Engineering Considerations

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I WILL NOT discuss the detailed technical aspects of freeway design. Many excellent technical publications are available on such subjects as geometric design, freeway capacity, theories of traffic flow, and the many other technical elements that are the tools of the highway engineers' profession. Instead, I will attempt to discuss some of the basic physical and operational requirements that must be considered in any joint development or multiple use highway project.

We must recognize that there are basically four possible combinations of multiple use of joint development. There is the possibility of (a) developing areas under an elevated freeway structure, (b) developing the air rights over the freeway, (c) developing land adjacent to the freeway, and (d) developing various combinations of joint development in the suburban and rural freeway setting.

In this discussion, I will deal principally with three separate phases of freeway development: first, with the design of the facility; second, with the actual physical construction of the facility; and last, with the operation of the facility once it has been completed.

Design Considerations

In the advance planning for an urban highway, the major decision lies in the question: Should the freeway be depressed or elevated? The question presumes too much for an unreserved selection without qualification. In practice, a considerable portion of any proposed freeway will make maximum use of existing public rights-of-way and is planned as an at-grade facility with depressed or elevated portions only where

dictated by land use or degree of interruption. With this understanding, we can consider other factors that should influence the final profile selection.

It is the generally accepted opinion that a depressed urban freeway detracts the least from the surrounding urban development for two principal reasons: the existing space profile or skyline is not marred by an embankment or an overhead structure nor are there intermittent humps in the profile caused by interchange ramps that must be provided for access to the elevated freeway, and the depressed expressway offers more opportunities for a safer design than those offered on elevated highways. Bridge rail components can be made strong enough to preclude traffic crashing and falling to the ground below, but even so, we end up with an unyielding obstacle relatively close to the traveled way that will not "give" with dynamic impact. It is apparent that an elevated highway cannot feasibly furnish the same lateral clearances as a depressed highway for recovery of out-of-control vehicles. If this were done, the cost of elevated structures would soar upward out of reach of practical economics. There are, however, certain advantages to elevated structures, not the least of which is the possible utilization of the ground surface under the structure for parking, recreational areas, etc. Coupled with this possibility is the general condition that right-of-way taking is normally much less than would be necessary for a depressed highway, with the end result that interruption to existing land use is minimized with commensurate savings in right-of-way costs.

Conversely, an elevated structure will invariably require increased maintenance cost for the life of the facility. Because of the densities of traffic that originally justify an expressway facility, an elevated structure requires almost constant pavement upkeep to retard deck deterioration. On heavily traveled freeways, we have found it necessary to waterproof all wearing surfaces on structures with a laminated coating of fiberglass fabric bonded with coaltar pitch emulsion, covered with a thin course of bituminous concrete.

Full knowledge of expected maintenance costs of an elevated freeway again is only part of the problem. It must be realized that in any maintenance program it will often be necessary to make deck repairs, thereby causing inconvenience and hazard to the road user. A further hazard to road users is the inherent bridge-width restriction occasioned by the necessary long ramp structures to funnel traffic on and off the elevated highway.

In summary, it might be stated that a depressed highway system is safer, more aesthetic, requires less maintenance, and is less interruptive to the local road system than an elevated highway. The proper answer to the basic question must, therefore, be a result of weighing all these factors, as well as factors related to the proposed joint use to furnish the best facility known for the corridor.

In considering the traffic capacity of the freeway and the traffic impact on the area, it must be recognized that freeway ramps cannot be constructed at any indiscriminate location to provide access for some joint-use development. The number of ramps to be provided and the spacing of these ramps must be in delicate balance with the capacity of the main traveled way of the freeway. When the generated traffic and the potential ramp capacity exceed the capacity of the freeway itself, turbulence and congestion will result. The technique of electronic traffic surveillance coupled with ramp metering can help offset this problem.

Any joint development or usage should be reviewed in depth with respect to its impact on capacity, operation, and access. There should be minimal reduction in capacity and little or no substantial impact on the operation of the freeway. Urban freeways are normally constructed in corridors where the existing streets and highways are already operating at or near their capacity. In considering multiple use, should we select functions that will increase peak-hour traffic flows by large percentages, we must insure that the surface street system, as well as the freeway, has reserve capacity to provide for this added traffic flow. Conversely, if the joint use functions are of a nature that will not generate additional peak-hour flows, it is possible that the existing surface street system may be adequate for some years to come. Joint use development should provide off-street parking, off-street loading areas, and adequate storage provision.

