HIGHWAY RESEARCH RECORD

Number 372

Design and Construction of Highways in Urban Areas

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HIGHWAY RESEARCH BOARD

DIVISION OF ENGINEERING   NATIONAL RESEARCH COUNCIL
NATIONAL ACADEMY OF SCIENCES—NATIONAL ACADEMY OF ENGINEERING

Washington, D.C.   1971

ISBN 0-309-01985-0

Price: $2.00

Available from

Highway Research Board
National Academy of Sciences
2101 Constitution Avenue
Washington, D.C. 20418

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FOREWORD

In recognition of its 50th anniversary, the Board scheduled special sessions during its Annual Meeting. Two of these sessions were sponsored by the Group 2 Council on Design and Construction of Transportation Facilities. During the first session, chaired by Robert Bartlett, papers were read and discussed that dealt with problems of the design and construction of highways in urban areas. Bartlett pointed out that the problems can be characterized as technical, political, social, and financial challenges or constraints and noted that we must think in terms of multipolitical groupings for decision-making in urban areas.

Fugate stated that too frequently not enough consideration is given to the impact that large new traffic generators have on the street and highway network serving the area and to the need for total land use planning. He said that political sentiment in a city sometimes changes between the times a project is initiated and is ultimately completed. He stressed that the key to urban problems of design and construction is cooperation among the municipality, the state, and the contracting agency.

Looper, Rottinghaus, Johnson, Alstot, and Whitton discussed the validity of the design-team approach but at the same time emphasized a need for a single experienced individual to head the team. They stated that, because political support is not committed until very late in the design process, there are instances when political objections or change in political leadership has occurred and required the study to begin again. They also stated that the consultant often experiences wastefuls delays in obtaining data from his client and that on occasion agencies are agonizingly slow to review the consultant's progress and preliminary report drafts and to make decisions on location and geometric designs. The constant change of emphasis in highway design such as preserving the ecology and other social amenities causes the consultant to have difficulty in getting sufficient funding in his fee to adequately study and evaluate these new factors.

Suloway described the Board of Underground Work of Public Utilities of Chicago, which was established in July 1910 and is a self-constituted body with voluntary membership and without statutory powers. He described its organization and the way in which it faces and solves problems. He also described the largest project the Board has faced to date—the central area subway system, estimated to cost about $750,000,000.

Gelbach discussed the problems of the contractor; these include labor, costs, phasing of the project, maintenance of traffic, safety, public relations, excavation, and theft and vandalism. He cited cases where front-end loaders and compressors were stolen off the project at night and during weekends. He concluded that all agencies involved in urban construction must cooperate to find satisfactory solutions to the problems and if they do not, because of sky-rocketing costs, the highway industry in urban areas will be priced out of business.

Goode and McCue categorized urban problems as relocation of displaced persons, expressway design for adequate access in local traffic circulation, citizen involvement in decision-making on relocation, access to neighborhoods and impact of new highways in the community, scheduling of construction and coordination of related projects, and public information and handling of complaints.

Elliott noted that today we are giving consideration to factors that no one seriously thought about a few years ago. For example, there would often be less actual community disruption if the highway went through the high-priced property rather than through the low-income areas because affluent people can generally fend for themselves better than poor people. He also noted that, if there were assurances beforehand that buildings such as stores or office structures would be built under highway structures, the spans could be made short and the columns plain, thus reducing the cost of construction.

Osterby described a tunnel built in Minneapolis where a freeze wall was used rather than sheet piling and underpinning adjacent to a large church at one edge of the tunnel. This resulted in a saving of about $10,000 for the highway department.

Watz discussed the 4 types of material that must be disposed of from construction projects: trees, stumps, and other vegetation; concrete pavement, curbs, sidewalks, and foundations; earth excavation; and junk and debris. He cited haul distance as a primary problem.

Harbert described his firm's public relations activities on 2 major jobs and the beneficial effects to be obtained from a good program.

A fast-assembly bridge, according to Koger, is a bridge structure that can be rapidly procured, quickly assembled, and subsequently disassembled. The one he described is across the Aegidientorplatz in Hannover, Germany, and was built to create a relief route for the main traffic flow at an intersection. The main part of the structure is a 2-lane central section having a roadway width of about 25 ft and four 1-lane approaches. The length of the structure is about 2,000 ft. Erection at the site was completed on 5 weekends when work was done from 4:00 a.m. on Saturday until 3:00 a.m. on Monday. The contract was awarded on May 17, 1968; the steel structure was erected from September 21 to October 28; the asphalt paving work was done from October 8 to October 30; and the fast assembly bridge was opened to traffic on schedule November 1, 1968.

The contents of this RECORD should be of interest to administrators, planners, and designers of urban highways and bridges; soils, materials, and construction engineers; and contractors.

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THE STATE HIGHWAY DEPARTMENT'S PROBLEMS IN THE DESIGN AND CONSTRUCTION OF URBAN HIGHWAYS

Douglas B. Fugate, Virginia Department of Highways

•THE CHALLENGES of planning and constructing urban highways are formidable indeed. City dwelling has always been in many respects a source of mixed blessing. Because the city is and will remain the center of employment, commerce, and culture, it attracts throngs of people who take advantage of its resources.

Some 300 years ago, William Penn, who knew much about the cities of his time, wrote, "The country life is to be preferred, for there we see the works of God, but in cities little else but the works of men." Somewhat later Lord Byron wrote, "I live not in myself, but I become portion of that around me; and to me high mountains are a feeling, but the hum of human cities torture."

The majority of Americans living in and around cities today presumably do not regard the urban hum as "torture." However, we all are aware of the awesome problems confronting the cities and those who are responsible for governing them and for providing essential public services. There simply is no way to mistake those problems.

The excellent report (1), The Freeway in the City, states that it is important to capture certain amenities that make the city a decent, satisfying place in which to live. The report describes the most basic of these as ecological, i.e., "the simple biological requirements which urban dwellers have every right to insist upon. Among these are a series of new freedoms—freedom from excessive noise, freedom from air pollution, freedom from physical danger." In addition, the report states, "There are the cultural and recreational amenities which the urban center must provide—open space, views, parks, playgrounds, cultural institutions, and an environment for commercial activity which makes downtown an exciting and colorful place to be."

What is needed so urgently in urban areas today is a broad, overall kind of community planning that sets objectives such as these and with which street and highway planning can be coordinated. The economic vitality of any city depends very much on freedom of mobility for those who live, work, and visit there; efficient, reliable transportation facilities are among the most fundamental of essential public services in a city.

In some of the Nation's great urban centers, such as the Washington metropolitan region, there is a growing need for rail rapid transit to help ensure this efficiency in mobility. In most cities, bus rapid transit is a more economically feasible approach.

It is a serious mistake to believe that any transit system—rail or bus—is going to cure all urban transportation needs, for in most instances one net effect of a rapid transit system will be to generate additional automobile trips in the area. One transportation system complements the other; it is not a matter of choosing one over the other. It all must be planned and coordinated carefully at the local level and between the local and state government. Transportation planning ought to be conducted against the background of total community planning.

Highway planning, whether it is done at city hall or at the state capitol, simply cannot be achieved successfully in the modern urban area without regard to other phases of urban development. One of the most perplexing problems in many urban areas occurs when the traffic capacity of existing and often recently completed streets is burdened unbearably as a result of huge and unexpected new land uses. Land use is controlled, and properly so, by local governments, and they naturally are heavily influenced in their decisions by the tax revenue that will accrue from, for example, a zon-

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ing change to permit a major commercial or industrial complex. Too frequently, not enough consideration is given to the impact that such large traffic generators will have on the street network serving the area.

As a highway administrator faced daily with needs for which there are no funds, I can understand the plight of municipal governments confronted with an identical problem. We must find an improved method of relating total land use planning more effectively to street and highway planning and of making the system work more satisfactorily in rapidly expanding metropolitan areas than it has in the past.

Conflicts are developing increasingly between the desires of those who live along the path of a new urban highway or along an existing traffic artery planned for major improvement and those who use or will use that facility. It is becoming steadily more necessary to seek compromises based, to the extent possible, on consideration of the wishes of both groups.

In most instances, the time required to bring a project from initial planning stages to completion extends beyond the terms of office of elected local officials. A change in municipal administration often means a change in priorities and plans, and this not only tends to delay, frustrate, and complicate a project but also raises difficult questions about the future of that project.

We have just experienced such a situation in one of our major Virginia cities. For some time, both local and state studies have pointed to the need to replace an existing, inadequate bridge on a primary route extension in that city. In the mid-60's, at the city's request, the highway department, working closely with city administrative staff people, began developing plans for replacing and financing the bridge. It was agreed that the project would be built under Virginia's normal urban highway construction program, with 15 percent of the cost to be provided by the city and 85 percent by the state. At the city's request, the highway department began the necessary right-of-way acquisition, and more than $400,000 was invested in right-of-way acquisition and engineering planning. The city council, with some new members, balked at completing agreements necessary to get the project under way, although the city itself initiated the request for the bridge replacement and has been a partner in developing the plans. The highway commission is hopeful, of course, that the council will reconsider its position so that the project may proceed. Highway funds and engineering time are far too scarce to be spent to this extent on a project that is not built.

State and local governments must accept the role of full partnership in highway planning. This partnership means avoidance of unnecessary delays in reaching agreements on projects. It means a shared responsibility for informing local citizens of the need for specific projects. It means a firm position to withstand extreme local pressures for design changes that could result in reduced capacity for the completed facility.

The current emphasis on environmental considerations has underscored the importance of this partnership to find ways to blend the highway into the area through which it passes, of giving citizens through the public hearing process and in prehearing discussions a voice in decisions, and of minimizing pollution of all types during and after construction.

Right-of-way acquisition for urban projects always has been a difficult phase of highway development because it almost invariably means displacement and relocation of people and businesses. This raises human problems that are not easily solved. Provisions for assisting those displaced have become more realistic in recent years, but finding new homes and business sites remains a responsibility demanding the best cooperation between the state and the local governments.

After state and local agencies have done their best in planning and design work, the construction stage itself presents a completely new set of requirements, most obvious of which is minimizing public inconvenience during construction. Travel patterns are interrupted or altered, noise and dust are generated, and public and private utilities often must be relocated or adjusted in some other manner. There are often temporary financial losses that result from construction of highway projects in business areas.

Consequently, projects on which construction time is drawn out unnecessarily bring criticism from the public, and this is quite natural. For this reason, a great amount of attention is being directed at present to finding ways not only to minimize public inconvenience generally but also to complete urban projects in the shortest possible time. Establishment of relatively short construction time allowances will result in somewhat higher costs, but reasonable additional costs are a wise investment in public convenience and goodwill.

All of this is quite difficult to attain when we recognize that the broad range of factors inherent in most urban construction projects by their very nature dictates a sequence of operations considerably less than efficient when compared to the sequence under which a rural project can be built. From the time a project is programmed to the time of the field inspection stage, when plans are perhaps 50 percent completed, little of tangible value can be achieved to ensure a smooth construction operation, for during this period geometrics, alignments, and grades are being established.

As early as possible, however, an accurate, dependable, and realistic schedule should be developed for each project. In this regard, scheduling such as this must be undertaken jointly by the highway department and the municipality. The schedule should include the approximate date for the project to be advertised for construction bids and for the award of the contract, allowance for construction time, methods for handling traffic, adjustment of utilities, and any other factors that tend to control completion time for the project.

It is important that citizens be informed of work schedules, progress, and specific details that alter in some way their normal travel or business patterns. The public is entitled to this kind of information, and it is a responsibility to be shared by the highway department, by the local government, and, after award of a contract, by the contractor himself. This is simply sound public relations.

A basic element of this preconstruction scheduling is a determination as to the best methods of maintaining traffic movement while the project is under way. Will traffic movement be served through construction? Is a detour around the site possible and desirable? How many lanes and what quality of riding surface will be provided for temporary traffic maintenance? These are among the questions to be settled, and the answers should be based very largely on the choices that will cause the least interference for motorists.

Just outside of Washington in northern Virginia, the Shirley Highway, which is a part of Interstate 95, is being reconstructed. In this area, the highway serves 100,000 vehicles per day and more, and there is no suitable detour. Consequently, traffic is continuing to move through the construction site, and the contractors, who were told in advance what would be required of them, are doing a magnificent job of working around the traffic flows.

As was true in this instance, plans must provide a clear indication of the method to be followed in handling traffic, or of the detours, and this information ought to be based on the judgment of traffic engineers. It is essential that these requirements be made clear by the highway department to the prospective bidders on a project, because they naturally would have an influence on the contractors' cost evaluation and subsequent bid.

Similarly, careful advance attention must be given to questions concerning adjustments and relocation of public and private utility lines, and it is imperative that designers have accurate information on the precise locations of these facilities. Unfortunately, most underground utilities, such as water, gas, and sewer lines, cannot be avoided in a major urban construction project and must be maintained continuously during construction of the highway. Generally, it is difficult to make these adjustments prior to actual construction work. This means that the utility company and the contractor must coordinate their work carefully to perform this phase at the most advantageous time, and it does indeed present difficult problems.

There are, of course, a substantial number of other questions that the state highway department and the municipality must decide in planning, scheduling, and constructing urban highway projects. The following are a number of questions that are considered:

1. Should a major project be divided into two or more segments, with intermediate completion dates for each segment?

2. Can projects be completed within a single construction season, and what steps are required to achieve this?
3. What provisions are needed for vehicular and pedestrian traffic during the winter on projects extending beyond one construction season?
4. Can pavement design characteristics be simplified by reducing the number of different types of materials?
5. Is it feasible to eliminate subgrade stabilization and use one type of material for the base?
6. To what extent may precast units be used?
7. How can one best provide for borrow and waste material, a problem that is becoming increasingly difficult in urban areas?

I would emphasize that in most of these areas the final solutions are not yet in hand. Although substantial gains have been made in urban highway planning and construction techniques, there remains a great need for creative and innovative thinking.

REFERENCE

1. Rapuano, M., Halprin, L., Kavanagh, L., Powell, H. R., Roche, K., Rockwell, M. L., Simonds, J. O., and Springer, M. R. The Freeway in the City. U.S. Govt. Print. Office, 1968, 141 pp.

INFORMAL DISCUSSION

Robert G. Bartlett

With regard to the design of a highway based on estimated land use and traffic projection, we are all well aware that in the United States the zoning or the control of land use is basically at the municipal level. This is a problem when the state plans the major facilities but has no jurisdiction over the land use development of a given region. Do you think that the state has a legitimate role in the zoning of land use to make maximum utility of these major investments?

Douglas B. Fugate

From the standpoint of the planner, this would be the perfect solution. However, I certainly think that local government is the place where this control should be. In Virginia there is never a thought of going to state zoning control. The answer lies in a liaison between state and local governments. This can be achieved through greater participation of the municipalities in planning transportation arteries, in maintaining the zoning as it is, or, if there is a change, in taking the highway facility into consideration before making a change.

Robert G. Bartlett

John McCue, how would you answer the same question with regard to the state plans?

John J. McCue

We feel that the closer the government is to the people, the greater is the thrust of the community. Therefore, the zoning controls should probably still be maintained at the local level. However, I do believe that there should be much more coordination among local, state, and federal governments because each is involved in projects that make a marked impression on any urban area. A large urban area that has the foresight to develop a master land use plan lays a good foundation for various levels of government to know essentially what will go on in that community.

Douglas B. Fugate

When the provisions of the 1970 Federal-Aid Highway Act were considered, there was some sentiment in Congress for requiring that once the planning process had been accomplished the locality would have to conform to the plan at the risk of losing federal aid. Unless there is better cooperation between state and local governments in carrying out the provisions of the planning process, the local government may risk losing federal financial support. We cannot use federal financing if the municipality changes zoning without regard to the transportation facility that has been built with federal funds.

THE CONSULTANT'S PROBLEMS IN THE DESIGN AND CONSTRUCTION OF URBAN HIGHWAYS

J. H. Looper, B. H. Rottinghaus, E. B. Johnson, Gary Alstot, and Rex Whitton,
Howard, Needles, Tammen and Bergendoff

•THE LOCATION and design of an urban freeway are important to the present and future well-being and growth of the city and the people who are directly or indirectly affected. The design is also enormously more complicated for an urban freeway than for a rural freeway because of the location in a tightly developed urban setting where a single block can provide more dollars of income and house more people and enterprises than many square miles of rural land. The multidisciplinary design team is a response to this complexity. It brings together people who can consider the far-reaching effects of an urban freeway from a variety of professional disciplines and can then make design recommendations that take into full account the major social, economic, and aesthetic impacts that an urban freeway has on the environment.

