Interchange Protection and Community Structure

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A general framework of research for interchange locations in rural and suburban areas is set forth. The framework involves three separate but related facets: prediction of growth, land-use planning for highway protection, and community structure favorable to the development of highway protection programs. Major emphasis is placed on the development of an empirical model for land-use planning at interchanges. The primary objective is to explain and demonstrate the interrelations existing among land management units for purposes of highway protection. The model assumes homogeneous land management (residential) units. Essentially, this model recognizes that land use will alter both the practical capacity of the interchange and the volume of traffic using it. The model may be expanded to include other types of land management units (e.g., commercial and industrial), thereby making it more comprehensive and more generally applicable. In the latter stage, the model provides a guide for land-use planning which indicates how many and what new developments can be allowed to locate until surplus capacity is utilized.

•THIS PARTICULAR presentation treats two separate but very related topics. The first is the design of land-use plans for interchange protection or, more specifically, the development of a model for land-use planning at interchange communities. The purpose of the model is to aid in establishing planning standards for interchange communities. In its final form, it is hoped that the model will allow the evaluation of alternative land-use plans for highway protection. The second aspect of this presentation is concerned with the implementation of plans for highway protection. The constituents of a local area have to put the land-use plans into effect. Some areas do a very good job in implementing plans and others do very poorly. The sociological aspects of the planning process are no doubt important, and community structure, for example, may be highly related to the implementation of plans.

The two aforementioned topics are visualized as two sides of a research triangle (Fig. 1). The third segment of the triangle, namely prediction of growth, is receiving attention concurrently. The purpose of the models being developed is to help estimate the amount of growth that may take place in different interchange communities and anticipate the adjustment problem that may be created by highway change. The objective of the intergrated research design is to provide the knowledge necessary for the rational guidance of social and economic change in communities affected by highway improvement.

DESIGN OF LAND-USE PLANNING MODEL

The Federal-Aid Highway Act of 1956 authorized a tremendous additional public investment in highway improvements. Highway change of this magnitude requires much

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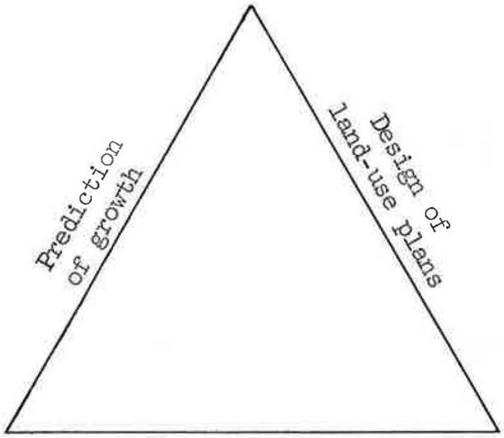

Figure 1.

adjustment that will no doubt continue for many years after this authorized construction is completed. The changes which have taken place already have usually been accompanied by transformations in the land use of the areas served by the new facilities. These land uses induce changes in the volume and composition of highway traffic. The traffic attributable to the new land uses in many instances has caused congestion not only on the limited-access facility but also on the ramps, and even on the connecting roads.

As congestion occurs in the interchange area, the facility becomes technically obsolete, frequently in a very short period of time. Changes in land use and subsequent traffic often occur at a very rapid rate, and some thought should be given to the protection of the public investment in the highway improvement. Land-use planning at the interchange area is one modus operandi of achieving this protection. However, if the land-use planning is to be consequential, it must be predicated on a comprehension of the relationship between highway use and land use.

It is well recognized that the composition and volume of traffic are determined to a large extent by the use of the land served by the highway and that any attempt to forecast traffic must consider expected land-use patterns. However, changes in land use and in associated traffic are not as well understood and are less amenable to control than are design and access features of our highways (1). The functional efficiency of the highway is often reduced by failure to control emerging land uses induced by highway improvements (2).

A conceptual framework for land-use planning at interchange sites was presented in an earlier paper (3). The specific objectives of the presentation included a delineation of the general problem of land-use planning for highway protection, the suggestion of a methodology for research into land-use planning at interchange locations, and a proposal of research needs for the development of improved land-use planning standards. In general, the analysis emphasized the relationships between land-use adjustments and highway capacity at interchange sites and recognized that land-use adjustments alter both the practical capacity of the roadways and the volume of traffic constituting the flow of traffic.