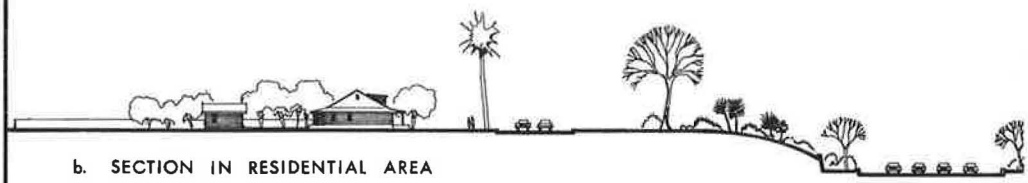
Multiple use of rights-of-way can restrict future expansion of the public highway facility and may eliminate any flexibility needed for future improvements. Careful consideration must, therefore, be given to the original geometrics of the highway in order to provide for any future expansion or development. Because of the permanency of some air use development and linear construction, it is imperative that an in-depth study be made of future needs. These needs should not only consider added lanes for capacity, but changes in vehicle design.

If space is to be provided for future rail mass-transit within the right-of-way, a preliminary design of such transit system should be performed at the same time the highway location work is going forward in order to accurately determine the amount of right-of-way to be provided for the transit project. Often a late addition of a joint use project within an existing highway may mean the loss of a highway shoulder, disruption of traffic operations, extensive revisions to the highway facility, alteration of access, geometrics, etc.

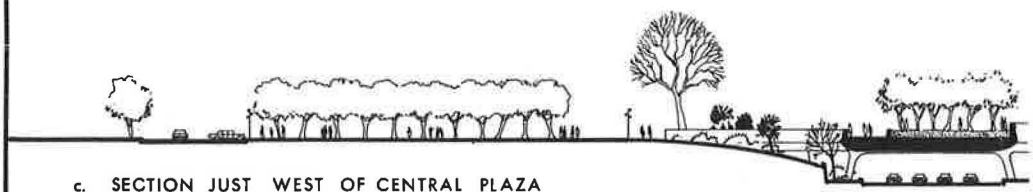
Joint development includes provisions for improving major arterial streets intersecting the expressway, generally in conjunction with the planned location of interchanges. These improvements, together with a reorganization of local streets to fit a comprehensive land use plan, provide an excellent opportunity to increase capacity and availability of access to areas that may have been previously restricted. Of course,

Cross sectional concepts for the Papago Freeway for Phoenix, Arizona, using simple below grade freeway for open rural areas and decked over park areas through the city's central business area. (Source: Johannessen & Girard Consulting Engineers, The Papago Freeway, A Report prepared for the Arizona Highway Department, Phoenix, Ariz., 1968.)

