhood establishments cause the least disturbance and dislocation to the immediate area; (3) remove from the tax books taxable property of lesser value; and, (4) cause less disturbance to existing underground utilities thus reflecting a tremendous saving in construction costs.

The proponents of the center of street location claim; (1), a wider right-of-way can be obtained by the acquisition of entire lot depths; (2), the economy in acquiring the rear portions of city lots is not as great as appears; (It has been the experience of right-of-way negotiators that the ultimate cost of a portion of a parcel of land represents nearly the total value of the entire parcel in most cases) (3), with a wider right-of-way, a better opportunity is afforded to design flatter slopes and attractively landscape the area; (These two erosion control devices will reflect a lower maintenance cost for years in addition to their beautification abilities) and, (4), the existing local streets flanking the improvement will serve as feeders and collecting arteries.

WIDTH CONSIDERATIONS

It is generally agreed by highway engineers that generous right-of-way widths should be provided for expressways. Some advocate right-of-way widths of three hundred feet or greater, if possible. A wide right-of-way properly landscaped is a guarantee against damages to the abutting property values. Fumes, noise, and dirt, the objectionable by-products of arterial highways, are effectively eliminated where ample space is provided between the pavement and dwelling units. On wide rights-of-way, medians between pavements can be of generous widths to provide proper planting which provides more safety to the driving public.

An improvement of generous width will allow for future expansion, should it be needed, without entailing acquisition of additional land for widening purposes. Subsequent widening is a costly procedure and should be precluded in the original purchase.

DESIGN CONSIDERATIONS

In order to function as intended, an expressway cannot usually intersect other traffic arteries at grade, although conditions may be such that the highway economically may be at grade between intersections. This is generally possible in the open country, but it is more difficult in cities or towns, where railroads, waterways, and particularly city streets, may be so close together as to make impracticable the construction of an expressway at grade In certain cases however, it may be possible to construct it essentially as a surface road, for example where it can be located parallel and adjacent to an existing railroad or waterway, or to a hillside, swamp, park or other natural man-made barrier.

The vertical location of an expressway in relation to the ground or street surface will depend on the specific characteristics of the terrain and the street system, and possibly to some degree on the likes and dislikes of the communities through which it will pass. It may depend also on the relative cost of right-of-way and construction. Generally speaking, the following types of structures can be used:

(a) Above ground (embankments with earth slopes or between retaining walls; viaducts of steel or concrete).

(b) At ground level (surface highway with over- or under-passes at traffic crossings).

(c) Below ground (open cut with earth slopes or retaining walls; cut-and-cover subway type; tunnel).

The engineering problems and economics involved in the construction of any of the types of structures mentioned above will usually follow the same patterns as those of similar structures used for other purposes. The following comments, however, may be noted as applicable to expressway structures.

Where the soil on which an embankment is to be placed is soft, the height should be limited so that undue settlement will not occur. Otherwise, the settlements may be costly, not only on account of damage to the expressway proper but also to adjacent properties. It may be possible to increase the permissable height of the embankment by excavating the soft material and replacing it with firmer soil, but in either case consideration must be given to this matter in order to obtain the proper economic picture.

The slopes of embankments and cuts should be quite easy, preferably not less than 2-1/2 to 1. This, together with suitable planting of the slopes, will protect their integrity and reduce the cost of maintenance, but in the economic study, consideration must be given the additional cost of right-of-way and material required for the easy slopes.

Where the width of right-of-way is limited, the earth slopes can be replaced with retaining walls, or steel or concrete viaduct structures may be used, but the cost of the structure will generally be greater then for embankments with earth slopes, although the cost of right-of-way may be less.

Public utility subsurface structures in existing streets, including gas and water mains, sewers, electric conduits, large water conduits, rapid transit subways, and others, will affect or make prohibitive the use of embankments or open cuts. Even the cost of foundations for viaduct structures may be materially increased on account of the presence of subsurface structures.

A characteristic of a viaduct structure is that there are open spaces below the deck and between the supports. Under certain conditions this open space can be useful for parking purposes, but it should not be used for storage in such a manner that it will interfere with inspection and maintenance of the structure. If not properly lighted and policed, the space may readily become a serious public nuisance or danger.