The design team approach is being used on an increasing number of urban freeway projects. The multidiscipline design team may be an in-house group assembled by a government agency or it can be provided by an outside consultant. If a consultant is selected for a job, there are many means of operation. The multidiscipline team may be within one consulting organization, which we think is preferable if the necessary competence and range of disciplines can be provided. Alternatively, the team may be composed of a prime consultant plus subconsultants to handle portions of the work that the prime consultant is not qualified to handle. Or, as a third method, there is the joint venture, in which two or more consultants join together as contractual equals to make up the disciplines needed for the team.

The most important internal problem is the coordination and management of the diverse disciplines, and this is true regardless of how the design team is put together. Leadership is needed, and one person must head the team. We believe that an engineer who is experienced in urban highway planning and design and knowledgeable in highway construction and maintenance is generally the one best suited to lead the team. The head of the team must be a capable manager and a skilled administrator, must be able to relate to the various professions and disciplines, and must be able to relate the professions and disciplines to one another along an organized line of effort.

Relations with public agencies and with the public itself are most important; in fact, the most important problems confronting the design team have to do with dealing with the public. Early in the study, a decision must be made concerning methods of working with and securing the local citizens' concerns and opinions. Public hearings are, of course, required by federal law as well as by state policy in most instances, but public hearings are not enough. The public hearing is, in fact, a poor means of obtaining input from interested citizens' groups and individuals. People who are content with the way things are going do not normally attend public hearings. People who are dissatisfied do. As a result, hearings tend to become loud confrontations between advocates and antagonists, shedding more heat than light. The public hearings must be held, but supplementary procedures seem highly desirable.

One or more persons of the multidiscipline team should be skilled in disseminating accurate and understandable information to interested citizens through all means including the news media. Perhaps better citizen participation could be accomplished by opening a storefront office at a location that is as convenient as possible to the proposed

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project where a trained person or persons could dispense and receive information from the concerned public. Small neighborhood meetings should be held for the same purpose. This type of public information program properly carried out could in many instances make the legal public hearing a mere formality without shouting, protesting, name-calling, and ill will being present.

These considerations are important because it is necessary for the consultant that the need and the general location of the proposed freeway be supported by the local government. It has been the general experience that political support is not committed until very late in the design process when community reaction can be weighed. There have been instances when political objections or political leadership has changed during the course of the team study, and the design team has been required to start again from the beginning. It is most essential and desirable for the political leaders, including the city, county, and state agencies, city council, city engineer, city manager, and city mayor, to be involved in the project from its outset. They should be able to understand and support the project during all phases of its development.

Delays throughout the study are a critical problem because delays cost time and money. The consultant often experiences wasteful delays in obtaining data, such as traffic analysis variables and population data, from his client. Furthermore, the client and other reviewing and approving agencies are often agonizingly slow to review consultant progress and preliminary report drafts and to make decisions on location and geometric designs. An urban freeway can become associated with the goals and participation of many agencies. The project can complement or hinder other projects, such as housing, commercial structure, institutions, and industry, and the operation and maintenance of existing and proposed facilities. Some method of resolving the goals and program concerns of the various agencies is definitely needed.

The concept of joint development and joint use of rights-of-way is extremely important in the highway planning program, and it must involve the participation of local agencies that have a commitment to share in the cost of such programs and that do not encourage the local citizens to believe that all such projects will be financed with highway funds. All public agencies interested in urban planning and development that include transportation planning should realize that continuing, cooperative, and comprehensive planning is required in the Federal-Aid Highway Act and must be complied with in order to obtain federal aid. The state highway or transportation department should take the lead in urban transportation planning. They have the knowledge and the personnel to do the job.

One solution is to set up, parallel with the design team, an interdisciplinary review team representing all of the major urban development agencies and led by the top-level political leadership of the urban area. This team would be able to consider the urban freeway as a major influence on all aspects of urban development. It would also help to overcome the problem of specialized review by single-purpose agencies of a project that has to be considered from many points of view.

Two major social problems confront the consultant—an equitable, rapid, and fair settlement with persons or businesses being displaced and restoration of the area adjacent to the highway and the treatment of the highway itself in such a manner that those left on the fringes are not permanently damaged.

The first problem requires considerably improved procedures to obtain early route approvals in order to begin right-of-way acquisition. The long period in which a route is studied, considered, argued about, and finally approved and further delays before right-of-way acquisition actually begins are most inequitable to all concerned. The private developer, wishing to know the location of the freeway so that his capital can be expended in relation to it, cannot be given any positive answers. Private developers, in this case, are driven away because they cannot afford to sit back and wait for the entire process to unfold. Homeowners buying or selling a property the day or shortly before the day that the proposal is announced are left in doubt until the final project is approved.

An even more critical social and financial problem deals with the relocation of the people who must be moved into "safe, decent, and sanitary housing" that is at least equal to housing they now occupy. The relocation must be done before the Secretary of Transportation will approve the construction of the project. If housing is not available, it must be constructed before project construction approval can be obtained. As yet, definite arrangements for building replacement housing are not in effect in many areas.

Delays in establishing the freeway location and design compound the consultant's problems, increase his costs, and may even result in changing some of the factors on which his decisions were based. The consultant's problem is this: How can this period of time be shortened?

The second social problem concerns the design of the freeway itself—elevation or depression, median widths, side slopes, landscape treatment, frontage roads, lighting and light standards, fencing, and other elements introduced by the freeway. A construction sequence with minimum disruption to local areas is also important, but these factors are often freely recognized by concerned agencies. The consultant's problem is one of recognizing the long-range social impact of various design features and endeavoring to obtain approval of these features and construction procedures that will minimize undesirable impact on the adjacent property.

It seems that we are living in a period of greater change than ever before. Perhaps we just imagine this, but it appears particularly true in the planning, location, and geometric design of urban freeways. Some of the new requirements that relate to ecology, environment, and other social amenities are not well understood and are therefore much more difficult to evaluate than the length of the project and its construction and operation cost. This causes the consultant a problem in getting sufficient funding in his fee to adequately study and evaluate these comparatively new factors. A complete analysis by the multidiscipline team of alternate route locations must be made before a final accurate decision can be made by the several governing agencies.

Some of the financial problems that create difficulties for the consultant are caused by reevaluations of the goals and objectives to be considered in the design of an urban freeway. Design goals dealing with aesthetics, environment, ecology, noise, pollution, parks, historical buildings and areas, and relocation of people and businesses have been elevated in importance because of the growing awareness of the impact of urban freeways. If the social amenities are not provided, the project may be blocked by political action. On the other hand, if the social amenities are provided at too great a cost, the project may be disapproved. The consultant must help to find the proper middle course. The solutions differ for different freeways, but criteria must be established for guidance in determining the amount of money that can be justifiably spent in providing the various social amenities.

Although highway development has created perhaps the most sophisticated planning process known to date, it is still deficient and causes problems to the consultant. For example, transportation studies have established the best transportation system based on land-activity projections. If community participation is to be a part of the study, then it is essential that a transportation need be established without a question or a doubt—perhaps by showing the impact to be expected in the entire urban environment with the lack of a transportation system. Present transportation studies usually predict future trips by a linear equation specifically developed for each transportation study area. For example, work trips are usually forecast by an equation using employment and industrial area. The question left unanswered is, Can the same equation be used to determine what will happen in terms of the reduction of employment and industrial activity, if the transportation system is not improved?

Another technical problem is in the consideration of such factors as aesthetics versus cost. Little is known about the user's pleasure or the adjacent neighborhood's pleasure derived from increased landscaping of an urban highway as it relates to cost. Little is known about the impact of an aesthetic improvement that is in conflict with assumed safety features. An example is the visual quality of concrete safety barriers versus side slopes, which might improve highway safety. Other questions of a similar kind that have emerged as problems for the consultant are as follows: How much can be spent to depress a highway rather than to elevate it adjacent to various land uses? Are right ramps safer merely because there are so few left ramps, or are lighting and signing that deficient in directing motorists? How important is standardization to the driver? How can we improve means of communications with the driver?

We believe in the multidiscipline approach to the planning and design of urban freeways. Moreover, we think the very range and complexity of the problems speak for that approach. How else can one hope to enmesh an urban highway in an urban fabric? Surely not by a return to the single-purpose approach in which a road is a road and nothing more!

There are problems reaching beyond the scope of the highway design team, and these problems must be solved if the team is to be fully successful. One such problem is the lack of funds for nontransportation urban improvements. Another problem has to do with the social amenities that are now a part of urban highway objectives. Consultants have been asked to design freeways that reduce noise and pollution. We are trying to do so, but the fact is that little can be done in highway design to reduce noise and pollution because the problem is with the vehicles. The designers and builders of cars and trucks, then, have a role in urban transportation design, a part that Congress recently recognized in its act requiring that pollution-free automobiles be developed.

The multidiscipline design team is part of a community of interest and enterprise that will have to be engaged in developing better urban transportation. This is because urban transportation is a part of urban life. The design team not only has the key role but also provides the format for a still broader kind of multiple-interest effort. The need now is to organize around the design team the other elements needed to make highways and cities really compatible.

INFORMAL DISCUSSION

Robert G. Bartlett

Although we are learning how to cope with quantifying social or nonphysical improvements, we civil engineers are still having difficulties communicating with sociologists or psychologists. Do you think we will see multiple-agency cooperation in which a park commission and a highway department can work together to develop a park by using the waste or fill excavation caused by highway construction? Do you think we will see a recreation agency put money into a project to build a bike trail parallel to the roadway? Do you think we will see housing agencies participate with agencies representing adjacent land to help solve the social problem? I see many people looking to the highway agency to solve this whole set of problems. Do you think we will ever get all governmental agencies to bear on the problem in a coordinated measure?

Rex Whitton

Yes, I think we will. I do not know when it will come about, but I feel that it has to come inevitably. That is why we stated that all agencies, with the highway agency as the leader, should work together in solving the total urban problem.

Marshall Suloway

I would like to point out the example of the Congress Street Expressway, which is now called the Eisenhower Expressway. When this project began, the excavation from this expressway was placed on the north side of Chicago for an extension of the Outer Drive. Now, even though it is true that the fill was placed for another highway project, there was enough fill to create parkland. We have plans for many other projects such as this.

Robert G. Bartlett

In other words, by using the excavation from the highway project, you were able to add to the parkland in Chicago.

Marshall Suloway

Yes, and this was planned well in advance. In fact, the grading was done probably a year earlier than it was scheduled.

Robert G. Bartlett

You were also able to reduce the cost because of moving the earth only once.

Marshall Suloway

That is correct. In this particular case, we were able to move it by barge, and movement by water is much cheaper and less disruptive than movement by truck.

Robert G. Bartlett

William Gelbach, from a contractor's point of view, what is your reaction to governmental agencies designating such areas for fill and the contractor basing his bid on their use?

William Gelbach

If a bid is bought out and the date of the letting is set, the contractor will have a problem trying to find such a place at that late date. Unless there is multiple-agency organization, such as the one in Chicago, the contractor has to find a place early because if he does not, particularly in the Philadelphia area, the land values sharply increase. The ideal situation is exactly like the one in Chicago.

Robert G. Bartlett

Joint development, then, is more than just vertical use of land over a given corridor. Joint development can be horizontal in terms of using these facilities to benefit other community or municipal programs. If the highway could be the catalyst to providing new parks, new housing, and new recreational facilities, urban highways would be more accepted by the public.

UTILITY PROBLEMS IN THE DESIGN AND CONSTRUCTION OF URBAN HIGHWAYS

Marshall Suloway, Department of Public Works, City of Chicago

•ANYONE who has occasion to cut through the pavement of any city street in any major city will find that others have been there before. Any excavation project in a public way is almost certain to encounter the works of other engineers who were there previously. The excavator will find sewers, electric lines, telephone and telegraph lines, gas pipes, water mains, and a variety of other utilities that may be in use or may be abandoned. Whatever it is, and whether it is currently in use or is a historical relic, the excavator must properly identify the utility and respect its presence. Whatever is already there probably has a right to be there. The burden is on the excavator to plan a project to avoid disrupting the facilities of the utilities that first claimed the subterranean space. Or, if they must be disrupted, the excavator must give proper notice to get them out of the way.

Unlike an iceberg, most of any modern city is above the surface. However, that unseen fraction of the city that is below the surface is vital to everything that goes on above ground. A break anywhere in the underground maze of utilities could immediately spoil the day for millions of people in the skyscrapers. In a dynamic city, something is always being planned and built to improve the quality of life for the people who live and work there or to meet the demands of changing conditions. Every new improvement must plant its footings in the ground with utmost care to avoid stepping on essential facilities that are already there.

The Board of Underground Work of Public Utilities of Chicago was organized in July 1910 for the purpose of coordinating activities of the various organizations involved with subsurface or overhead equipment used in connection with public improvement projects. The board is a self-constituted body with voluntary membership and without statutory powers. The members have sufficient authority, influence, and standing in the organizations they represent to make and meet commitments. The board consists of representatives from the following agencies and companies: Chicago Departments of Public Works, Streets and Sanitation, and Water and Sewers; Illinois Department of Public Works and Buildings; Cook County Department of Highways; Chicago Park District; Sanitary District; Chicago Transit Authority; Commonwealth Edison Company; Illinois Bell Telephone Company; Peoples Gas Light and Coke Company; and Western Union Telegraph Company.

The board employs a full-time secretary and has an office in City Hall. The secretary acts as a clearinghouse, receiving and promulgating notices and information on planned public improvements. The secretary's work is carried on under the active direction of the officers and the executive committee. The executive committee meets frequently as required and prepares schedules for relocation of underground utilities as soon as possible after public improvement contracts are formally awarded. General meetings of all the board members are less frequent and are scheduled as needed to resolve conflicts and plan work schedules for projects involving relocation of a number of utilities. A primary consideration in all deliberations of the board is that of the public convenience. All work involving the subsurface use of the public ways must be planned for minimum delay, overall economy, and the least possible interference with traffic and residential or business locations on the street.

Perhaps the most useful means of explaining the procedures that have been developed by the board would be to follow the steps of a typical case. Figure 1 shows the steps

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Presented at the 50th Annual Meeting.

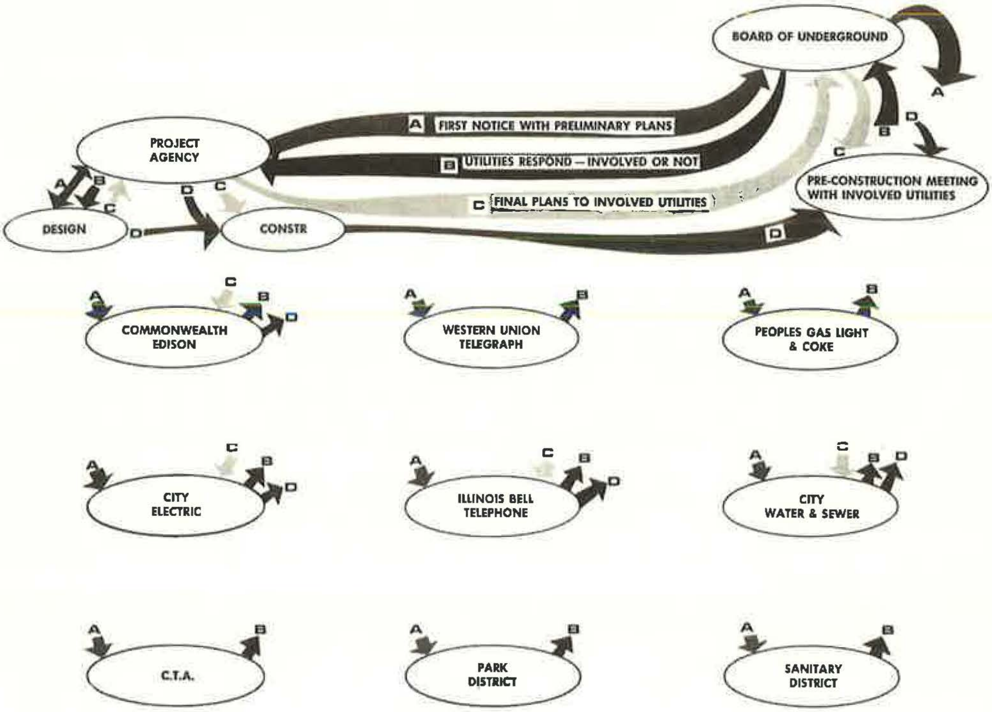


Figure 1. Steps in a typical project.

that are taken in an average project. When a project is adopted, the project agency notifies the board and supplies preliminary plans for distribution by the secretary to all of the member agencies who are asked to report promptly (and the secretary sees that they do) on whether they have any facilities at the site that would be affected by the proposed improvement. The replies and pertinent information from the members are then relayed to the project agency and used in preparing design plans and contract documents. At any point in this stage, informal conferences may be held between the designers and the agencies involved to work out problems. When final plans are completed, copies are sent to the board and relayed to the member agencies. Finally, when construction contracts are awarded, a meeting prior to construction is held at the board at which the member agencies, the construction agency, and the contractor work out detailed work schedules. Conflicts are extremely rare throughout this procedure, and when they do occur they are amicably and efficiently resolved on the spot.