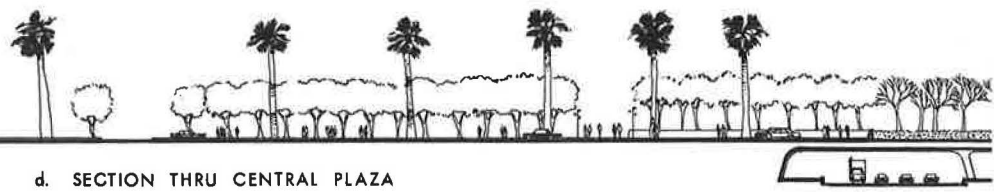
a. SECTION IN PAPAGO PARK



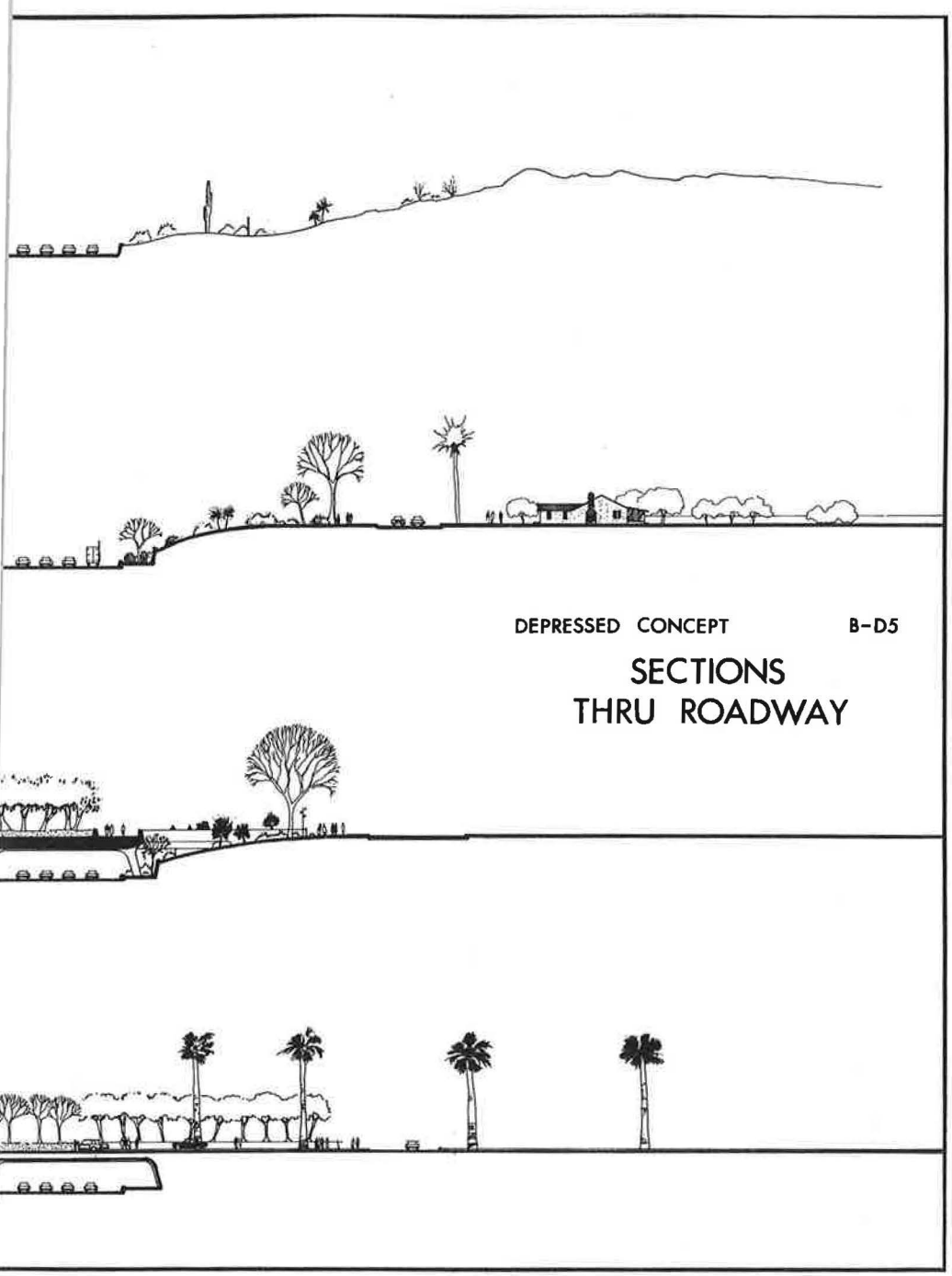
b. SECTION IN RESIDENTIAL AREA



c. SECTION JUST WEST OF CENTRAL PLAZA



d. SECTION THRU CENTRAL PLAZA



DEPRESSED CONCEPT B-D5

SECTIONS THRU ROADWAY

the redevelopment of the land, in line with appropriate land use planning, also provides an opportunity to coordinate the land use with the revitalized street and highway systems. This should result in the optimum use of the highway facility and eliminate undesirable traffic impacts such as the routing of commercial and industrial traffic through residential areas while traveling to and from the freeway. In a nutshell, joint development affords a "second chance" to implement modern techniques to integrate land use and highway planning for the purpose of achieving the objective of total functional mobility.

Critical to the proper operation of a freeway is the capacity of the arterial streets that act as feeders to the freeway. The capacity of signalized intersections at the ramp terminals on these feeder arterial streets is critical. In considering joint use, locations adjacent to these ramp terminals may be expected to be highly valued because of their ready accessibility both to the arterial street and to the freeway. However, to locate major traffic generators at these critical points could present some monumental traffic problems. It would be much preferred to locate joint development projects that may become major traffic generators a block or so away from the ramp terminals with access provided along frontage roads adjacent to the freeway corridor. It should be remembered that the freeway must serve a wide corridor of land and not just that land immediately adjacent to the freeway. For this reason, the traffic capacity of these arterial feeders to the freeway must not be impaired.

Joint development and joint use should assure the safety and public health of not only its tenants but also the highway user. Serious consideration must be given to the effects of air pollution, noise, dust, and distractions on the freeway and on any development over or along it.