Advantage should be taken of any means to bring daylight under viaducts and bridges, and this should be supplemented with adequate artificial lighting. Arrangements for the lighting should be carefully made in the early design stage and should not be an afterthought.

Expressways in open cuts are sometimes felt, by the communities they pass through, to be less objectional barriers than would be embankment structures. They may involve extensive reconstruction of existing structures and consideration must be given to the elevation of the groundwater level, in its relation to the structure as well as to the methods and cost of removing water and snow from the roadway.

Where the right-of-way width is limited, retaining walls can be used in open cuts in place of slopes. As high unbroken vertical retaining walls on both sides of the expressway may have a depressing effect on the users of the road, a terraced design giving an opportunity for planting and landscaping will be worth considering.

Where additional surface street area is needed the open cut can be covered over part of the width of the expressway, and used for street purposes.

Subway construction should have the roof below the general depth of sub-surface structures. Ample means of ventilation as well as for pumping and lighting must be provided. Owing to the high cost and the want of scenic possibilities, the use of subways for expressways is not indicated except for short lengths, or where other suitable means are not available.

In hilly areas the use of tunnels may be found of economic advantage. They may shorten the length and time of travel, and cause improved traffic conditions in foggy and wintery weather. If the tunnels are short, artificial ventilation may be unnecessary if the cross

section of the tunnel is sufficiently large. For longer tunnels, ventilation may be provided by properly spaced ventilating shafts, or longitudinal ventilation. Suitable fan equipment is required for both.

The principal purpose of an expressway in a city is to improve travel conditions. A common obstruction to travel is a vehicle which has become disabled on the road. If it remains on the regular travel lanes it becomes an accident menace and may seriously delay the traffic. Therefore, whatever the type of structure may be, the expressway should, throughout its length, be provided with a shoulder strip outside of the land area, preferably as wide as a lane, but at least wide enough to permit continuous traffic when a disabled vehicle is using the shoulder strip for refuge.

LOCATION OF TRAFFIC INTERCHANGES

The primary function of controlled-access urban expressways is the provision of an adequate artery to serve the vehicular traffic needs within the urban area. In the designation, "controlled-access" is the connotation of the restriction of immediate entrance and exit between the expressway and properties fronting on the expressway. Access is provided only at designated points. Thus, spacing of the accesses becomes one of the most vital aspects in the planning and design of urban expressways.

The term, "traffic interchange", as used in this discussion, means literally any point where there is an interchange of traffic between the expressway and other highway or street, even though the interchange may not be necessary or possible for all direction flow of traffic. The term, "interchange" is used to designate the turning facilities at the intersection or junction of two or more main highways in conjunction with grade separation.

An expressway is a highway which provides express service for vehicular traffic. As in railroads, a highway which "makes all the stops" is not an expressway. However, a "non-stop" highway through a city in similar manner to a by-pass, would serve only through traffic and benefit the city only by removing the through traffic from the city streets. The urban expressway is usually planned to serve various types of traffic. For through traffic it should provide a relatively uninterrupted flow. However, its greatest service is in facilitating the flow of traffic between the business district, or districts, and outlying residential areas or other points outside the city. The pattern of spacing of interchanges must conform to this principal function.

It follows, therefore, that access should generally be more frequent in these terminal areas, that is, in the outlying residential districts and in the central business district with access somewhat less frequent in the intervening areas. Access at a distance from the business district would not conform to this function. Ordinarily such traffic can be best served by the existing streets.

No exact or fixed criteria for the spacing of interchanges have been developed. For instance, no rule has been, nor can be, developed which states that access should be provided at regular intervals such as one thousand feet or one mile. In this discussion, which is restricted to urban expressways, the subject or problem is one of proper location rather than of spacing of interchanges. The question, rather than being primarily of how far apart should they be, is one of where they should be. The criterion for location of an interchange is usually one of economic justification balanced against its effect on the efficiency and function of the expressway.

1. Volume of Traffic Justifying a Traffic Interchange.

First in the consideration of the location or spacing of interchanges is the question of traffic volumes. No expressway can be planned or designed wisely without adequate counts of traffic volumes within the area affected by the expressway. These counts must be carefully compiled, analyzed, and plotted to present a clear picture of the existing traffic pattern.