Ninety-nine out of 100 underground utility relocations are handled in this way as routine business. The hundredth case might require some minor modification of the procedures because of the unusual magnitude or complexity of the project. For instance, Chicago's newly authorized central area subway system will provide the largest scale test of the board's services to date. This $750-million improvement, financed by formation of a special rapid transit tax district for one-third funding and federal funding for the other two-thirds, is expected to be in construction beginning in mid-1971 for completion late in 1978.

Figure 2 shows the transit project that involves construction of about 10 miles of subway lines in 2 separate but fully coordinated systems. The Distribution System will be a high-level system and, the Loop Subway will be underground, will do away with the unsightly elevated structures that have tortured the eyes and ears of Chicagoans since about 1900, and will contribute greatly to the growth of the city. Figure 2 shows the existing subway systems of the area and the elevated lines that will continue to serve until the new subways take over. Staging of construction is of paramount importance,

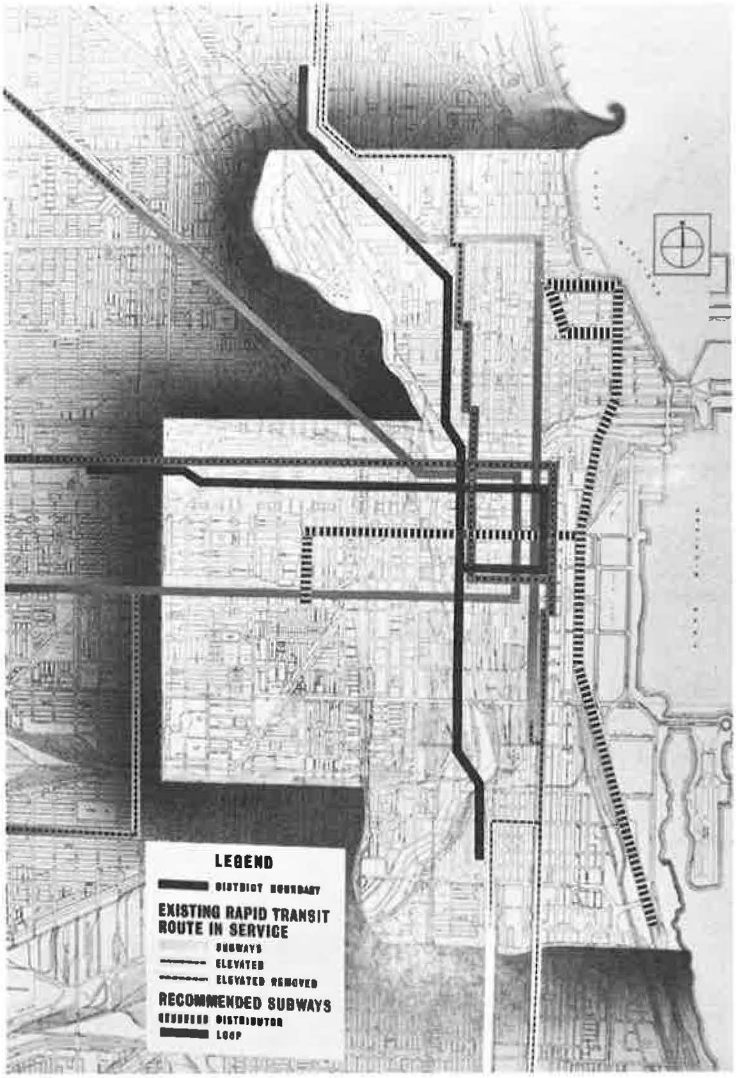


Figure 2. Central area transit project.

and the work must be accomplished without interrupting transit service or underground installations; streets must be kept in at least partial service throughout the project. During stage 1 (Fig. 3), the entire Distributor System will be constructed because all existing rapid transit lines will remain in service. No elevated structures will be removed in this first stage. Construction of the Distributor System will be mainly by the cut-and-cover method.

In the first step of cut-and-cover construction (Fig. 4), soldier piles will be placed as street traffic is carried on the outside lanes only. Excavation will begin in stage 2. Underground utilities will be exposed and supported, and beams will be placed to carry temporary timber decking for traffic. When the timber decking has been placed (stage 3), street traffic will be able to resume on the full width of the street as excavation and utility work goes on underneath. The subway structure and all utility work will be finished in stage 4. The excavation will be backfilled in stage 5, and the street will be repaved.

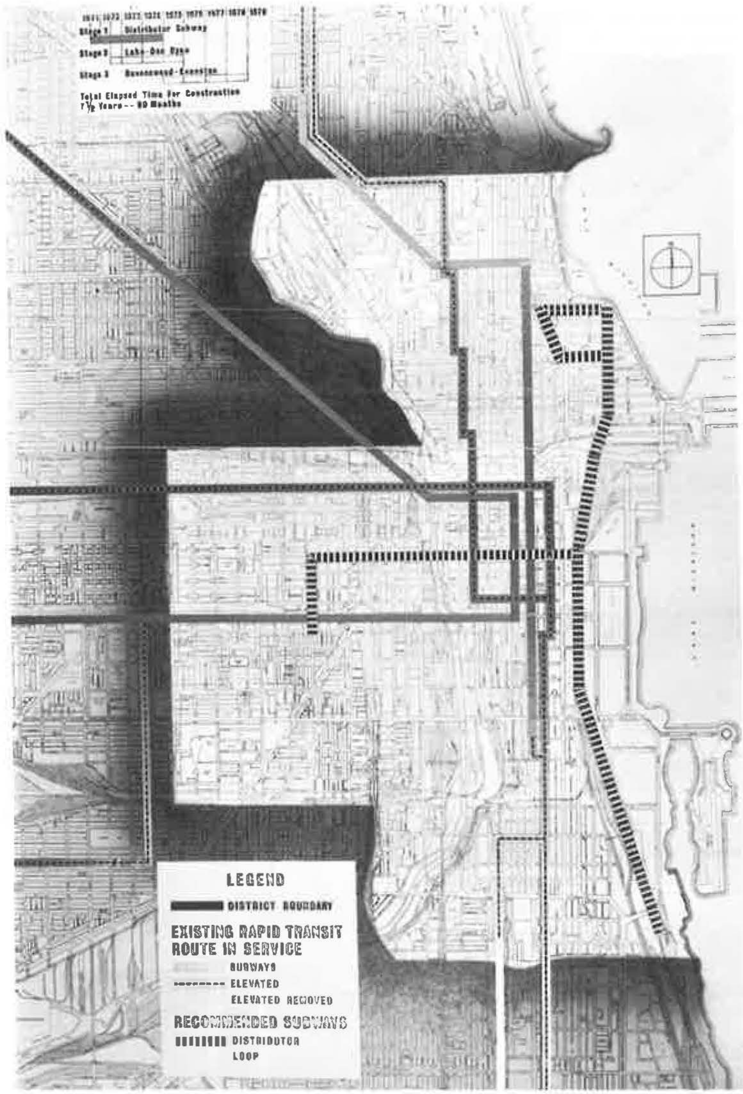


Figure 3. Stage 1 of central area transit project.

This cut-and-cover construction method has some complications. For example, the Distributor System is a shallow system that is extremely shallow at some points. At the Monroe Street Station where it crosses over and provides a transfer point with the existing Dearborn Street Subway, there will be only about 8 ft of cover above the Distributor System tubes, and all of the underground utilities must be accommodated in this cramped space. Obviously, there is no room above the tube for a fare-collection mezzanine level, so in the central area these must be built to the sides in the right-of-way of cross streets, and this will involve relocation of underground utilities there too.

In such cramped quarters, it would be difficult for each of the utility companies involved to carry out its own relocation work—the problems of scheduling so many different types of work with the precise timing needed would be almost too much. Therefore, it is probable that the construction contracts in cases of this sort will specify that the utility work be carried out by the prime contractor under supervision of engineers of the utility companies involved. That is one of the procedural departures from the normal routine described previously.

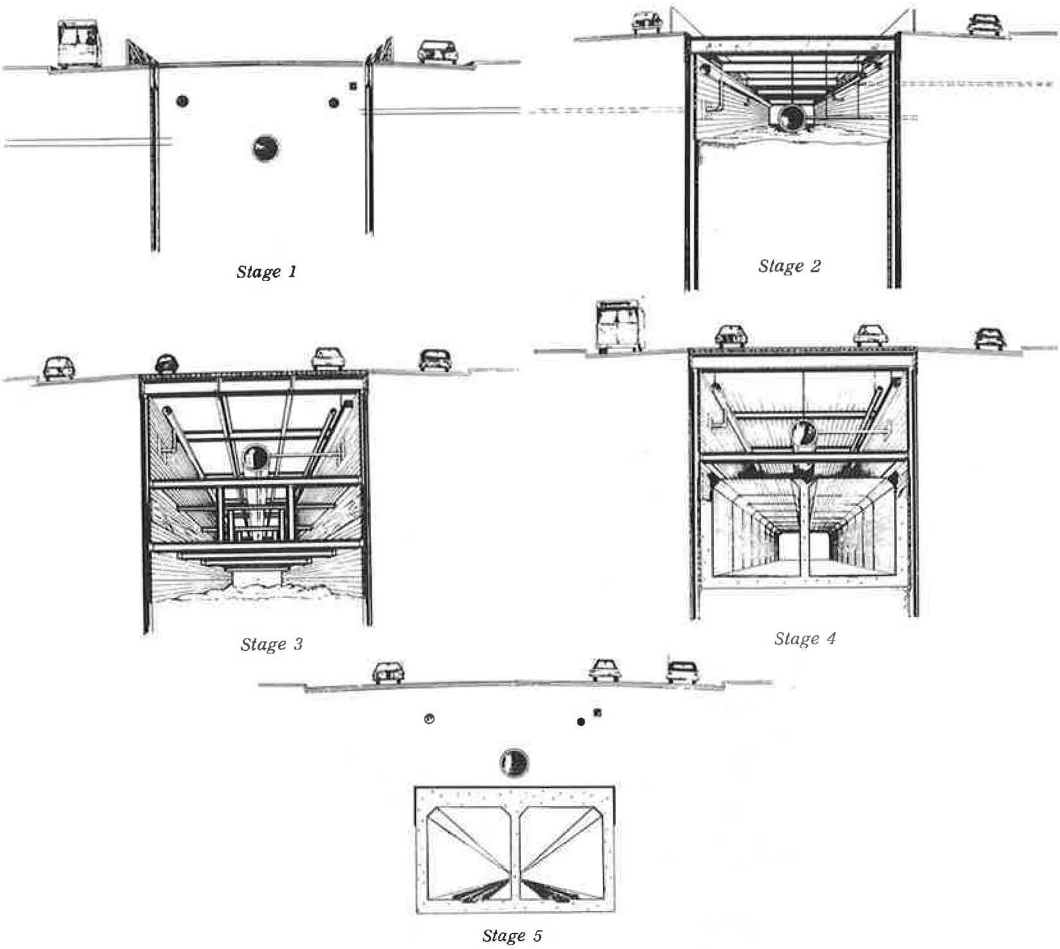


Figure 4. Stages of cut-and-cover construction.

Stage 1 of the construction, the building of the Distributor System will take about 42 months. Stage 2, construction of the west and south sections of the Loop Subway (Fig. 5), will also take 42 months and will begin about 1 year after the start of stage 1. Figure 5 shows all existing elevated lines and subways that will remain in service during this stage, together with the new Distributor System that will begin operation when completed. Some of the old elevated structures will be removed after completion of stage 2.

Because it will be at a deeper level, some sections of the Loop Subway will be constructed in a tunnel by using several types of mining such as the bench method or the shield method (Fig. 6). It is likely that machine mining (not shown) will also be used. Tunnel construction, of course, avoids much utility relocation work by simply going under the existing installations, but other complications of tunnel construction are caused by bascule bridges (Fig. 7) that have foundation piers going to bedrock and make a tight squeeze for the tunnel builders.

The existing elevated loop will remain in service during construction of the new Loop Subway. This presents some special problems that can be met only by cut-and-cover construction. Along Wabash Avenue during stage 2 construction, it will be necessary to sink soldier piles along both sides of the street (Fig. 8). Then it will be necessary to excavate to expose the footings of the elevated structure and install cross beams to support the temporary timber decking for the street, with trusses to take the load of the elevated structure while the concrete footings are taken out and construction goes

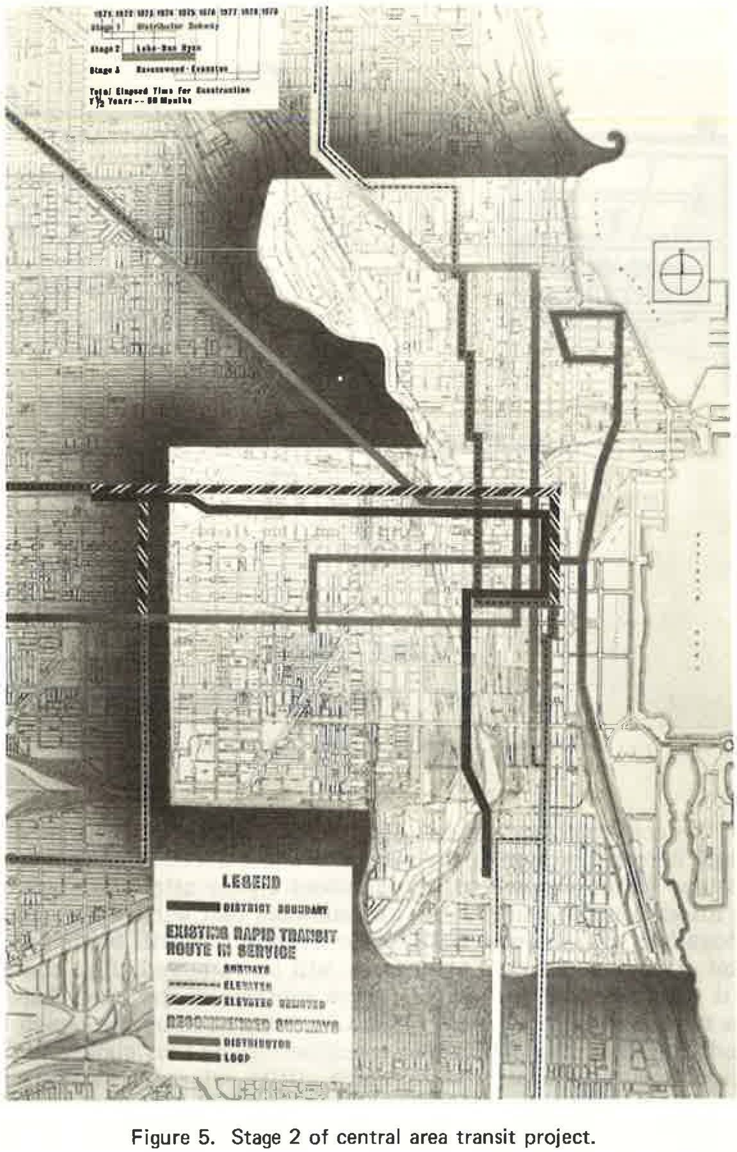
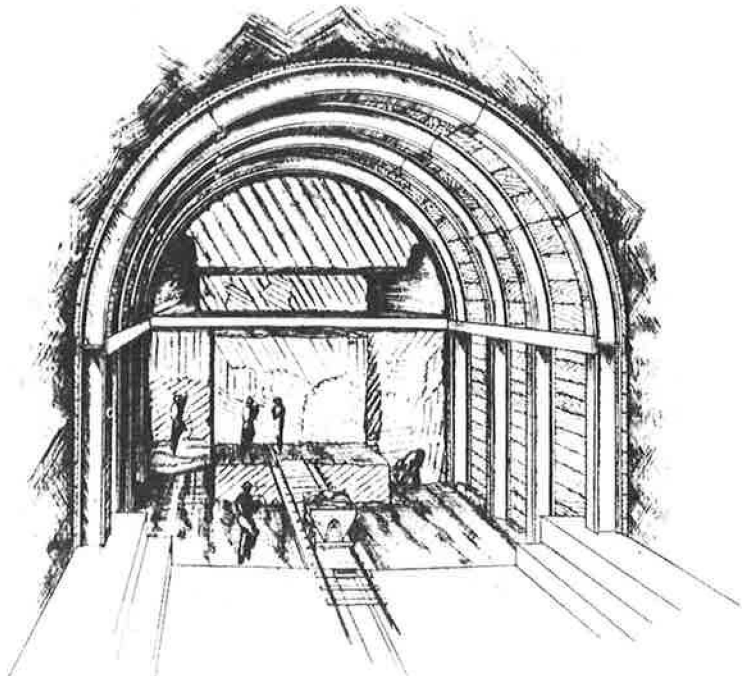
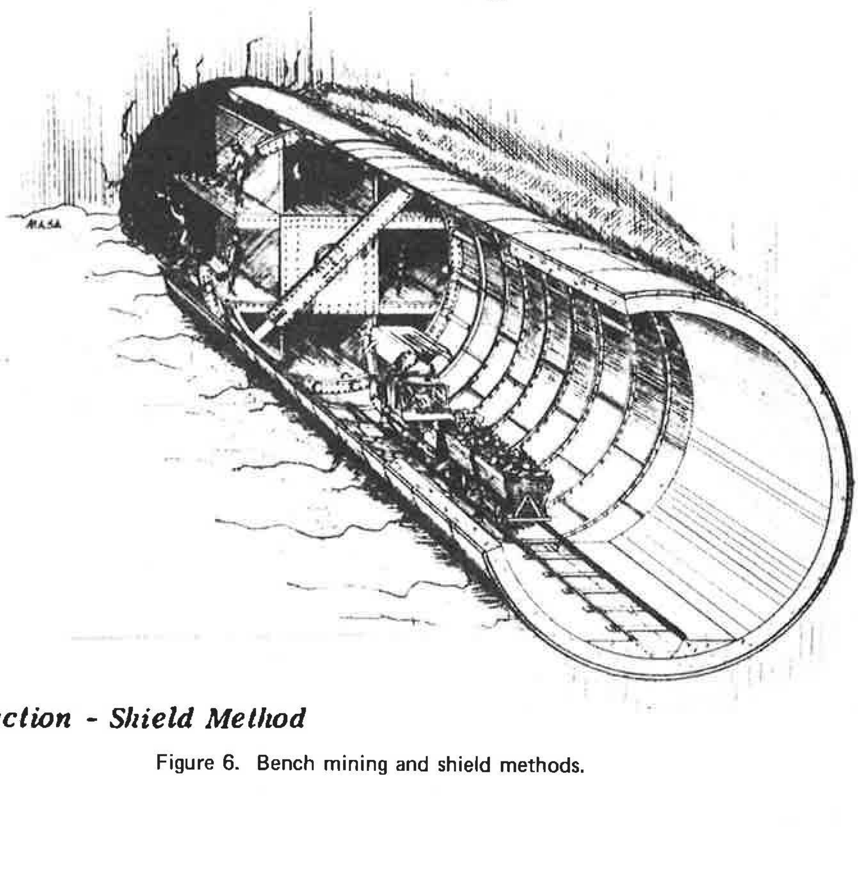