Adequate provisions for light, space, and air should be made. Pedestrians should be properly segregated from the vehicular traffic and the motorists should be protected from vandalism on the part of delinquents over and adjacent to the highway. If space is not sufficient to provide a buffer, this protection can be provided by proper screening. Proper safeguards should be provided so that damage and injury from destructive fires and explosions from either the joint development or the highway can be minimized. The lighting of tunnel sections passing under developments over the freeway is a particularly difficult problem. Most critical is the portal area where the motorists pass out of sunlight into the artificially lighted area. Research is needed to aid in the development of designs permitting progressively less natural illumination within the subterranean area. The lighting system for the highway should be compatible with any development over or alongside the highway to preserve uniformity and for aesthetic reasons. Governmental control must be retained over lighting to prevent the installation of distracting lights that would affect the safety of the motorist.

The multiple use of rights-of-way must take into consideration the signing necessary along the freeway. It may be necessary to increase the headroom in tunnel sections to provide space for overhead illuminated signs and to provide catwalks from which they can be cleaned and maintained.

If air rights are to be developed in a linear manner over any substantial length of the freeway, ventilation requirements must be considered. Depending on the joint use, it may be necessary to collect, clean, and exhaust the fumes and impurities at a point well above the top of the buildings over the freeway. With other functional uses, it may be acceptable to merely force the fumes out of the tunnel without treatment. We must not only be concerned with the vibration, noise and air pollution caused by the highway as they may affect the adjacent area or joint use, but we must be equally concerned with environmental problems developed by the joint use facility that would have an adverse effect on the operation of the freeway. These could include things that would distract the motorist's attention, the emission of steam, smoke or other pollutants or the dropping of water or snow on the roadway surface.

Vibration and noise caused by vehicles using the freeway should be considered in choosing the type of joint use function so that their combined effects will not adversely affect the usage of the development. Vibration and noise are particularly incompatible where residential, hospital, or transient motel-hotel usage is contemplated, unless the effect of vibrations can be dampened and the noise controlled. Linear park development can be screened by plantings to reduce the effect of noise. It must be borne in mind that certain types of use can emit noises that could be particularly distracting to motorists. Where joint uses are found incompatible because of the noise problem, we may have to explore the possibility of installing acoustical materials.

Because vehicles are propelled with combustible fuels, fires resulting from traffic accidents are a frequent occurrence. This is further compounded by the fact that many flammable and explosive materials are transported on our freeways. It is therefore imperative that any development over the freeway be designed to withstand intense heat with consideration given to the installation of sprinkler systems that would be automatically turned on in the event of fire.

A similar situation in reverse would develop should a fire occur in the structure above the freeway. The collapse of a structure due to fire, explosion, or sabotage would result in a complete closing of the freeway until such time as the debris could be cleared away.

Proposed development and multiple use of rights-of-way impose a particular responsibility on the highway agency. In the past, the primary responsibility has been to provide construction standards that would be compatible with other public and private agencies. For example, the construction of highways over railroads would be designed

to accommodate the use of the railroad right-of-way. Construction of a highway over a navigable stream is also designed to accommodate the use of that stream. The use of air rights, however, now presents the additional problems of establishing standards that will protect the safety and usage of the highway right-of-way. It is therefore necessary for the highway engineer to establish some minimum criteria for clearances, lighting, ventilation, and other necessary elements as a guide to the architectural discipline.

Construction Phase

Since urban freeways are usually constructed in areas already plagued with traffic congestion, every effort is made to provide for the normal movement of traffic during the construction period. Careful planning must be done to phase the work so as to cause the least disruption to traffic circulation. The construction activity along any given section of freeway will probably last about 24 months. This places a financial strain on adjacent businesses and an annoyance to adjacent residents.

If fringe landscaping and land forms were created during the first phase of construction, those businesses and residences adjacent to the freeway could be shielded from the many highway activities and be afforded a more pleasant environment during the construction phase.

Some disruption due to construction is necessary, but every effort should be made to keep it to a minimum. There is a temptation to build urban freeways in an assembly-line fashion, that is to say we may place all the bridges under contract in one year, then follow the next year with grading, and then with paving. This gets the overall job done in minimum time but it keeps the overall linear area torn up throughout the entire construction period. We should study ways to husband our construction forces so that when we move into a neighborhood to construct a facility, all work on all phases could proceed without delay or interruption until the project is completely finished. In too many instances we move in and out of a particular area several times during the construction of the project.