In an effort to provide information that could be used in the development of more comprehensive standards, emphasis was placed on an arrangement of land management units which would minimize the need for new highway construction. The analysis developed was built around the objective of permitting and encouraging the economic growth that any given highway segment could accommodate. The principle of selection was that the number, kind, and location of land management units should not create traffic demands that would bring about congestion.

Determination of surplus capacity is the first requirement of the research design. To be able to determine surplus capacity, it is first of all necessary to determine design capacity of the highway. Design capacity, Dc, is defined as the maximum number of vehicles that can pass through a highway segment, considering safe speed commensurate with engineering satisfaction. The design capacity is a function of the width of the highway (w), the obstructions (o), and the surface type (s). This may be written as:

$$Dc = f\ (w,\ s,\ o) + e \qquad (1)$$

in which e equals other variables, treated as constant.

The next phase is a determination of the practical capacity of the highway segment which is a function of the preceding variables, but the factors previously held constant (e) now become variable. Practical capacity (Pc) in this context is a function of the volume of traffic entering the highway, the volume leaving the highway, the proportion of different classes of vehicles in the traffic stream, and any other unique or special factors affecting the highway segment in question. Viewing these factors as restrictions to the designed capacity, the relation can be written as

$$Pc = Dc - H \tag{2}$$

in which H is equal to the volume of traffic hindered or obstructed.

The total traffic hindered or obstructed (H) can be estimated by classifying various public and private intersections (e.g., those with stop signs, traffic lights, etc.), by determining the volume of traffic that is restricted by various amounts of traffic entering and leaving these intersections, and by taking into account the product mix or proportion of different classes of vehicles in the traffic stream, as well as any special factors that restrict traffic on the segment. These variables can be symbolized as follows:

Ve = type of intersection with a given volume of traffic entering the highway segment;
Vl = type of intersection with a given volume of traffic leaving the highway segment;
Mx = product mix or proportion of different classes of vehicles in the traffic stream; and
E = any unique or special factor which restricts traffic on a given highway segment

The next requisite is a knowledge of the actual volume of traffic (Av). The difference between the practical capacity and actual volume gives the surplus or absorption capacity (Sc). This can be stated as:

$$Sc = Pc - Av \text{ or } ADT \tag{3}$$

The actual volume of traffic is composed of four basic types: generated traffic (G), attracted traffic (A), local traffic (L), and through traffic (T). The actual volume of traffic can thus be stated as:

$$Av = G + A + L + T \tag{4}$$

The volumes of generated and attracted traffic were subclassified according to land management uses. For purposes of simplification, the following categories were used: residential units (R); commercial units (C); industrial units (I); other units (O); and public intersections (K) abutting the segment. (Although the public intersections themselves do not create a flow of traffic, they are treated as generators and attractors when they intersect the segment in question.)

SPECIFIC ILLUSTRATION OF MODEL

Assuming the existence of a homogeneous group of land management (residential) units, the initial objective was to present a computerized simulation model programmed to include the unique characteristics of a specific interchange area. These are, among others, topography, the existing highway network and the present land-use pattern. The present lack of the complete empirical data precludes the immediate presentation of the pertinent program. Some applicable data, however, are presented to illustrate their relevance to planning for interchange protection.

Although the use of a simulation model of land-use planning may be questioned, it was felt that in this instance a dynamic model is needed to allow the researchers to make many repetitions of the process and thereby to foresee the outcomes of various mixes of land management mixes. Further, a simulation is designed to incorporate the most significant features of the process being examined (4), and a properly designed simulation model simultaneously considering many variables will allow investigators to visualize some probable effects that any plan could have and will permit an opportunity to modify and refine first thoughts into a more meaningful plan. Thus, the model provides an experimental laboratory which allows study with no influence on the real situation.

Site Application

The present application of the model will focus attention on one interchange in the York, Pa., area. The data presented herein were gathered at this particular interchange, designated as Interchange B. The interchange is located south of York and is part of I-83 which superceded US 111. The new route was opened in segments from 1956 through 1958. A bypass east of York and a number of interchanges constitute the development in the York area. Four of these interchanges, two north and two south of York, are under study at our institute; all four interchanges are within 8 miles of downtown York. Seven civil subdivisions are included in whole or in part in the study area.