Figure 5. Stage 2 of central area transit project.

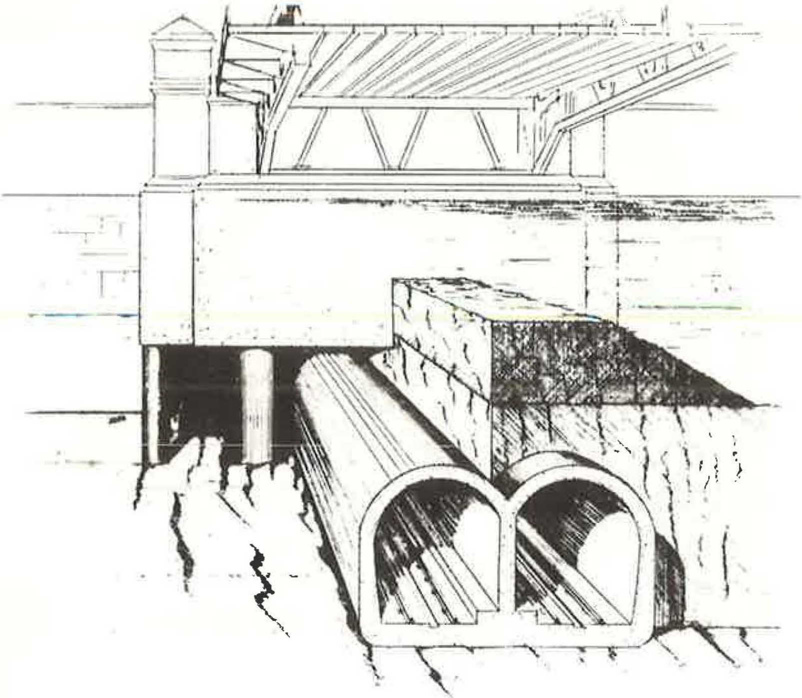


Tunnel Section - Bench Mining Method



Tunnel Section - Shield Method

Figure 6. Bench mining and shield methods.



Monroe Street River Crossing

Figure 7. Tunnel river crossing under bridge.

on below. The diagonals and vertical struts between the upper and lower chords of the trusses will somewhat complicate the work of supporting the underground utilities. Here again, the cramped space and multiplicity of work in progress may make it advisable to specify that much of the utility work be done by the prime contractors.

Stage 2 construction of the Loop Subway will include the South Connection to the existing Dan Ryan Line in the median of the Franklin Street Connector, an expressway extension that will be under construction at the same time as the subway. Although the exact alignment has not been worked out, Figure 9 shows the plan of underground utilities that will have to be dealt with where the expressway and subway join. The highway lanes will be in box structures under Harrison Street, with the subway tubes in tunnels, one above the other. Figure 9 also shows the profile at this location; and, if it resembles a 3-dimensional nightmare, it is! Almost every type of underground utility will be involved, and the Board of Underground Work already is working with the utility companies on the basis of preliminary plans so that construction design and contract documents can be prepared quickly when we receive final approval.

Stage 3 (Fig. 10) of the subway project will begin about 1 year before completion of stage 2 and will require about 4 years of work. The Franklin Street leg of the Loop and the North Connection will be constructed in this stage, and then the last of the old elevated structures will be removed in the central area of the city.

Throughout this major project, the Board of Underground Work will play an important role in clearing the way. The system has worked well for Chicago since 1910, and I am confident that it will continue to work well in the years ahead when we will be engaged in projects of unprecedented magnitude. If the methods developed by the Board of Underground Work of Public Utilities of Chicago seem simple and straightforward, I would observe that this is the principal virtue of the system. Its effectiveness depends on the sense of common cause shared by the participating members. The key is common purpose, common sense, goodwill, and confidence in the future of our city.

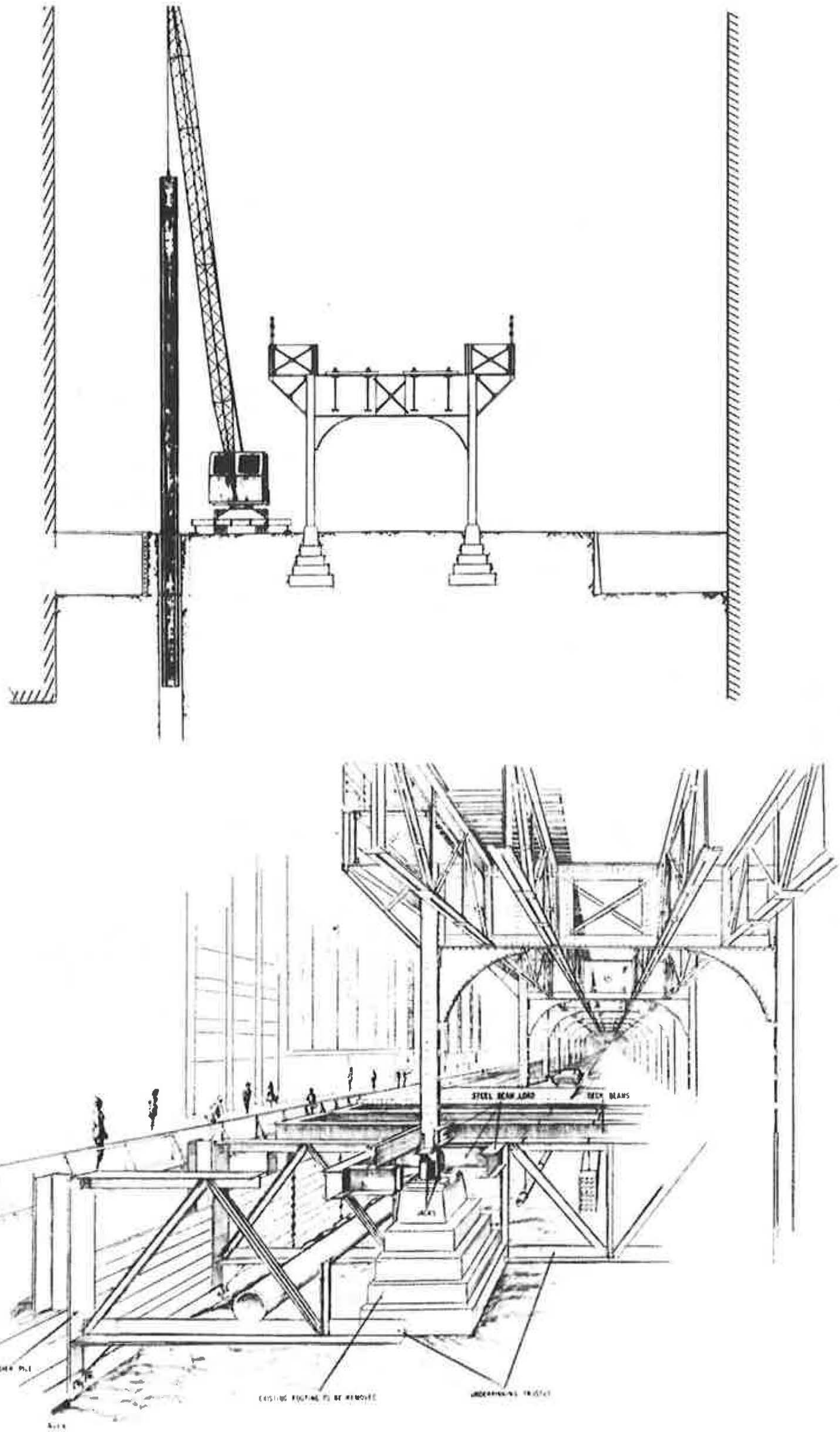


Figure 8. Placing soldier piles and underpinning elevated structure on Wabash Avenue.

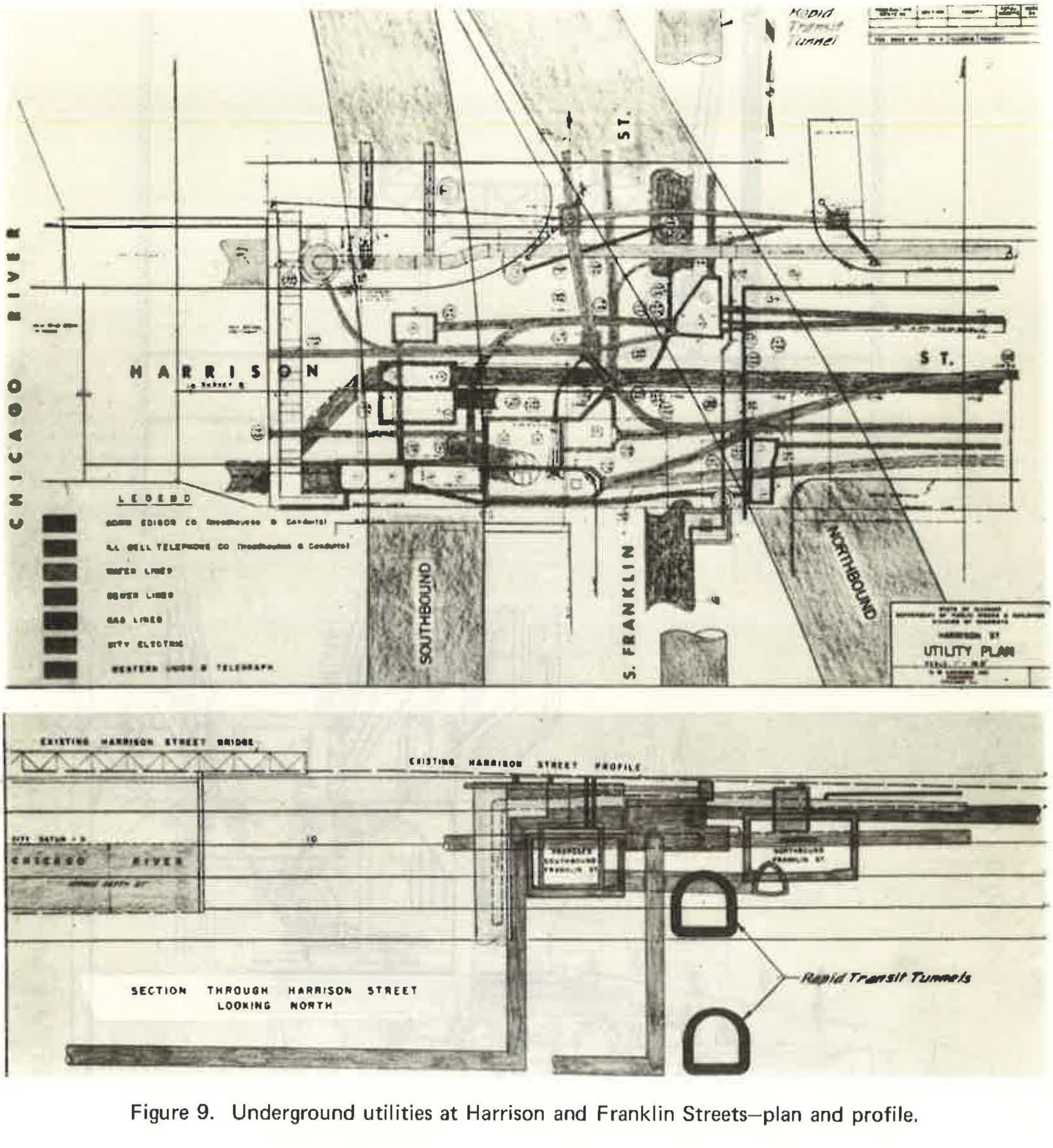


Figure 9. Underground utilities at Harrison and Franklin Streets—plan and profile.

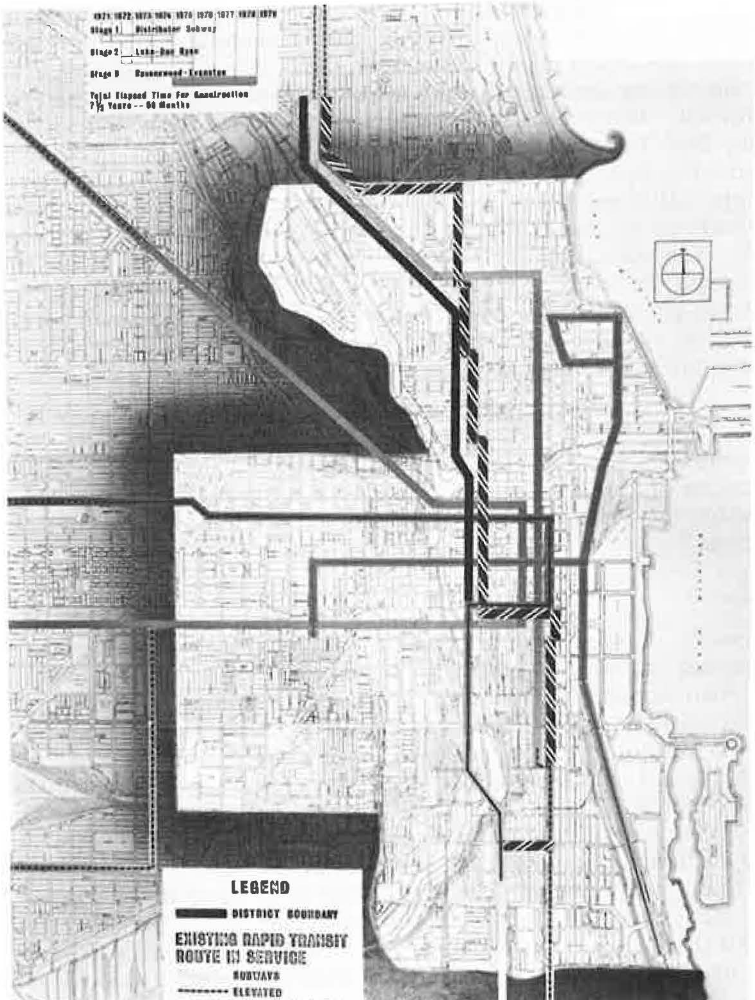


Figure 10. Stage 3 of central area transit project.