Construction problems could be greatly reduced if all components of a joint use project were constructed prior to the time that the freeway is opened to traffic.

If structures are to be constructed over the freeway at a later date, we most certainly must presume that the freeway will be left open to traffic and that construction procedures will be adopted that will not hinder the flow of traffic or endanger the highway users.

Operations

The occupancy of the area below the roadway structure could have an adverse effect on certain maintenance operations such as full-depth deck removal and patching. Pier construction should be such as to

provide for emergency maintenance in case of failure or damage to bearings or rockers. There will have to be space available for cribbing up the structure from the ground or pier widths will have to have adequate width to permit jacking or cribbing from the top of the pier.

The question of liability for improper maintenance should be resolved at an early stage and recognition of added maintenance or operations costs due to joint development over, under, and adjacent to the road should be studied in the formative stage so that every effort is made to reduce such costs and arrive at a proper division of such costs.

Ideally, all maintenance should be performed without adversely affecting either the highway operation or the joint use function. Certainly every effort should be made to minimize the effect. Choice of materials and type of construction can minimize the need for maintenance and its distracting effect.

Where developments are proposed under a freeway or structure, new and better ways must be found to provide drainage for the roadway surface. Past experience with cast iron plumbing systems has left much to be desired. These facilities become clogged with debris and freeze in the winter. Most bridge designers have resorted to the age-old use of scuppers that permit the water to fall dirctly onto the land below. If the space below the freeway is to be utilized for development, a solution to this problem must be found. In freeway snow-removal operations, it is not uncommon for our large plows to throw snow over the handrails of our structures. This procedure has not presented a problem where the land below the freeway is undeveloped. With development under the freeway, snow removal could present a problem unless adequate storage space is provided on the structure where the snow can be stored and permitted to melt; otherwise it will be necessary to perform the costly and time-consuming operation of loading and hauling the snow away.

In considering maintenance problems connected with structures developed on air rights over the freeway or on land immediately adjacent to the freeway, we can expect icing problems in the winter where short stretches are shaded from the sun and scattered icy spots develop. The sun is the maintenance engineers' strongest and best ally in his fight to remove snow and ice from the roadway surface.

To prevent objects from being dropped on the highway below, it would seem appropriate that buildings built in air rights should be provided with windows that cannot be opened, and any walkways above or adjacent to the roadway should be screened to prevent vandals from throwing objects onto the roadway.

Of major importance is the ability to bring emergency service in the form of police, fire, and ambulance to the site of an accident, in a joint use development. Due to the critical nature of any accident, fire, or explosion over, under, or immediately adjacent to the highway, a special study of the need for emergency service and for an early warn-

ing system may be in order. The occupancy of space over or adjacent to the highway by apartments or a similar activity could pose a special problem if adequate provisions are not made in the design stage. Adequate right-of-way and access must be provided to allow unimpeded progress for emergency vehicles both to the transportation rights-of-way as well as to adjacent facilities.

Summary

Most of our attention has been directed to the problem of fitting the freeway into the urban setting especially where we must pass through built-up sections of our cities. It is entirely proper that we should do this and I hope that we can produce some significant results. However, hundreds of miles of freeways must soon be built to serve the rapidly developing suburban areas surrounding the cities. It is here that we can make the best use of the joint development concept without having to alter or disrupt existing developments. We must start at once to develop plans for these facilities so that the rights-of-way can be protected.

We have one such facility planned in the Chicago area where the freeway is to be located along a stream in an area unsuitable for residential development. Retention basins will be formed in conjunction with the freeway construction to effect flood control and aid in raising the ground water level that provides the water supply for the adjacent communities. There is no limit to the joint uses that can be conceived for freeway development in these yet undeveloped areas.

Panel Discussion

MR. RUBIN: The Bureau of Public Roads policy has been fairly firm with respect to providing direct connections from freeways to shopping centers and other types of traffic generators. Do you think that in view of the intense concern expressed about joint development and multiple use that perhaps this position might be rethought, and what kind of problems would you envision there?

MR. NUSBAUM: I envision that the Bureau will eventually change their position with regard to very heavy traffic generators. Initially it will be directed toward the public type of traffic generator such as the airport and the recreation areas. I doubt if we see the time that they would relax this to the point to permit us to construct ramps into privately developed facilities unless they were of tremendous impact.