Initial Constraints

The beginning model focuses attention on one segment or link of the local road leading to the expressway. This roadway is a two-lane highway with two-way traffic. Weather conditions are assumed to be ideal and, consequently, the road surface is clear. The lane width is 10 feet with normal shoulder width. The segment or link of the road to be considered is defined as 1 mile in length with maximum curvature of 5 degrees.

Residential units are adopted as the starting point for the illustration of the model because they represent the primary generators of traffic in this country. Also, residential units are important with regard to the attraction of traffic. The consequences of household generation and attraction can hardly be overstated. This point is illustrated by the fact that approximately 80 percent of all urban area trips are made either to or from the household (5). The residential units in this analysis are assumed to have equal traffic generation and attraction factors, and each unit is assumed to have a similar private intersect with the road link. Each of the lots on which the residential units are located is assumed to be standard, i.e., 75 front feet. This means along a roadway 1 mile in length, it is possible to locate 140 units if both sides are amenable to development.

Design Capacity

As stated previously, the starting point for analysis is the establishment of the design capacity of the roadway. The design capacity provides a point of departure for estimating the practical capacity of the road segment and, as previously defined, is the theoretical maximum flow of traffic for the link in question. The illustration assumes a design capacity of approximately 1,700 veh/hr. This figure includes allowance for commercial vehicles (6, pp. 35-65).

Actual Volume

The household as a land management unit uses up a portion of capacity by adding traffic to the system; that is, the actual volume of traffic increases. The increase in the actual volume is derived from Eq. 4:

$$\Delta Av = \Delta G + \Delta A + \Delta L + \Delta T \qquad (5)$$

The household information was obtained during the summer of 1960 as part of an origin-and-destination study. The field work followed standard procedures for gathering household origin-and-destination information. An interviewer visited the sample households several days before the initiation of the travel period and returned to complete the travel schedules when the period ended. A sample check was made by telephone to verify that the information had been obtained by the interviewers. A 3-day travel period was utilized during the study which commenced at 4:00 AM on Tuesday and terminated at 4:00 AM on Friday.

For purpose of analysis, there is the additional assumption of no development along the 1-mile segment of the local road in question. The hinterland beyond the link does, in fact, generate and attract traffic which utilizes the link; that traffic is considered in the illustration.

One could work with average daily figures for generated, attracted, local, and throug traffic. However, this approach would not be meaningful because traffic will be peaked at certain time periods during a 24-hour period. Therefore, it becomes necessary to determine when the traffic appears on the roadway because congestion will be reached at certain hours much sooner than at others. The data collected at the interchange site showed that the heaviest hour of travel occurred between 5:00 and 6:00 PM as can be seen from the tables to be presented subsequently. The initial volume of traffic using the roadway between 5:00 and 6:00 PM is 159 vehicles (117 east and 42 west). In comparison with the design capacity of the segment (1, 700 vehicles), this initial volume is relatively light.

It now becomes necessary to consider the impact of adding 140 households to the segment. From the traffic generation for households in the general area (Table 1), it can be seen that 195 households generate 38 vehicles during the 5:00 to 6:00 PM period. With 140 households, the appropriate traffic generation figure for the segment under consideration would be approximately 27 vehicles. When this is added to the initial volume figure of 159 vehicles, the new volume is 186.

In addition to the traffic generated, the attraction factor of the households has to be considered. Table 2 indicates that 89 vehicles were attracted to the 195 households in the sample between 5:00 and 6:00 PM. Converting for 140 households yields the appropriate attraction figure of approximately 64 vehicles. Adding this figure to the previous total of 186 yields a new volume of 250 vehicles.