INFORMAL DISCUSSION

Robert G. Bartlett

It is obvious that Chicago has both private and public types of utilities. William Gelbach, what do you think of the prime contractor doing the multiple-purpose utility relocations and the related implications involved with coordination on the job?

William Gelbach

The idea from the standpoint of the overall construction is certainly appealing. However, the persons who are not involved in heavily unionized areas probably could not see the problem that could occur in Philadelphia. For example, there would be no problem for the prime contractor when such things as sewer work and water work would be involved. However, the electrical work, especially the electrical work handled by the Bell Telephone Company, could create a fiasco. The jurisdiction of labor problems has become a national problem. For example, there are problems between the operating engineers and the electrician. Throughout the nation today electricians want to run the bulldozers and the cranes where they are to put the cables in the trench. The operating engineers say, "No, we are going to run the machines; we will let you put the cable in the trench." The idea is wonderful and it would certainly help in the phasing of the construction if the contractor could control such operations. It would be cheaper and certainly faster. If we did so in our area, however, and had to relocate a utility other than water and sewer, we would have a fiasco.

Robert G. Bartlett

Marshall Suloway, what sort of problems do you encounter in Chicago with regard to the jurisdiction of labor problems in this type of utility relocation? Do you have the problem in which the private utility companies do not want the public agency to handle their relocations?

Marshall Suloway

It is, of course, a more simple problem when dealing with water and sewer lines than it is when dealing with electrical or telegraph cables. It is a problem but certainly not an insurmountable problem. The union problems in Chicago are the same as those in Philadelphia. I think that we are very fortunate in Chicago to have good cooperation. In addition, the top political leadership in Chicago has caused, if I may use that word, a good relationship between management and labor. If we are in a trench, we feel that at least we should put in the most disruptive thing and that is the duct work, whether or not it is put in by members of the electrician's union manning the rigs (they do this normally for the contractor anyway). Illinois Bell will probably elect to have them pull a cable. The main thing is building the manholes and getting the ducts in. Maybe we can go one step further, and I think we can. The prime contractor will put the duct work and the cable in, and then probably Illinois Bell will want to go into the manholes and do the splicing. This is no problem to the contractor coordinating the job. I think it is essential that the telephone company do the splicing because there are millions and millions of splices to be taken care of in a central area. Some construction for the public utilities has been accomplished in the past by the prime contractor. This is the first major job in which I feel confident that we will have the full cooperation of the utilities to permit the prime contractor to do the heavy work such as the ducts, manholes, and vaults.

Robert G. Bartlett

That is a very good point. I think it should be emphasized that a city must have responsible political leadership. Too often, political decisions deter the proper implementation of necessary programs. When there is a mature political process, many things can be accomplished because the coordination of the various agencies—private sector, labor, management—can then be achieved because there is proper leadership.

John McCue, do you have similar problems in Miami Beach dealing with utilities of the type that Marshall Suloway has just discussed, or do you have a different problem?

John McCue

I think the utility problems are universal. One question that I have related not to what to do to relocate utilities because of new construction but to what to do to find the utilities in the first place.

Marshall Suloway

This is a problem we have all experienced. One thing that an engineer knows when he goes in the utility space is that the utility is where it is supposed to be. On a job such as this, of course, the whole street is being torn up, and we are always lucky to find the utility. I must admit that the utility map of Chicago has been kept up to date extremely well. For example, suppose an engineer must relocate a gas main, and while underground he can see the telephone company's lines alongside the trench. If the old maps and old construction drawings have placed the lines in the wrong place, correct maps are done on the spot to replace the old ones. This is another board function—to alert everyone involved about the location of all the utilities.

Douglas B. Fugate

This question is related not to the relocation of utilities but to financing a subway system. We are planning a system in Washington, D. C.; financing has become a terrific problem. Have you any idea how much the Chicago system is going to cost and who is going to pay for it?

Marshall Suloway

Our latest estimate is $750 million, and it is to be financed one-third by local funds and two-thirds by federal funds. The local funding is through a tax district. This was decided by referendum in the state of Illinois and passed at the last legislature. We now have the vehicle to get the local funds.

William Gelbach

The Board of Underground Work is the best thing I have heard of in a long while for keeping records of the locations of utilities and maintaining the proper plans to know where the utilities are located. Unfortunately, contractors often find the utilities where they should not be found and we hit a water line or a telephone cable. If a situation exists such that the plans are current and accurate, it would certainly save many people from many problems.

Robert G. Bartlett

This would be particularly true of an urban area in which dense utility distributions exist. Is the secretary of the Board of Underground Work paid by the city?

Marshall Suloway

I cannot answer that question. I do not believe so, but I am not sure.

Robert G. Bartlett

Regardless of who pays for it, the city obviously gives its blessing and backing, and this makes it operate. All the utility companies, both public and private, and the city agencies are involved so that there is a clearinghouse.

Marshall Suloway

Another important function of the board is coordination. At the beginning of the year when the state highway department issues its annual program, everybody gets a copy of it. They also get the city's capital improvement program and the park district's program. In addition, the utility companies distribute their annual improvement programs. At the beginning of the year or near the end of the year, the Board of Underground Work will be informed by the gas company, for example, that it is going to install a gas main in one street and another gas main in another street. A list of the proposed additions is provided with the proposed time schedule. An electric company will do the same thing, and so will the other agencies. The programs are submitted early enough so that, if we can see a year ahead of time that we are going to have a sewer project in a location coinciding with a project of another utility, they will be scheduled for the same time. Why tear up the street twice? All utilities and agencies alert each other not only at the start of a project but also well enough ahead of time so that everyone is cognizant of what the other is doing.

THE CONTRACTOR'S PROBLEMS IN THE DESIGN AND CONSTRUCTION OF URBAN HIGHWAYS

William Gelbach, Glasgow, Inc., Philadelphia

•OUR COMPANY has been involved in constructing major highways in urban areas for many years. We first began during the time when the difference between rural construction and urban construction presented no extraordinary problems. The present problems of urban highway construction have snowballed because of the phenomenal growth in the number of automobiles and their constant use by their owners, to say nothing of the social changes that have occurred. It is my intention not to cover all of the many problems involved but to highlight a few of the more important ones such as labor, costs, phasing of the project, maintenance of traffic, safety, public relations, excavation, theft, and vandalism.

Urban areas are usually centers of strong union activity. Therefore, labor costs are much higher in urban areas than in other areas. Because of high labor costs and the longer period of time to complete urban projects, it has become increasingly difficult to predict the escalation of the various labor rates, fringe benefits, and restrictions on working conditions.

Urban areas normally have a great deal of nonhighway construction such as hospitals, schools, commercial buildings, and industrial plants. The availability of employment on these large building projects puts members of the labor force in the position of being particular in choosing where they wish to work. The result is that the productivity level of the workers seems to be decreasing at approximately the same rate that wages and benefits have been increasing. In rural areas it is often possible to offset these two factors by using larger, and therefore, more productive equipment, but the normal working areas on urban projects preclude the use of this type of equipment.

In the past, even though a highway was being constructed in an urban area, the site was usually not too congested. Therefore, phasing of the project was not of prime importance. Because of the ever-growing congestion of our cities, however, maintenance of traffic and relocation of utilities have led to the use of complex phasing by the contracting agencies. Many projects today are built in as many as 4, 10, or 12 different phases that make it impossible for the contractor to obtain respectable production on any items of the work. In many areas the utility-relocation problems have become so great that the contractor must come to a virtual standstill between various phases of the construction.

The consultant, when setting up the construction phasing of sequence, naturally makes his analysis so as to arrive at a construction sequence that will cause a minimum disruption for the local residential and business community. Although this is a very desirable and in many cases a very necessary concept, the costs involved become exorbitant. Take, for example, a case in which construction can proceed only from 9:00 a.m. to 3:30 p.m. in order to maintain maximum traffic flow during the peak hours. In this case, the contractor is required to pay 8 hours of wages for 6 hours of work.

Maintenance and protection of traffic were never critical nor expensive items of highway construction in the past. However, the car owner today considers his car as an extension of his home, and it seems that, in spite of the hazards and delays due to traffic problems, he still prefers to drive his car to and from work and to travel most of the time alone. On projects where heavy traffic flow must be maintained directly

Presented at the 50th Annual Meeting.

adjacent to and parallel with the new construction, the maintenance and protection of traffic become very major problems. Add to this the "curiosity crawl" of drivers in their attempt to watch the new construction work, and the magnitude of this problem becomes obvious.

If a traffic snarl does occur, it is not unusual for the contractor's material trucks to be stopped in this tie-up. If some of these trucks contain ready-mixed concrete, for which travel time is a critical matter, these tie-ups can be extremely costly. Therefore, good traffic maintenance is a must not only for the public but also for the contractor. In the past, a contractor could estimate these costs in his various items and the costs were reasonable. Today, however, on major urban projects it is not unusual to have the costs for maintenance and protection of traffic on multimillion-dollar projects run as much as 20 to 25 percent of the total project.

The Federal Highway Safety Act covering construction has made safety another item of prime importance that will require a more formal approach by the contractor. This is not to say that highway contractors were not safety oriented in the past. I am sure that any reputable contractor will tell you that "safety is our business" not only because of the physical and material discomfort involved but also because of the economics involved. A contractor who continues to have a bad accident record incurs increasingly high insurance premiums to the point that his high costs would reduce his competitive capabilities.

The contractor doing urban construction must attach great importance to public relations, particularly in the early phases of construction. In recent years many projects have received strong opposition from local community groups and, in some cases, from the news media. To offset this opposition and the continuing problems it could cause, the contractor should have either individual or group meetings with the people in the area to explain his activities to them. In some cases the contractor should even take small groups for a tour of the project.

Particular attention should be given to informing the local people of the projects using large quantities of explosives. Excavation and grading in this type of project present a set of problems entirely different from those encountered on rural work. For example, a 90-ft deep cut in solid rock is proposed. In the unpopulated areas this presents no great problem. However, if this same cut is made in an area where the top of the slope comes to within 30 ft of $100,000 to $150,000 homes, the contractor is confronted with an entirely different problem. The use of safety and public relations is the key to this situation. Let us assume, for example, that we are to widen an existing expressway carrying approximately 100,000 cars per day. We must maintain the traffic while we drill, shoot, and excavate a sliver cut approximately 8 ft wide and from 2 to 40 ft high. To further complicate the situation, let us assume that, when the original project was constructed and the rock excavated, cracks and faults occurred within the rock mass during the original blasting. Blasting this type of cut, therefore, is not only a very difficult operation but also a very expensive and time-consuming operation. Again, safety is the key.

Urban highway construction presents a very costly problem when excavated material exceeds the embankment requirements and when waste areas must be obtained. These areas are usually a considerable distance from the project, and the cost of purchasing the waste site is exceedingly high. When the situation is reversed and borrow excavation is required, the contractor is also faced with the high costs.

Hauling excavated material has become increasingly difficult not only because of traffic but also because of the many hauling restrictions placed on contractors by the various motor vehicle codes concerning overweight loads on urban streets and highways. This involves using much longer routes to move the material from one location to another and much smaller and, therefore, less economical hauling units.

Theft and vandalism in the urban areas have become almost intolerable. In the past 1 or 2 years in Philadelphia there have been cases where front end loaders and compressors have been stolen from the projects during the night and during weekends. Acts of vandalism are everyday occurrences and include the putting of sand, sugar, and other materials into the fuel tanks. These actions, to say the least, have a very disruptive and costly effect on these projects. Even the use of police and uniformed guards on constant patrol has not stopped these actions.

These problems are not unique to any one contractor. All contractors doing this type of work are faced with these situations and many more. We are striving daily to arrive at better solutions to these problems. All agencies involved in this type of construction must combine their efforts to find satisfactory solutions to these problems. If we do not, we will price our industry out of business because of the skyrocketing costs involved.

INFORMAL DISCUSSION

Robert G. Bartlett

It is good to know that the contractor is aware of the public relations aspects and implications of his work and assignment. The use of letters to the adjacent property owners, tours of projects to enable people to know the contractor personnel and the work schedule and tours of projects also help make the project's neighbor a watchman for people who may come on the property to perform acts of vandalism or theft. Ads in newspapers, signs, and other materials help to cultivate the goodwill of the local people. Building in an urban area is a challenge. If the highway administrator or the highway designer is not aware of the contractor's problems and he does not prepare for them properly, it is only going to result in an increased cost to the taxpayer with fewer results being achieved per available dollar.

Marshall Suloway

Have you ever thought of not hiring a safety engineer, and of hiring a noise consultant when working in urban areas on projects that involve heavy construction and moving or blasting rocks? Do you know of contractors who have done this?

William Gelbach

It is true that we have a man who handles safety. However, when we have a job in an urban area where there is much rock, we usually hire a technical outfit to take readings of every blast from the houses in the area adjacent to the construction. First, a survey of all the houses in the area is made by our safety man and an engineer from the firm that is going to take the recordings. They go around to all the people in the neighborhood, explain to them what we are going to do and why, and explain what effect it may have on them. However, with regard to noise, ecology, and all the things that are to be faced in the future, we have not had to deal with all these things yet. We have had a problem with noise, particularly on jobs that require 2 work shifts per day. The present earth-moving equipment, such as a TS-24, is louder than a sonic boom, but this is the way the machines are built and we have to use them. I think the manufacturer is looking into the problem, we are looking into it, and we are still involved with the economics of getting the job done as reasonably as we can.

Robert G. Bartlett

It is true that earth-moving equipment or construction equipment is basically a real noise producer. I know that an extensive amount of research is being done to eliminate having the steel-on-steel moving paws and to coat the parts with certain plastics or other noise-suppressor pieces. The turbine engines generate high pitches and whines and lack appropriate means to muffle exhaust noises. The construction agencies will have to specify what equipment they will permit and what decibel range they will consider as a maximum, and they will have to work through the contractors and equipment manufacturers to have the kind of equipment produced that will meet these requirements. It is going to cost money; I think we have mentioned this several times. We can protect and enhance the environment, and we can pay more attention to the design involved. The point remains, however, that it is ultimately going to be the taxpayer who pays the additional tariff.

THE MUNICIPALITY'S PROBLEMS IN THE DESIGN AND CONSTRUCTION OF URBAN HIGHWAYS

R. Ray Goode and John J. McCue, Dade County, Florida

•TRADITIONAL classifications of the county as rural and the city as urban are no longer accurate. For example, nearly two-thirds of our Model Cities area is included in the unincorporated area of Dade County and one-third in the city of Miami. The line marking the city limit does not mark any physical differences or change in population density.

Some of the problems related to highway design and construction as they are seen by the public administrator are described in this paper. To establish the range of these problems, let us assume that the decision to build a road has already been made. There are certain questions, difficulties, and problems that occur, and these fall into several well-defined categories: relocation of displaced persons; expressway design for adequate access and local traffic circulation; citizen involvement in decision-making on relocation, access to neighborhoods, and impact of new highways on the community; scheduling of construction and coordination of related projects; and public information and handling complaints. The following sections define the procedures associated with these categories.

RELOCATION

Urban highways can be classified as expressways or arterial streets. If we classify problems as "people problems" and "thing problems," then expressways seem to create more of the former and arterial streets more of the latter.

The greatest problem caused by expressways is the relocation of people displaced by the expressway construction. This relocation is really only an inconvenience if the person displaced can obtain suitable housing with the money provided him. Our laws require the condemning authority to pay fair market value to the owner of property needed for highways, and this ordinarily provides sufficient funds for that person to buy similar property elsewhere. However, if the expressway goes through an area where buildings are old and unsound or where real estate values are otherwise depressed, then the fair market values of these properties are small and insufficient for the owners to buy any other dwellings. In rental properties, which predominate in the deteriorating central urban areas, tenants are forced to look for other housing in an already crowded and now diminished area. The Federal Highway Relocation Assistance Act provides a solution to this problem where federal-aid roads are involved. For state and locally funded road projects it may be appropriate for us to review our statutes on eminent domain for any revision needed to provide similar relief.

However, in my opinion, a problem for the municipal official greater than that of obtaining relocation funds is coping with increased social dependency, crime, disease, fire hazard, and decline in property values caused by forcing people deeper into the slums when proper relocation cannot be made.

EXPRESSWAY DESIGN

From the viewpoint of the local government administrator, one of the design problems is the difficulty of providing adequate access to the expressway while maintaining safety. For optimum service to the traffic-generating sections within an urban com-

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munity, there is a demand for access ramps at intervals along the expressway closer than can be allowed for the weaving and speed changing involved in using ramps. Expressway traffic speeds require access points to be spaced as much as 1 mile apart for safety in making maneuvers, and this interval is much greater in the vicinity where 2 expressways interchange. This interval is also greater than the distance between arterial streets in many cases, and it means that some arterials cannot be connected directly to the expressway. Thus, the urban expressway is limited in its capacity to serve the travel needs of the community in which it is located. Many citizens who could receive benefits of saved time and cost of travel between home and work except for this limitation must continue to use the slower and still-crowded arterial streets.

Traffic engineers frequently would like to have arterials be one-way to facilitate entrance to and exit from expressway ramps and to use a split-diamond interchange to fit a parallel pair of one-way streets. Merchants claim that a change in the existing traffic pattern will ruin their businesses. The inevitable compromises afford ample opportunity, if diligently pursued, to annoy just about everybody.

Urban expressways tend to become nearly complete barriers that separate portions of a city. The grid pattern of our planned expressway system, part of which has been built and the remainder is in preliminary planning or design stages, could result in what appears to be a deliberate attempt to physically define and contain ghetto areas. At-grade construction and solid fill create Chinese-wall situations. In our extremely flat terrain, grade separations between expressways and arterial streets require costly solutions.

Many of our local community leaders have suggested that all expressways in urban areas be entirely elevated. This, of course, is extremely expensive because elevated construction costs approximately 6 to 10 times more than at-grade construction. However, even if 20 percent of these expressways have to be elevated anyway for grade separations at major arterial streets and if present urban area right-of-way costs generally equal construction costs, the most likely effect of elevating the entire expressway would be to approximately double the present cost.

This cost increase could be offset by the benefits of multiple use of rights-of-way, such as for parking lots (revenue producing) and for miniparks and schools (nonrevenue producing), under the elevated expressways. In addition, with appropriate amendments of present laws, air rights could be sold for private development above the expressways. If expressways in urban areas were entirely elevated, no existing surface streets would have dead ends, and this would be another benefit to local traffic circulation.

Economics seems to indicate that the Chinese-wall effect cannot be entirely avoided in urban expressway construction; yet, imaginative design can greatly reduce this undesirable feature. It may be a valid conclusion that the social ills created by the Chinese wall are more costly ultimately than the money saved on construction.

CITIZEN INVOLVEMENT

Citizen involvement may lead to the question, Where can an expressway be located if, indeed, it should be built at all? Although I have assumed that the expressway corridor already had been agreed on, it should be pointed out that the real question for a municipal official is, Where should an expressway be built? If there is no place where it can be built without producing more problems than it solves, then the question arises, Should the expressway be built?

Our state highway officials have been rudely rebuffed at recent public hearings held in our area to receive the community's response to expressway corridor location proposals. These adverse public reactions would indicate either that some proposed expressways should not be built at all or that a more effective public information program is needed to enable citizens to recognize the need for such highways within the community. Unless they fully understand their transportation needs and the alternatives available to satisfy those needs, citizens cannot constructively participate in the decision-making process intended by federal regulations prescribing public hearings during the planning phases of federal-aid road projects.

A centerline location of the proposed expressway does not answer a citizen's question as to whether his house will be condemned. He needs to know where the right-of-way lines will be; he also needs to know the time schedule. He does not want to live a few years in limbo while the government searches for money or debates on right-of-way lines.

SCHEDULING AND COORDINATION OF ROAD IMPROVEMENT

There are more than 730,000 motor vehicles registered in Dade County. When roads are built, improved, or just maintained, it makes sense to try not to inconvenience these drivers more than reasonable practice requires. However, to make approximately 20,000 per day out-of-state tourist drivers uncomfortable enough not to come back is suicide for us. Thus, we try to schedule work to occur during the off-peak tourist season. This is most difficult for 2 reasons. First, most arterial road improvement projects in urban areas require about a year of construction time, thus overlapping the season no matter when they are scheduled. Second, for the past 10 to 15 years more tourists have arrived in the summer than in the winter, and indeed we now have almost a year-round season. The months of April, May, October, and November are what is left of the slack periods. However, excellent promotion of the convention business does not allow a comfortable decrease in traffic; thus, scheduling alone does not help very much except on a small project.

Another approach that we frequently must use is to require that the road-building contractor maintain 2-way traffic on the road he is rebuilding throughout the construction period and that, where expressways cross existing arterials, the arterials be kept in operation except for certain short periods. In especially critical situations, we even require the contractor to do certain kinds of work between midnight and dawn to avoid intolerable traffic congestion. The result is, of course, that the contractor is hampered in his operation, and construction done in this manner costs more and takes more time.

For some time the design of improvements to a series of our main east-west arterials in the populous southwest section of our county has been complete; and, although these improvements are badly needed, we are scheduling only one project at a time because simultaneous construction would leave commuter traffic without any alternate routes.

Coordinating the various efforts related to urban highway construction is a difficult job. Few government projects are so embarrassingly obvious as the newly completed pavement that is torn up to lay utility lines. In Dade County we have attempted to overcome this planning deficiency by creating a construction coordinating council to keep all agencies involved in public works construction informed of current work programs and future planning. The monthly meetings of the council are attended by representatives of county and municipal public works organizations, the local utility companies, the Flordia Department of Transportation, and other state and federal agencies when their projects are concerned. Good coordination is thus effected, but, of course, the situation in a large urban area is much too complicated to gain perfect coordination; however, the procedure we have adopted has eliminated many problems of the past.

PUBLIC INFORMATION

Another problem the local government administrator is concerned with is providing prompt and effective response to citizen inquiries and complaints about projects affecting them. Too often we hear the complaint that a citizen's efforts to get the information he wants are fruitless because he does not know whom to call and his call is repeatedly referred to a succession of agencies until the right one is finally reached. Sometimes the citizen gives up before he reaches the agency that is responsible for the matter concerning him, and he is left frustrated and disillusioned about government efficiency.

This problem is, of course, magnified in a large urban area because of the multiplicity of governmental jurisdictions in such areas. In Dade County we have not only the county government engaged in public facility construction and maintenance but also the Florida Department of Transportation, the Central and Southern Florida Flood Control District, several federal agencies, and more than 24 municipalities—not to mention the many utility companies who also construct and maintain public service facilities.

To help reduce this problem in our community, the staff of the county manager's office handles citizen inquiries, transmits them to the proper county department or other agency, and follows up to see that they are given adequate answers. Although we do not claim to have eliminated the difficulties citizens encounter in seeking information, we believe we have reduced them substantially not only by organizing to handle inquiries and complaints but also by establishing good liaison with the other agencies active in our jurisdiction. Through exchange of information about projects under way or planned we try to keep ourselves well enough informed so that we can answer many inquiries without having to refer the citizen to the responsible agency for the answer. This not only saves time for the citizen and helps reduce the burden of public inquiries on the other agency but also improves our own image in the eyes of the people we serve.

CONCLUSIONS

Some of the municipality's problems in the design and construction of urban highways can be mitigated to a large degree if effective and continual communication is established between citizens and government agencies. This is important not only prior to construction but also, and especially, during construction of projects.

This would require the contractors, subcontractors, utility companies, and other persons involved in construction, as well as the transportation industry as major road users, to become partners with the government unit responsible for road construction and maintenance to form a public relations team. We feel sure that many complaints of property owners, residents, and road users could be eliminated if courtesy, concern, and helpfulness became an integral part of our daily construction practice.

INFORMAL DISCUSSION

Robert G. Bartlett

We have been criticized for the highway that pierces into an urban area, cuts across the fabric, and causes barriers. We are now trying to rectify the wrongs of the past, if they were that, and develop a highway that is compatible with the social fabric of the community, that flows with the existing street lines, that enhances the residential or the parkland areas, and that receives support of the people. The growing problem of the lack of credibility of the citizens in their governmental agencies is not limited to highways; it is another aspect of the political circumstance in which we live. We must, as highway engineers and planners, encourage programs that inform the public well before the public hearings occur so that the formal public hearing is the last step in a series of events in which the public has participated in the decision-making process.

William Gelbach

In reference to a previous statement, I feel that the public agency should participate in the problem of the high cost of construction. Many people would agree but would ask what the public can do. I think that the only way that we can ever solve the problem of the high cost of construction is to have some sort of wage and price control. I have read in a reliable source that construction workers are making $1,000 per week. Of course, we can say that, if the job is worth $1 million, it will cost $2 million, and the contractor is going to build it. If we are only putting in place 1 mile of highway instead of 2, 3, 4, or 5 miles of highway, taxpayers' money is being wasted. We must stop this inflation, We all talk about it, but we do very little about it. Anything that can be done to stop it will allow us to do a better job and to build better highways.

Ecology is something we need to concern ourselves with, and we should be able to spend the money for it. However, if we are going to spend more money to do the very simple things, from where will the money come to deal with the problems of ecology and noise abatement?

Robert G. Bartlett

These are very valid concerns. Can the public agency or should the federal government take the leadership of controlling construction inflation, or is there a need for federal legislation or wage and price controls?

Question From Audience

With the cost of construction becoming more and more expensive, is there an advantage to the state to improve the capability of the state highway department so that its own forces do the construction?

Douglas B. Fugate

I do not believe that this is the answer. The contractor is a specialist. He can construct highways better than can the highway organization that uses state labor. The state's role is maintenance and not construction. I do think, however, that the state highway commissions can help to control the problem that has been raised. More and more, we tend to cancel highway projects that exceed our engineer's estimate by a percentage that we feel is unrealistic. We use the money elsewhere and, fortunately, we are able to do that because we are still primarily a rural state, although we do have high-density urban areas. Sooner or later, people in the urban areas are going to find out that highway construction in their areas cannot be afforded, and they are going to become aroused. This is at least one way of dealing with this problem. I agree that wage and price control is the only absolute way to control the high cost of construction and whether we are ready to go to that is, of course, a question of national significance.

Robert G. Bartlett

Having been in the Pennsylvania state government, I am not convinced that government operations are the most efficient way of getting things done, from a cost-performance standpoint. We have looked at such things as the contracting out of certain maintenance services, such as snow removal, ice control, and other operational activities. In comparing costs, we find that the ingenuity of the American competitive enterprise system is still the most effective cost-performance way of getting things done. I am not convinced that taking over the construction activities would be wise.

Marshall Suloway

The system of free enterprise has reflected only a minor escalation in the cost of construction in the past years. This is because the contractors, in the competitive spirit of free enterprise, have been forced to cut down their costs because of the new technology, new equipment, and new methods of construction. However, with recent increases of labor costs, contractors can no longer make profits as they have in the past 15 or 20 years when new equipment and modern methods of building projects were common.

Robert G. Bartlett

The tailing off of productivity increases is well known. During the decades of the 1940's and the 1950's with the advent of the big earth-moving equipment, contractors were able to absorb the increasing cost because the productivity measures were increasing. I think one of the other things we must have is more openness. We must have the environmental hearings and the double public hearing. We must think in terms of time from project conception to project implementation and in terms of cost. A project could previously be completed in 5 years, but it now takes 8 years. The cost of these 3 years is denial of benefits. We must somehow use all of the measures needed to evaluate a project and make certain that a project is sound and in the best interest of the people.

PLANNING AND DESIGN INNOVATIONS OR HOW TO MAKE A FREEWAY A GOOD NEIGHBOR

A. L. Elliott, California Division of Highways

•WE HAVE plenty of problems and very few adequate solutions. It is difficult to build any kind of a highway through a congested city. It is difficult to plan. It is difficult for the contractor. It is difficult for those who must put up with the mess. People fear that the highway will bring noise pollution, fumes, smog, odor pollution, degradation of property values, congestion, and general disruption of a neighborhood. We have heard startling figures as to the amount of paved area there is in the average city that is used just to carry vehicle traffic. The laymen cry that the engineers will not be happy until they have paved the whole country and made it into one vast freeway.

Many of the solutions to these problems are really not solutions at all. They are merely stop-gap expedients to cope with some emergency. In a few years, some of these expedients will actually add to the overall problem. We must also face the fact that there are no perfect solutions. We are stuck with the fact that, no matter what we do, we are going to make a lot of people unhappy.

However, we should not lose sight of one fact—a fact that frequently gets obscured in the fog created by well-meaning crusaders. We highway engineers are not doing this maliciously. We get no sadistic delight in projecting a freeway across a city. We are not seeking ways to cause people unhappiness and trouble. Neither is the automobile an inhuman monster that is destroying us and our civilization. Very few automobiles run about by themselves. They always have a human at the controls, and all of the terrible machinations of this vicious automobile are merely being carried out to serve the whim or convenience of some human. No matter how bad the automobile is, we seem to prefer it to anything else and we tolerate it because it serves a purpose for us. We moan and cry about the trouble and nuisance it is causing. We advocate rapid transit systems to get other people off the road so we will have more room on the highway. The truth is that, with all its faults, the automobile has given man the greatest individual freedom that he has ever had to move about on the face of the earth. He is not going to give that up easily. Our problem as highway engineers, then, is not eliminating highways but making better neighbors of them.

What are we doing? What have we done in specific instances? What really should we be doing to adequately meet the future?

Let us start with the planning of the highway. Today, we are giving consideration to factors that no one seriously thought about a few years ago. It used to be standard practice when a highway was built through an urban area to head for the cheaper property. The highway people missed all the schools, hospitals, churches, and cemeteries and generally ended up going through the low-cost housing area. They often patted themselves on the back and explained how they were performing a sort of automatic and painless redevelopment for the city. They were getting rid of the unsightly housing, and the city did not even have to initiate a redevelopment project.

Somehow no one seemed to worry too much about all the people who lived there. There seemed to be a feeling that they were just sort of squatters anyway. For a long time, we did not find out how wrong this approach was because too often the people affected accepted their lot with the sense of overwhelming futility. Many families were not transients but lived in these stringent conditions generation after generation. Many found a sense of security in the crowded conditions in their neighborhoods and were definitely disturbed when well-wishers uprooted them and transferred them to small

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individual houses in open spaces. I am reminded of the Indians on a reservation in northern California who, when the great white father in his supreme wisdom built them frame houses and moved them in, moved their animals into the houses and pitched their teepees in the backyards.

We no longer head for the cheap property. Serious studies are made to see just how the neighborhoods will be disrupted and how many people will be displaced. I submit that there would often be less actual community disruption if the highway went through the high-priced property rather than through the low. Bought out and turned loose, those people have the means to fend for themselves far better than the people from the poor neighborhoods. This is not done, however, because the people with the high-priced property know to whom to complain to stop such an idea, while the people in the low-priced houses usually do not know how to effectively resist. All of this has been helped immeasurably now that we can spend highway money to relocate and resettle the people we displace. In our planning we are now concerned about the broader community impacts.

A controversy we continually get into when we plan a freeway through a city involves the question, Shall it be depressed, elevated, or at ground level? Where there is opposition to the freeway anyway, the common cry is to depress it; in some cases we have had to do that. Although there are far more good features in an elevated structure, a viaduct through a city reminds people of the Chicago El with all its noise, dirt, and general unpleasantness. People generally seem to feel that a viaduct will be more objectionable than a depressed section. To combat this feeling, we built several viaducts in Sacramento, making every effort to make them as attractive as possible. We made them with long spans and few columns and gave a great deal of attention to aesthetics. I think that we have succeeded to a degree in creating a desirable viaduct.

A viaduct is also a good answer to the argument that an urban freeway takes great quantities of land off the tax rolls. After the viaduct is built, the land under the structure can be occupied by stores, offices, service centers, parks, and recreation facilities. We have a great number of offices, post offices, banks, restaurants, warehouses, and automobile repair shops, and parking lots planned, but it takes a while to get them going. In spite of the seeming convenience and cheapness of building under a freeway, it is still cheaper to build away from the structure unless the adjacent land is quite expensive. These users do return the land to the tax rolls, though, and afford the city a return on the land that would otherwise be occupied only by the highway.

There is a material saving to be realized in the construction of the freeway viaduct if there were assurances beforehand that there would be stores or offices under the structure. Rather than being made long with various attractive architectural treatments, the spans could be made short and the columns plain. In this way, the construction cost could be greatly reduced. However, we have not yet found this possible. If the state is to take the risk of being left with an unattractive design if the buildings are not built, the intended occupant must put up a sort of guarantee bond. We have not yet found anyone willing to do this. At the planning stage, it may well be 4 to 6 years before the tenant can move in, and there are not many businesses willing to tie up their money and guarantee what they will be doing that far in advance. Therefore, we are still faced with building a structure that looks good even if nothing is done to utilize the land under it and it stands there alone.

Freeways and rapid transit evoke common complaints—they cut swaths across the urban community. A suggestion that works well is to put them both on the same right-of-way and minimize the disruption. We have done this on several occasions with both trains and special bus lanes. We have run the transit lines down the middle of the freeway, and we have provided special bus lanes where the buses can travel unhindered by ordinary traffic. Both of these ideas work well as far as quieting criticism and taking the least possible land. There are many other difficulties that this common usage causes, but these are surmountable and the net result is a better facility for the community.