According to Eq. 4 consideration must still be given to local and through traffic. A sample of 200 trip cards from households in the area indicated that 10 percent of the traffic was local. Assuming that this is a typical figure for local traffic, this traffic would account for approximately nine vehicles on the segment during the pertinent time period. This figure was derived by taking 10 percent of the generation and attraction

TABLE 1

HOURLY TRAFFIC GENERATION FOR RESIDENTIAL UNITS

Time	No. of Vehicles	
	AM	PM
12- 1	8	54
1- 2	0	22
2- 3	0	18
3- 4	1	17
4- 5	1	34
5- 6	3	38
6- 7	51	31
7- 8	8	55
8- 9	31	29
9-10	27	34
10-11	24	43
11-12	14	10
Total	168	385
Grand total	-	553

TABLE 2

HOURLY TRAFFIC ATTRACTION FOR RESIDENTIAL UNITS

Time	No. of Vehicles	
	AM	PM
12- 1	9	38
1- 2	6	18
2- 3	2	13
3- 4	1	26
4- 5	1	57
5- 6	6	89
6- 7	26	34
7- 8	26	34
8- 9	31	32
9-10	26	46
10-11	32	34
11-12	42	14
Total	208	435
Grand total	-	643

data presented for households (91 vehicles). Including local traffic in the generation and attraction data and not treating it separately would have amounted to double counting.

In this particular framework of analysis, the through traffic is treated as a constant and would be equal to the initial volume of 159 vehicles. Through traffic is the residual after G, A, and L have been determined. Therefore, with a known Av, through traffic can be determined as follows:

$$T = Av - (G + A + L) \quad (6)$$

The through traffic may also be treated as a constant with allowance for a growth factor if a solution for some future Av is required.

Summarizing the data in the context of the original formula yields Av = 27 (G) + 64 (A) + 9 (L) + 159 (T). As stated previously, the household would use up a portion of the capacity by adding traffic to the system. Viewed in this context, with an initial design capacity of 1,700 vehicles there remains a theoretical absorption factor of 1,441 vehicles (1,700 - 259). However, in addition to this facet of the problem, the households also reduce the practical capacity.

Practical Capacity

The effect of the households on practical capacity is a function of certain factors. The appropriate relationship is expressed as follows:

$$\Delta Pc = f\ (\Delta Ve,\ \Delta Vl,\ \Delta Mx,\ \Delta E) \quad (7)$$

If a variety of public and private intersections exist, they must be subclassified, e.g., those with stop signs, traffic lights, and yield right-of-way. However, in this particular analysis, the only intersections handled are private, and it was assumed that these intersections were all similar. Therefore, it is only necessary to determine the reduction in practical capacity by various amounts of traffic entering and leaving these private intersections, taking into account the product mix or proportion of different classes of vehicles in the traffic stream and any special factors which restrict traffic on the segment.

The initial design capacity of 1,700 veh/hr allowed for a normal element of commercial traffic, and there were no unique factors restricting traffic on the segment in question. Therefore, the pertinent problem becomes one of determining the restriction factor of the volume of traffic entering and leaving the private intersections. The volumes have already been determined and previously presented.

Considering the volume of traffic entering the road segment from the private intersections of the households, the assumption may be made that this traffic would not restrict the vehicles already on the road segment. In other words, there should be a sufficient gap in the traffic to allow the vehicles entering the traffic stream to enter without obstructing other traffic. What constitutes a sufficient gap is resolved by individual drivers entering the stream. The size of the gap would vary to some extent depending on the driver and the physical features at the point of intersection. Also, the longer the period of time the driver waits, the shorter would be the gap he would probably accept as sufficient. In addition, the direction the driver wished to turn would be important because a left turn necessitates a gap in two different streams of traffic. Therefore, the volume of traffic in both lanes and the proportion of turns in both directions have some impact. Another facet worth mentioning is the timing of the traffic entering the stream within any given hour. An hourly volume is really too long a time interval to have much meaning within the framework of this analysis. Because there was a total of 36 vehicles, 27 generated and 9 local, it is improbable that they all entered the segment of the roadway at the same point in time.

This analysis is not concerned with how long vehicles in private intersections wait to enter the roadway. The important question here is how by entering the road segment they delay the traffic flow already on the segment. Referring again to the gap that drivers of entering vehicles will accept, one source indicates that when there is a car spacing of 9 seconds, drivers are affected by the presence of the vehicles ahead. Further, under nearly any conditions of speed and traffic volume, approximately two-thirds of the vehicles will be spaced at the average distance or at less than the average distance between vehicles (6, p. 39). Thus, if the traffic volume in one direction is 100 vehicles, about 42 percent of the constituent vehicles will be separated by an average time interval of 9 seconds or less. With 200 vehicles, about 55 percent will be spaced in this fashion. However, another source reports that over 80 percent of the drivers making left turns onto a major roadway and over 90 percent making right turns consider a gap of 9 seconds as sufficient for entering the traffic stream (1). Also, on a two-lane highway with no restrictions on sighting distances, it is possible for an hourly traffic volume of 800 vehicles to travel at least 45 mph. Because there were only 159 vehicles originally on the roadway and only 36 entering the roadway from the households during the 1-hour period under consideration, it would appear safe to conclude that no traffic was restricted by the turning movements. Stated more specifically, it seems reasonable that the drivers entering the traffic stream accepted gaps of sufficient length that no traffic was obstructed or hindered.

The remaining facet of the determination of practical capacity is the number of vehicles leaving the traffic flow of the road segment to enter a private intersection. During the 1-hour time interval, the actual volume leaving the segment was 73 vehicles, 64 attracted and 9 local. (Local traffic must be considered twice in the determination of practical capacity because of its dual impact, the initial movement onto the segment and the terminating movement off the segment.) In this particular instance two major factors must be considered: (a) the direction of proportional volumes on the segment, and (b) the proportion of left and right turns from the segment. Other things being equal, left turns should have a greater impact on practical capacity. The driver negotiating the left turn has to wait for a sufficient gap in oncoming traffic to negotiate the turning movement. If the traffic volume in the opposite direction is of considerable magnitude, then the left turn would probably cause considerable delay.

Even though the impact of a right turn would probably be less, traffic must slow down to sufficient speed to negotiate the turning movement, and the deceleration process varies with drivers. If there is a queue of traffic of sufficient length behind the right-turning vehicle, there could be considerable delay to the vehicles following.

Empirical evidence is necessary to determine how a segment's practical capacity is affected by the traffic which enters and leaves the segment. When this information is available, the absorption or surplus factor can be solved for as follows:

$$Sc = Pc - Av \tag{8a}$$

or

$$Sc - (\Delta Pc + \Delta Av) = 0 \tag{8b}$$

In dealing with a homogeneous group of land management units, these relationships can be rewritten as:

$$\frac{Sc}{\Delta Av + \Delta Pc} \geqq 1 \tag{9}$$

Additional Research Considerations

The remaining factor to be considered is that of public intersections abutting the segment. In the model it is assumed that ramps lead to and from the expressway abutting the road segment. Vehicles entering the segment from the expressway will be generated randomly by Monte Carlo techniques from a given distribution at a preselected hourly volume. As the vehicle is generated, it is randomly assigned a turning movement.

As suggested previously, the basic objective is an arrangement of land management units which will protect the highway against congestion and at the same time maximize the development of the interchange area. The increase in traffic associated with land management units and the resultant effects of the traffic on practical capacity are very important. In the computation of average daily traffic, a very simple formula (Eq. 4) was utilized. The preceding analysis dealt with one segment of the local road. A more realistic formula for traffic on this segment would appear to be

$$Av = Gs_1c + Gs_1e + As_1c + As_1e + Ls_1c + Ts_1c + Ts_1e \qquad (10)$$

in which

Gs_1c = generated traffic from land management units on Segment I to connector;
Gs_1e = generated traffic from land management units on Segment I to expressway;
As_1c = attracted traffic to land management units on Segment I from connector;
As_1e = attracted traffic to land management units on Segment I from expressway;
Ls_1c = local traffic on Segment I, i.e., moves entirely within the limits of Segment I;
Ts_1c = through traffic on Segment I (connector road); and
Ts_1e = through traffic on Segment I entering the expressway.

Once again it would be more reasonable to deal in terms of capacity at peak hours. It was assumed that capacity designation was a moving figure for the entire segment. Actually, there are different capacity figures at different points along the segment. The most crucial point of congestion probably would be where the public intersections from the ramp leading to and from the expressway are located. These particular intersections would probably lower practical capacity more than would any other intersection, especially private intersections.

The analysis of households shows that they would have a twofold impact on highway capacity: (a) they would add volume to the system by increasing the actual traffic flow, and (b) they would reduce the practical capacity of the segment by adding a congestive factor attributable to the turning movements of vehicles entering and leaving the added private intersections. An increase in traffic associated with households would be important, but the potential absorption capacity of the roadway would remain large in spite of the added households. Reduction in practical capacity has not been measured empirically, but it appears that its impact would not lead to congestion unless through traffic were to increase significantly.