One of the curses of expanding traffic volumes is that, almost before the concrete gets a weathered look, it must be taken out to widen the structures. No one has money enough to build the ultimate facility the first time around. We try to build for the next

20 years and frequently end up barely building for the next 10. This brings the headache of widening freeways and structures without interrupting the heavy traffic that is already overloading the facility. We have developed a number of alteration procedures whereby the structures can be changed to a semicantilever construction and the spans lengthened without tearing out the whole structure. This saves some money, but the main benefit is the convenience and safety of travelers and the avoidance of a lot of traffic disruption.

Noise pollution is becoming increasingly important. We have made several special solutions that solved nasty problems. A couple of large walls and the underside of a structure reflected noise down into a small group of houses in a hollow. We faced the walls and the soffit with sound-absorbent material and cut the noise level down to a tolerable amount. Many of the viaducts we are now studying have sound-barrier walls at least along one side. It is an expensive and not-too-aesthetic solution but may be necessary in some cases.

With regard to noise and pollution, I think we have to be careful lest we get misled into curing the effect rather than the cause. We have built lengthy berms surmounted by concrete walls to act as sound barriers. We are considering building unsightly sound barriers on our viaducts. We have sunk freeways into slots and tunnels to cut down the noise. Are we not, however, getting the cart before the horse? Is burning down a maternity hospital the proper way to effect birth control?

If your dog annoys you by barking, do you get bigger earmuffs? We ought to be thinking about the source. Most of the highway noise comes from trucks. Proper mufflers and adequate housing of the engines would cut down the major part of the noise, but there seems to be a general hesitancy to press this line of attack. If an aroused citizenry can make Detroit build cleaner automobiles and force the oil industry to produce cleaner gasoline, there seems little doubt that the truck manufacturers can build quieter trucks. This is something that should be given careful thought before we spend millions of dollars building unsightly solid barriers to confine the highway noise.

The aesthetic treatment we apply to our structures has had a great deal to do with their acceptability. We have gone to great lengths to make the structures attractive and also to fit them into the environment. These treatments include special shapes for the superstructures, rounded corners, special railings with colored parts, columns with new and interesting shapes, and abutments that enhance the lines of the structure. We have worked with teams and committees of people to get early agreement and approval of the design of the structures. We have found that when we do this there is general agreement and approval of the structures after they are built. In the construction stage there is a similar attempt to alleviate the pain.

One of the big problems of urban construction is building over traffic. Where it is possible, it is nice to be able to use precast or prefabricated members and swing them into place in the wee hours of the morning. The spans are getting so long and the members so heavy, however, that this is not always possible. More and more we are forced to use falsework and run the traffic through it. Inevitably when there is a heavy volume of traffic running through falsework, someone hits the falsework and occasionally brings the whole bridge down. We have worked hard on safety precautions to prevent catastrophies. We require steel or timber supports of considerable strength and then make sure that they are securely anchored at both top and bottom. The exposed face of the falsework is sheeted with 2-in. timber, and a regular metal highway guardrail is placed in front of all that. These precautions, coupled with generous openings, have served to minimize the hazard when falsework must be used with traffic.

There are many other things that can be done to ensure that the freeway will have a better reception in its new neighborhood. Noise and dirt during construction must be held to a minimum. We are careful about where we permit double shifts so that we do not get complaints about keeping people awake. Haul roads must be kept well watered to keep down the dust. Hauling on city streets is avoided wherever possible.

In some cases, contractors have launched their own public relations drives. Teams of men have visited all the neighbors and distributed literature telling about what will be going on and offering to discuss any complaints they may have. It is no surprise that a little personal attention will forestall a lot of criticism. A contractor was to build a skyscraper in the heart of the San Francisco financial district. He knew that for months a pile driver would be shaking the whole area. He hired a public relations firm that gave the pile driver a name and put out daily reports on his foibles and accomplishments. The pile driver developed into a personality rather than a nuisance. A lot of criticism and unpleasantness can be avoided by the proper approach.

Many of these solutions are merely expedients to combat the problem of the moment. We are slowly moving forward and raising our sights. Rather than dodging the rocks and trees, we are getting more foresight to look to see if there is not a better way to travel. We have come so far so fast that we wonder where we are going. We struggle through the design and the public resistance and finally get a freeway constructed through town, but everyone knows it is far from an ideal situation. A freeway is not easy to live with. The noise, the pollution, the division of the neighborhood—these things are all there to some extent no matter how well we plan. There must be a better way, and we wonder what it is.

We often say we should build the freeway first and let the community develop around it. The way it would probably develop would be that the businesses and commercial places would be as close as possible to the freeway to get the access and the exposure. The residences would probably be as far away as possible and yet still have access. This leads to another solution that is being tried in some places in the world. That is to buy a wide strip of land instead of just a 200-ft right-of-way, open up maybe a mile-wide strip with the freeway down the middle, and then let the commercial development take place along the freeway and the residential development away from it. The end result would probably be a much more desirable solution, but this embodies redevelopment, community planning, land use management, and a lot of things other than highway design. Right now this approach seems a long way in the future. Assuming that the highway is here to stay—and I do not think that any of us can assume otherwise—we are going to have to aim toward some such satisfactory solution. We are still trying, but it may be some time yet before we can really feel that we have made the freeway into a good neighbor.

THE LOWRY HILL TUNNEL FREEZE WALL

Norman R. Osterby, Minnesota Department of Highways

•THE TERM "bottleneck" was adopted years ago to describe the intersection of 2 main arterials at the edge of downtown Minneapolis. The streets—Hennepin Avenue and Lyndale Avenue—intersect in an extremely acute angle and resulted in an intersection that not only looked like a bottleneck in the plan view but behaved like one from a traffic operations standpoint (Fig. 1). Traditionally, this intersection led the city's list of the 10 most accident-prone intersections.

Placing the corridor alignment of the Interstate highway through this intersection taxed the imagination and design abilities of engineers. Eventually placing the Interstate in a tunnel under this complex evolved from designs submitted by a consulting engineering firm for the state. Although vehicular tunnel construction may not be unique to many, this length of tunnel was a first for Minnesota; and the construction problems associated with excavation, foundations, and protection of traffic and adjacent structures presented a challenge. Much local interest was generated by a unique method of excavation and earth retention employed in the construction of the tunnel. The method we used was a huge freeze wall.

The Lowry Tunnel is a 2-tube, 6-lane reinforced concrete tunnel 1,500 ft in length. It cost $8 million. It was constructed by the cut-and-cover method underneath the Lowry Hill bottleneck. When the tunnel is complete, the same basic local street pattern will be reconstructed on top of it with one important exception. The traffic will no longer intermingle and criss-cross the intersection as it once did to produce some monumental rush-hour traffic jams.

The tunnel itself was constructed extremely close to the southwest corner of Hennepin Avenue Methodist Church (Fig. 2); in fact, the tunnel footing at the critical clearance point measures 15.5 ft horizontally and 26.5 below the church footings. The local soil in place is a fine sand, of which 80 percent passes the No. 40 sieve. How is it possible to excavate so close to the church structure and yet absolutely prevent dangerous soil movement? Engineers of the Minnesota Department of Highways were concerned. Conferences held with various engineering experts ruled out tie-back systems, chemical soils solidification, and interior bracing of sheeting for various reasons. This left ground freezing as the first choice. It was recommended that the earth between the tunnel and the church be frozen from a point 80 ft north of the critical point to 40 ft south of this point before excavation commenced in this area.

The installation of freeze piping and refrigeration equipment at the job site is relatively simple. In the construction of a vertical freeze wall, it is necessary to drill freeze holes at a predetermined spacing. This spacing usually varies from 3 to 6 ft on centers along the length of the freeze wall, and holes are drilled to a depth of approximately 10 percent greater than the required depth of the freeze wall (Figs. 3 and 4). The removal of Btu's from soils is the simple function of time, but it can vary with the thermoconductivity of the soil. As a rule of thumb, 3-ft spacing of freeze holes would provide a freeze wall in, say, 10 to 14 days. A 7-ft spacing of freeze holes would provide the same freeze wall in 50 to 60 days. The spacing of the freeze holes also provides the thickness of the freeze wall. A 3-ft spacing would obviously give a 6-ft thickness. In the case of the Hennepin Avenue freeze wall, we used 3 rows of pipes on 3-ft centers, giving an effective width on top of 9 ft (Fig. 5). The front face of the freeze wall was vertical. The back face was battered. This was accomplished by installing

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Figure 1.

Figure 2.

the front row of freeze pipes vertically, slightly battering the middle row of pipes, and installing the back row on the slope desired as batter for the back face.

Freeze holes are usually drilled approximately 4 to 6 in. in diameter. Freeze piping is installed in these holes as the drilling progresses. Freeze piping consists of either two 1½-in. freeze pipes, which act as a supply and return in each hole, or one 4-in. pipe in the hole, which will have a 1½-in. pipe contained inside to act as a return.

When the freeze holes and freeze piping are completed, the surface piping is installed. This piping includes manifolds that control the flow of brine in each freeze hole and the supply and return lines to the freezing unit. Freeze piping that is used in the freeze holes is generally black iron pipe. The surface range piping is generally plastic pipe; the main supply and return lines or headers are black iron pipe. All of the surface piping is insulated.

The hookup to the refrigeration unit is simply a matter of connecting the supply and return lines (Fig. 6). The refrigeration unit requires either 220- or 440-volt, 3-phase power. Water supply of about 3 gal/min is required for use in the cooling towers. In addition, certain instrument holes are drilled to monitor the freeze wall. These holes are usually 1½ in. in diameter and cased with black iron pipe.

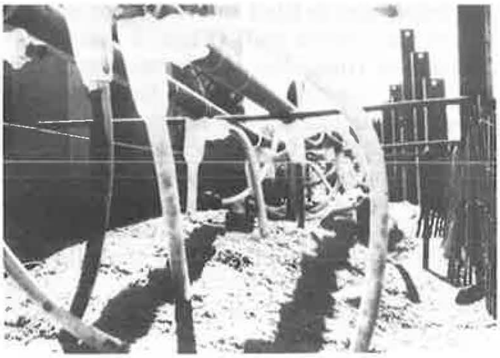

Figure 3.

Figure 4.

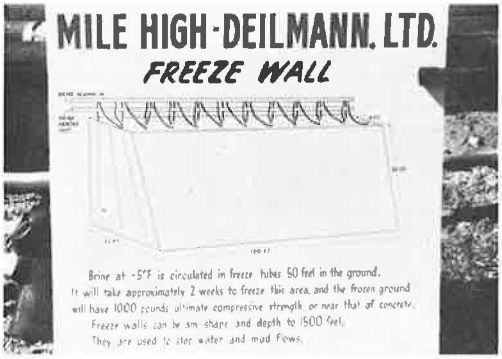

Figure 5.

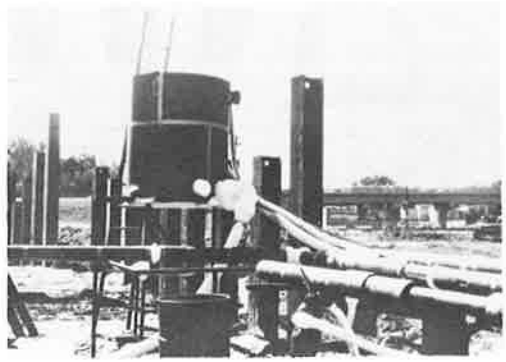

Figure 6.

Once the freezing unit is connected and the initial freezing process is taking place, it is necessary to have one man on the job site to balance out the freeze lines and monitor the instruments. Once the desired freeze wall is obtained and excavation commences, the refrigeration unit operates only to maintain the existing freeze wall. During this period, the unit is operating at about 50 percent capacity and requires little maintenance. The unit is completely automated and has automatic shut-offs to take care of contingencies such as broken brine lines or loss of power or water.

When the freezing operation is complete, the freeze pipes can be removed easily and economically. It is usually worthwhile to remove these pipes for the value of the pipe. The surface piping can, of course, all be salvaged.

The refrigeration unit used at the Hennepin Avenue site consists of three 75-ton compressors and three cooling towers (Figs. 7, 8, and 9). These are mounted on a standard flatbed semitrailer for over-the-road maneuverability. Freon is used in the compressor units, and the brine is pumped through a heat exchanger on the unit and into the freeze wall circulatory system. The temperature in the freeze pipes is generally between 0 and -10 F. A medium used as a cooling agent must have a freezing point sufficiently lower than these temperatures. Magnesium chloride or calcium chloride are generally used for this brine.

A common question we have been asked is, "What about expansion of soils caused by freezing?" There is an increase in volume in certain soils due to freezing. We are all familiar with the fact that a given volume of water will have a volume increase of 9 percent when it is frozen, but this simple fact does not necessarily hold true in the construction freezing process. A volume increase of water is in a contained quantity of water. In construction freezing, the 0-C isotherm is a continually moving thing radiating out from the freeze pipes. Depending on the permeability, a portion of the

Figure 7.

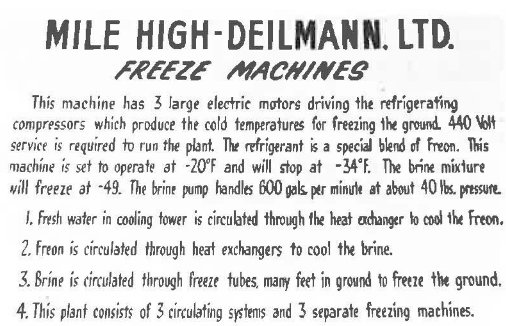

Figure 8.

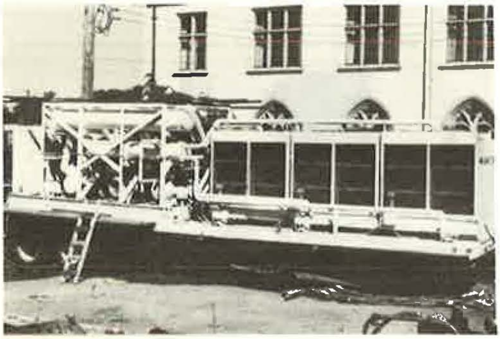

Figure 9.

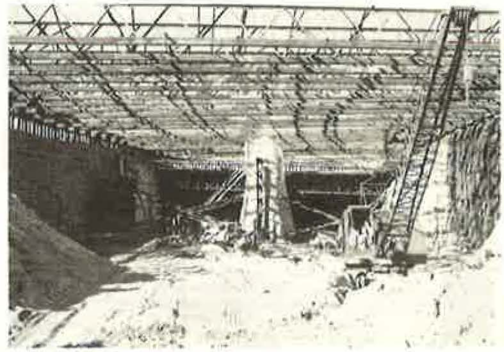

Figure 10.

water is forced out of the material ahead of the 0-C isotherm and is not contained in the freeze wall. The volume increase of the water remaining in the soil after passage of the 0-C isotherm is usually absorbed in the soil pores and does not increase the bulk volume.

From a practical standpoint, the following rules of thumb can be used: In sand and gravels, the volume change is negligible and usually cannot be measured. In clays with high moisture content, increases as much as 2 percent have been noted, but this amount of volume change is the exception rather than the rule.

It may be of interest to note that laboratory tests are, of necessity, always made in containers. For years it was a question of why volume increases and ice lenses that were developed in the laboratory did not develop when freezing was used in the field. It has only been recently that the significance of the moving 0-C isotherm and containment has been recognized.

The fundamental requirement for the application of the freezing method is that the ground must contain enough moisture to gain stability when ice is formed. Complete filling of the pore space with water is not necessary. A very thin film around the soil particles is all that is required. Conversely, water saturation does not cause any problem. The appearance of groundwater currents, however, requires special attention and might make other supplementary procedures necessary.

In the case of the Hennepin Avenue project, we estimate we had a freeze wall with a shear strength of more than 600 psi and an ultimate compressive strength of more than 1,000 psi.

To our knowledge, this is the first application of a freeze wall for temporary earth retainage on a highway construction project in the United States (Fig. 10). Increasing construction and reconstruction projects in urban areas and costly temporary earth retention designs and devices required to protect expensive property may cause engineers to look more and more to ground-freezing techniques.

The opinion of our engineers is that safety of the church structure was ensured about equally by underpinning and by the freeze wall. The factor that tipped the scales toward the freeze wall, however, was cost. Estimates placed the cost of the freeze wall about $10,000 less than that of the underpinning. The cost was as follows:

Item	Cost
Furnish and install 220 to 440 volt, 3-phase power source	$ 2,000
Construct freeze wall	29,609
Maintain freeze wall (88 days at $447/day)	39,336
Cost to state	$70,945

Item	Cost
Credit allowed state by contractor (resulting from sheeting not required in area of freeze wall)	$20,000
Maintain freeze wall (additional 5 days at $447/day)	2,235
Cost to contractor	22,235
Total cost	$93,180

Although underpinning appeared to be $10,000 more in cost, sheeting would still have been required to hold the subsoil firmly against the underpinned church footings. Installing this sheeting would have meant more vibration than we felt we could tolerate this close to the structure.