Service Stations

Some preliminary data on service stations also were obtained. It was felt that service stations represent a type of land management unit ubiquitous to interchange areas. The information obtained at service stations included the following: (a) a count of all vehicles passing the service stations, (b) the number of vehicles entering and leaving the premises, and (c) delay information associated with turns into the service station because it was deemed important in ascertaining the impact of turning movements on practical capacity. In addition, information pertaining to the origin and destination of all people using the service station was gathered by the researchers. Eight service stations were sampled in the interchange area.

Subsequent analysis for service station development will follow the same outline as that presented for residential development. The assumptions will be the same; i.e., that there is a 1-mile segment of road with no development, that the vehicles utilizing the segment are associated with development in the general area, and that there is an estimated design capacity of 1,700 veh/hr. Once again, the peak traffic periods assume paramount importance.

The first item to consider in determining the increase in actual traffic associated with the addition of service stations is the volume of traffic generated, but the situation for service stations differs from that of households. The primary source of traffic generation for residential units are the members of the household. For service stations, the only analogous type of traffic is the departure of employees to make service calls or to return home.

The conception of the service station primarily as an attractor of traffic poses an analytical problem. When service stations are added to the segment, they tend to attract vehicles from the existing stream of traffic and would not, therefore, be too important in terms of added traffic. The major concern here is the determination of the increase in traffic associated with the addition of service stations.

In the sample information gathered on service stations, customers were questioned as to whether they had used or intended to use the interchange at origin and/or destination. Vehicles using the interchange at origin and destination can be classified as new traffic or added traffic in the accepted sense. Although there were as many as 74 vehicles which entered the service stations during a 1-hour period, there were never more than 5 per hour which used the interchange at both origin and destination. Thus, the new traffic was relatively light. It should be noted that some of the other vehicles would probably be classified as added traffic, but how much would be difficult to determine. Special mention should also be made of the fact that the sample information indicated that service stations located off the throughway ordinarily do not have a wide drawing area.

The greatest impact of service stations would appear, therefore, to be on the reduction in practical capacity caused by vehicles entering and leaving the business. The analysis for this situation would closely follow that presented for households. However, in this particular instance some empirical measurement was obtained by clocking the delay caused by vehicles entering the service station. The total time delay to all vehicles during the entire sampling period was only 73 seconds. Therefore, it would appear that the addition of one service station would not seriously reduce practical capacity under the present conditions. If the actual volume, however, was closer to the capacity of the highway, then impact would, of course, be much greater.

COMMUNITY STRUCTURE

Once the results of the various land management mixes are known and the optimum arrangement is selected, the appropriate control mechanisms must be implemented. The latter may include such factors as zoning, subdivision regulation, programming, taxation, and private controls (8). The specification of suitable control measures is important, and it is necessary to be cognizant of which controls are most effective. Preceding the selection of appropriate controls, however, the community must be organized for action. The degree of organization poses a problem of major proportions, and it is in this realm that community structure becomes important. Stated specifically, community structure may be instrumental in determining whether institutional control measures are adopted.

Some measurement of community structure could enable one to predict the probability that control measures would be implemented. In other words, are the social conditions conducive to interchange protection? Community structure is assumed here to involve demographic data, community organization, leadership attitudes, and social stratification.

Demographic Information

Population changes in a community can be important because significant increases bring changes in the citizenry which may stimulate interest in the adoption of planning standards. As new people arrive on the scene, new homes are built and auxiliary enterprises enter the picture. The development which takes place, of course, may follow some haphazard pattern with consequent incompatible land uses and unused land parcels. The view of this as a possibility may become the driving force behind the adoption of measures for control.

At Interchange B, there were 4,502 people living in the area in 1950. By 1960, this figure had reached 8,506. The population change represents an increase of approximately 89 percent. The considerable increase is indicative of some susceptibility to change because an increase of this magnitude means new people moving into the area. This movement of new people into the area means that this location must have some desirable attributes. The migratory nature of the population is substantiated by the fact that the community had a migrant ratio of 63.2 (number of migrants per 100 non-migrants). It is believed that new people, having themselves made a recent change, are usually much more susceptible to change.

TABLE 3

AGE DISTRIBUTION OF INTERCHANGE COMMUNITY B

Age	Number
0- 4	1,013
5-14	1,703
15-24	1,045
25-34	1,294
35-44	1,337
45-54	948
55-64	633
65 +	533
Total	8,506

Other demographic information about the community substantiates this hypothesis concerning the community being amenable to change. The relative youth of the population is indicated by 1960 census figures (Table 3). The raw data show a significant concentration in the lower age groupings. The mean age of the population is 29.15. A previous paper suggested that a young population appears more likely to be receptive to change and take the necessary steps to initiate some protective land-use programs (9). This conclusion is justified on the basis that younger people, particularly recent arrivals, do not have deep-seated feelings about existing surroundings. One can appeal to reason with younger and, in this case, better educated people, whereas older people are more likely to be sentimental and/or emotional about the status quo. Here demographic data appear favorable for control implementation.

Community Organization

In the present context, community organization has a somewhat limited definition. It refers only to a number of factors controlled by local communities, weighted factors that indicate some movement toward community planning on a comprehensive basis. The total of these weights is referred to as the Index of Community Complexity. The factors making up the index are assigned weights based on a judgment as to the difficulty of implementing them. These factors along with their weights are as follows: master plan, 7; planning commission, 6; zoning commission, 5; land subdivision control, 4; school district change, 3; building code, 3; sewer authority, 3; water authority, 2; annexation, 2; parking authority, 1; and classification change, 1. The respective weights of the items were developed with the assistance of the University's Institute of Public Administration. The index score for the community in question is given in Table 4.

None of the communities under study has attained the maximum score. As another point of reference, the study community had a score of only 9 in 1956. The latter demonstrates that a considerable amount of progress has been made. The score on the Index of Community Complexity validates what was concluded with respect to demographic data.

TABLE 4

INDEX OF COMMUNITY COMPLEXITY—1962

Factor	Score
Zoning	5
Land subdivision regulation	4
School authority	4[a]
Building code	3
Sewerage (partial)	2
Water authority	2
Classification change	1
Total	21[b]

[a]Assigned a higher weight because they have a complex jointure.
[b]Score will probably be higher in near future due to development of planning commission and master plan.

Leadership Attitudes

Community leaders' opinions concerning the community complexity situation may indicate a potential for future changes. Sherif and Sherif (10) propose the committal dimension of an attitude as follows:

> Forming an attitude toward a group, an institution, a social issue is not an idle matter. It means one is no longer neutral to them; they are value laden for him in a positive or negative way.

Bressler and Westoff (11) have the following to say about leadership attitudes and action:

> . . . it seems safe to say, if attitudes are at all predictive of behavior, that the leadership group as a whole will exert its influence to affect positive adjustments to change.

Eight area leaders were questioned concerning the complexity situation. All eight were in favor of a master plan, a planning commission, zoning, land subdivision regulation, building code, and a sewerage authority. The only difference of opinion was on the topic of a water authority, and here there was still a majority (5 to 3) in favor of the authority.

Along with the leadership attitudes toward the elements of the community organization, their attitudes toward local highway improvements are important. When asked how they felt at the time of the proposal of the highway construction, seven were in favor and one was against the proposed expenditures. When asked how they felt at the time of the interview, all were in favor of the expenditure. When asked about the major purpose of the major route, five of the eight had a particularistic viewpoint as opposed to an universalistic viewpoint. The former means they felt the major route was important in terms of local access and not as a part of an overall system. Keeping in mind the local orientation toward the highway, the fact still remains that the leaders looked with favor on the highway change and, therefore, the general atmosphere should have been good during the development period.

Another interesting question posed to the leaders was how they felt about highway expenditures. Of the eight questioned, three felt too much had been spent, two felt the expenditures were adequate, two felt that not enough had been spent, and one did not express an opinion. These responses are somewhat difficult to interpret because it is not known for sure that these individuals were cognizant of the total highway expenditure. Nonetheless, opinions are in many instances the basis for action.

There are not enough responses here to gage their real import. However, four of the leaders who responded felt that the expenditures were about right or too little, which would indicate that there was no overwhelming antagonism toward the amount spent for highways. At least, it would be difficult to conclude that the leaders were against highway expenditures.

Social Class

The information reported here was secured from interviews with a respondent sample in the York Study Area. First, respondents were classified according to whether they migrants or nonmigrants. The former were those individuals who had moved into the community before December 31, 1956; the latter had moved into the community since that date. The second aspect of the classification was social class rating. The social class of the respondent was established by utilizing a modified version of the method suggested by Bell and Meier (12).

Using the Bell-Meier classification, each respondent is given a certain number of points relative to his income, education, and occupation. The points for each of the variables are added and the sum expressed as a single score for the social class rating. The information obtained for this area is given in Table 5.

TABLE 5

DISTRIBUTION OF SAMPLE BY SOCIAL CLASS RATING[a]

Class	Migrants[b]		Nonmigrants[c]	
	No.	%	No.	%
Upper	19	28	17	16
Middle	40	60	65	61
Lower	8	12	24	23
Total	67		106	

[a]Mean class value of both groups, 15.60; $n = 173$, $t = 2.58$, $0.01 > p > 0.001$.
[b]Mean class value, 16.60.
[c]Mean class value, 15.00.

The cutoff points for the various classes were upper class 21 to 27 points, middle class 11 to 20 points, and lower class five to ten points. The migrant average score or rating was higher than that of the nonmigrants. This finding is somewhat typical in terms of migrant-nonmigrant comparisons as substantiated in other studies. The score of the migrants is relatively high and based on the findings of previous studies of adoption practices, would indicate an atmosphere conducive to interchange protection via planning. The difference between migrant and nonmigrant scores is statistically significant. The influx of new people raised the community's overall social class and, as previously suggested, there is reason to believe that this higher social class rating indicates greater receptivity to new ideas and procedures.

SUMMARY

Traffic congestion on roadways represents one of the most vexatious problems highway officials have to consider. This presentation has treated two areas related to the problem of protecting against congestion, namely, the impact of land use on highway efficiency and the effect of community structure on the implementation of land-use plans. The effect of alternative land-use plans on traffic flows is important, but without knowledge about the implementation of these plans, the analysis would be fruitless.

Households were selected as the starting point for the illustration of the model because they are so important in terms of traffic generation and attraction. Attention was devoted to a 1-mile segment of a local road leading to Interchange B where it was assumed that no development had taken place. The analysis proposed the addition of 140 households to determine their potential impact on the efficiency of the roadway in question. Households would have two effects on the segment. The first would be to add volume to the system in the form of generated, attracted, and local traffic. The impact of this traffic would be to reduce the capacity of the segment by the amount of the actual volume introduced into the stream. The second effect would be a reduction in practical capacity because of the congestive factors associated with the movement of traffic to and from households. Yet, in this analysis, the actual volume of traffic associated with 140 households was interpolated to be 259 vehicles during the pertinent time period. Assuming a design capacity of 1,700 vehicles, a theoretical absorption of over 1,400 vehicles would remain.

Measurement of the reduction in practical capacity caused by vehicles associated with the households presents an obvious problem. Although a specific measure of this reduction was not determined, some salient considerations were analyzed. In addition, attention was devoted to the possible effects of a few service stations.

Several factors related to community structure have been presented. Each of these is believed to be associated with a community's inclination to engage in such practices as are essential to highway protection. The demographic features, the development of community organization, the attitudes of community leaders, and the social class ratings all appear favorable in the study community.

By and large, the increase in numbers has resulted in a younger population which has at least condoned land-use controls. These controls, as measured by the Index of Community Complexity, have increased. Community leaders were favorable toward local highway development and toward the major controls conducive to the prevention of the unplanned obsolescence of the major thoroughfare. Additionally, if the findings of other research are applicable here, the community's social class rating indicates an atmosphere in which further necessary change would be favorably received.

This paper has dealt with partial treatments of the design of land-use plans and the implementation of plans for highway protection, two legs of the research triangle set forth previously. As the model for the prediction of growth, the third leg, is developed, additional empirical evidence will be introduced and analyzed. Growth, design, and implementation theoretically and practically are inseparable. Taken separately, they provide a mental gymnasium; taken together, they can provide the knowledge necessary for rational adjustment to highway change and thereby to both community and highway protection.

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