We are satisfied with our first trial of construction freezing. Construction freezing has been in existence, however, since the early 1930's in Germany and Russia. In the United States, we understand that ground freezing was applied as an emergency measure in the construction of the Grand Coulee Dam. A notable freeze wall was used during construction of a nuclear generating plant for the Public Service Company of Colorado in Platteville 2 years ago.

ACKNOWLEDGMENT

Grateful acknowledgment is extended to Mile-High, Deilmann, Ltd., Wheat Ridge, Colorado; Lake States Engineering Corp., Park Ridge, Illinois; Oster and Pederson, Inc., Minneapolis; Foley Bros., Inc., St. Paul; Wheeler and Tillett, Inc., Minneapolis; and W. M. Crawford and M. H. Herbers, Minnesota Department of Highways.

DISPOSAL OF MATERIALS IN URBAN FREEWAY CONSTRUCTION

Glen R. Watz, Michigan Department of State Highways

•THIS paper will present some of the problems of disposing of materials in urban freeway construction and discuss some of the means used by the contractors to cope with the problems. This should also shed some light on factors contributing to the constant rising cost of the construction. Keep in mind that, by specification, all material not specifically designated for use on the project becomes the property of the contractor.

The material to be disposed from freeway construction can be grouped into 4 major categories: trees, stumps, and other vegetation; concrete pavement, curbs, sidewalks, and foundations; earth excavation; and junk and debris. Until recent years, trees and stumps caused no particular problems because they could be bulldozed to the middle of the right-of-way and burned. The only inconvenience was that of obtaining a burning permit from the local governmental agency. As the people became more conscious of air pollution, burning permits were no longer issued. The organic material then had to be hauled to the city dumps where burning was permitted. This too passed, and areas on which burning could be done were found in the neighboring communities. Eventually, no place within an economical haul distance could be found, so the contractors turned to burying the material in the bottom of worked borrow areas. This method requires haul distances sometimes of 40 miles to the disposal site.

The most recent innovation for the disposal of trees and the like is a chipper that will handle trees up to 21 in. in diameter. Anything larger than this must be split into a size the machine will take. This operation, along with the stump chipper, reduces the entire tree to chips that may be disposed of in the city dumps. Much of the material is lost within the right-of-way and is mixed and disposed of with the excavation. Oddly enough, little of the timber is used for firewood or lumber. The market is so undependable that it is not a bidding consideration.

Methods are now being pursued to develop a market for the wood chips to be used as a mulch. Recent reports indicate that wood chips may be an excellent mulch for erosion control, and this fits very nicely with the present emphasis on control of water pollution.

The toughest disposal problem is posed by the concrete rubble created by the removal of pavements, sidewalks, curb, and foundations. If this material is not massive and contains no reinforcing steel, it can be salvaged and run through a crusher to produce coarse aggregate for paving mixes. Even this simplified disposal method is not without its shortcomings. With all the zoning, noise and air pollution, and other "anti" ordinances, the contractors often have trouble keeping up with the changing of the times and moods of the people.

The rubble or so-called "hard stuff" that cannot be reduced to a usable size must be disposed of in other ways. Infrequently, there will be a fill area on the project of such size that will permit the incorporation of some of this material. Generally, the material has to be hauled away.

Hauling is an expensive operation because weight is the prime consideration, and capacity loads, in relation to volume, cannot be hauled. Free dumping areas for rubble are never found. People just do not want a field or ravine full of large blocks of masonry, concrete, and reinforcing, especially when the vacant land surrounding the urban areas is a potential development site.

Presented at the 50th Annual Meeting.

Where the contractors are able to buy dumping privileges, the restrictions are very rigid. The material must be spread and interspersed with earth to form a fill much the same as required for highway construction. The situation is such that most contractors try to maintain 2 or 3 dump sites to provide adequate areas over which to spread the material and keep the operation moving. Again, hauling distance is a very important factor as some of the dump sites are 40 miles from the project.

Where the situation permits, the rubble will be hauled to the sand pit being worked for the project. Although this generates some saving because the contractor is able to haul in both directions from the pit, part of the saving is expended in that the material must be piled someplace on the project, out of the way of construction, and later rehandled for loading when the sand operation is being carried on.

Although the junk and debris category is not necessarily the most troublesome, it is the most aggravating and is created by the "midnight dumpers." This material grows on the right-of-way every night throughout the term of the contract and often for sometime thereafter.

The people in the vicinity of a project find a very convenient disposal ground for all the junk that has been accumulating and is otherwise difficult to dispose of. This debris ranges all the way from sacks of garbage to kitchen stoves, refrigerators, and even abandoned automobiles. It is not uncommon to find loads of trash and garbage, an indication that commercial haulers do not object to using the right-of-way as a convenient accessible dump. On one particular job this material was reported to average about 1 ft deep over the entire area. Prior to opening one short stretch of highway in the downtown area of Detroit, 3 stripped and abandoned automobiles were seen on the roadway.

Because of the nature of this debris, most of it has to be hauled to and buried in the bottom of the sand pits along with the concrete rubble. When the quantity warrants the work involved, the metal objects go to the salvage yards and the automobile bodies to the crusher. One contractor reports that, depending on the size and location of the project, from $3,000 to $10,000 are included in the bid prices for excavation just to dispose of the junk and debris.

Most expressways in urban areas are constructed as depressed sections, and all of the excavation material is waste. Occasionally, a situation will develop where some of the excavation material can be used to construct embankments. However, this is rare. Although seams of granular material are at times found in the excavation, the contractors do not find it economical to salvage the sand because the magnitude of the operation prohibits the changes necessary to do the selective grading and stockpiling.

During the early part of the expressway construction in Detroit, dumping areas for sound earth were relatively easy to come by. Vacant lots were in abundance, and those who owned the floodplains along the rivers were more than happy to receive the earth on their sometimes inundated property and thereby to salvage it for a more profitable use. Generally, this type of dumping involved no payment. Occasionally, the contractor would receive up to $1.00 a cu yd for material in small lots as opposed to paying as much as 25 cents a cu yd for dumping rights in large volumes.

Now the situation has changed. Most of the vacant lots are full, and those that are not are too small to accommodate the large hauling units. The floodplains have come under the close scrutiny of the Corps of Engineers, the State Department of Natural Resources, and county government. The current rules and regulations effectively preclude these areas as dump sites.

As the availability of the local sites waned, the disposal problems were compounded. To economically haul greater distances, contractors purchased larger hauling units. What started out to be an operation with 5- and 7-yd trucks has now developed into hauling with 15- to 18-yd loads on the triple or quadruple axle units and 30- to 35-yd loads on the trains. These hauling units require an area about three times their length, or up to 180 ft, in which to maneuver, so large dump sites are needed. The open spaces of adequate size are farther out, and this increases the haul distance. Earth is now being hauled as far as 20 miles from the project.

Most of the mining and dumping is controlled by local ordinance. Ecology is now in the foreground, and every low spot does not automatically provide a disposal site.

The local agencies have restrictions on hauling activity, and haul routes must be established before work commences. The quality of the local road systems does not always permit the shortest direct route to the dump site. The contractor has the responsibility for making arrangements for the haul roads, and this means he must post a bond to ensure repair of the route used. As the construction proceeds farther out from the downtown areas, better roads are found and haul-route problems tend to decrease.

The populace is becoming more and more intolerant with the inconveniences created by trucking, noise, congestion, and dust. Noise and congestion are difficult to control, but the dust problem has made it necessary for the contractors to purchase sweepers, especially for city streets, to keep the dust at a tolerable level.

In the past 5 years the cost of excavation has about doubled. Because trucking represents more than two-thirds of this cost, the increase can be contributed directly to much higher labor rates and longer hauling distances. In the event that the design of a given section of expressway lends itself to balanced grading, trucks are necessary because the city prohibits the use of scraper type of equipment.

I stated earlier that all excavation becomes waste to the project. That does not mean that it becomes waste in the strictest sense because nearly all of it is put to some use that benefits either an individual or a community as a whole. No market, as such, exists for the earth, so it is disposed of as a mutual benefit to both parties, the contractor and property owner. When it is convenient, the highway department will designate areas where the contractor may dump the material. This may be an embankment area for future construction or on the right-of-way of existing facilities. Some examples of this include filling a wide depressed median to provide an effective glare screen, removing and backfilling an old interurban railway, and filling the median of a divided roadway. The drainage course was tiled, and the backfill greatly enhanced the safety aspects of that section of roadway. The contractor was required to furnish the work and materials necessary for turf establishment in all of these cases.

Some community improvements made possible by the availability of free fill dirt are parks and parking lots along the river front, golf course and civic center at the Southgate Recreation Area, a community bicycle track, and a township-sponsored combined pistol range and ski hill. Land, or perhaps area would be a better word, was available for these projects, but they would not have been economically feasible if borrow had to be purchased to establish a suitable grading elevation.

Many areas are filled for no particular purpose; others are planned industrial sites. One site had about 10 million cu yd deposited on it, and now a church and many homes appear there.

Most local governments no longer permit holes to remain after a sand mining operation, thus the contractors restore these areas to the original elevation with waste material. The land is then returned to some profitable use such as building sites and, in some cases, agriculture.

Not all land fills turn out to the satisfaction of all concerned. Certain problems developed where a contractor purchased 300 acres of land and stripped the sand from 4 to 8 ft deep. The backfilling operation left a house setting on a sand island. Of course, it did not take long for this sand to fill with water. The water created no end of trouble with the basement and sanitary drain field. To date, the situation has not been corrected satisfactorily.

A little searching will reveal a disposal site for earth. Getting the material from the expressway construction site to distant disposal sites is the real challenge that causes the construction costs to soar.

HOW TO RUN OVER PEOPLE AND MAKE THEM LIKE IT

John M. Harbert, III, Harbert Construction Corporation

•TO SOME people, public relations means little. I understand that attitude, for I felt the same way a few years ago. I could not have cared less about what the public thought, and my attitude was, "To hell with public relations! Let's get on with the job and the public be damned if they get in the way!" One would suspect in viewing urban construction over the country that this attitude is shared by a majority of contractors. It may be more charitable to say that it is a subject that they do not think about or that it is a problem that is so vast that to find a solution would be hopeless.

Today I am a firm believe in the value of establishing good public relations and of creating a positive image for the construction industry. It is a subject that I am constantly thinking about as it applies to all of our construction and mining operations. No problem in this area is so great that it cannot be solved. I am not saying that public relations problems can be solved without thought, effort, and money. It takes plenty of all three to do the job successfully. Neither do I believe in gimmicks or slight-of-hand tricks to fool the public. You may get away with this once or twice, but I do not recommend it. It is true that we occasionally use gimmicks in some of our programs, but we use them not as solutions to a problem but as aids to get the public's attention in order to make them aware of what we are trying to accomplish.

It takes a great deal of thought, effort, and money to solve urban construction problems. Many people feel that contractors are willing to put the thought and energy into the effort to solve public relations problems but, because there is no bid item to recover any money expended for this, they are not willing to put out the cash. I think it is fun to think about these problems and create solutions with positive ideas. The money required to execute them is not wasted but is rather an investment that pays annual, as well as daily, dividends.

Several months ago, our state highway department advertised for competitive bids on many projects throughout the state. One was less than a mile from our main office. In reviewing the many jobs we planned to bid, our chief estimator made the remark that he did not want to bid the project close to our office because all of our people who had looked at it were of the opinion that the work was difficult and complicated by the necessity of maintaining 2-way traffic on 5 major streets tying into an expressway. His comment was that there would be too many problems in dealing with the public. He said we would ruin our good reputation if we got the job and blocked the 30,000 cars that would have to pass through the work daily. I initially agreed to his decision but after some reflection suggested that we figure a way to build the project with the least inconvenience to travelers and that we base our bid on handling the work in this manner. No one felt at the time that we would be low bidders on the project; our bid price was approximately $250,000. Apparently, however, our competitors felt the same way because the state received only 2 bids and ours was the lowest. Even so, we were considerably above the state's estimate for doing the work. Subsequently, the highway department engineers called me and asked why our bid was so high. I gave them a copy of our estimate, showing more than $35,000 allowed in this small job to protect the public and do those things that would prevent interference with the smooth movement of traffic. Another costly item in handling this project was our planned schedule to start work in traffic areas after 10:00 in the morning and to move out at 4:00 in the afternoon, prior to the heavy evening traffic. We also planned to work at night.

Presented at the 50th Annual Meeting.

I explained to the state engineers that we did not want the job unless we could handle it without major traffic interruptions. I further said that I thought the time of the travelers, i. e., the taxpayers, if properly evaluated, could be said to be worth several hundred thousand dollars and that this vital point was being overlooked. Normally, a bid above the state's estimate is rejected, but the highway department awarded the project to us. We have not started the work yet, so I cannot tell you how we will come out; but I can say that our public relations program, which is well known to the state highway department, was responsible for the project being awarded to us.

The other example concerns an experience in public relations my company encountered during the construction of Birmingham's Red Mountain Expressway. This project had all kinds of public relations problems. They started in the courthouse with lengthy legal battles over condemnation proceedings long before any construction commenced. When we were awarded the construction contract, we knew that we had to develop a positive public relations program. We reviewed all the potential problem areas in an effort to anticipate everything that might happen. We made a basic decision that an educated and, therefore, knowledgeable public would more readily accept inconveniences and changes in travel routes than would a public that did not know or understand what was going on. With this in mind, we developed a program to inform every concerned person of what we were trying to do and to explain why delays and inconveniences would be required if rapid progress were to be made in the construction of this expressway. We implemented this program in many ways, and I will list only a few.

1. We mailed more than 600 personal letters to community leaders outlining our plan of executing the work required in the contract;
2. We placed weekly "plan-ahead" notices in the Sunday newspaper, calling attention to street closings and changes in detour routes;
3. We used radio and television advertising to alert the public to all major traffic interruptions;
4. We created and gave away automobile bumper stickers bearing our expressway slogan, "slow go today—go go tomorrow";
5. We gave 2 elaborate cocktail parties for the residents of 2 major apartment buildings that we had to tunnel under in the course of construction;
6. We published weekly progress bulletins and posted them on public street corners adjacent to the work;
7. We identified to people living in the area all of our workers, not just our superintendents and foremen but every single man on the job including equipment operators and riggers; and
8. We put up bleachers for people to sit in and watch the work and provided programs to explain what was going on.

What were the results of this positive public relations program? We literally ran all over the people, and they loved it.

It was expensive in terms of dollars but, frankly, I would not have believed it possible to accomplish what we did. In one area we were able to completely change the character of the work; the Bureau of Public Roads at first acted as if it did not want to go along, and the highway department followed closely behind in that sentiment. Public pressure, however, forced them to move into the area that we wished to go. This was worth many times the cost of the actual public relations program. We, as well as the Alabama State Highway Department, expected that there would be more than $2 million worth of lawsuits in claims filed before the project was completed. Not only were there no suits filed but neither we nor the highway department received a single complaint during the entire period of construction.

Most construction disrupts or inconveniences some people, particularly those living or working nearby. Understandably, those inconveniences and interruptions cannot be eliminated entirely, but they certainly can be kept to a minimum. I strongly feel that doing this should be a part of the cost of the construction and that maintaining good public relations is just as important as doing quality work or completing a project on schedule.

FAST-ASSEMBLY BRIDGE OVER THE AEGIDIENTORPLATZ IN HANNOVER

Elmar Koger, Fried. Krupp GmbH

•WITHIN our large cities, the sudden increase in motor traffic during the past years has very often resulted in bottlenecks that lead to traffic congestion, especially at peak times. Responsible building authorities had to find means to both open new ways for the increasing traffic and obstruct as little as possible the traffic in the vicinity of the construction site while new roadways have been built. The solution of these novel building problems requires a novel bridge type, and in recent years there have been developments of this kind in various countries. This paper outlines how such urban bottlenecks can be overcome speedily and without major traffic impediments by steel bridge construction and briefly gives a typical example of building the fast-assembly bridge across the Aegidientorplatz in Hannover.

"Fast-assembly bridge" means a bridge structure that can be quickly procured and rapidly assembled and disassembled. It must be versatile and conveniently adaptable to changed traffic conditions. Contrary to permanent bridges, fast-assembly bridges are intended for uses limited in time, and it frequently happens that the bridge has to be adapted to changing site situations during its first term of service. After the first job has been completed, the fast-assembly bridge must be capable of being reused quickly without loss of material and without difficulties under greatly different conditions at another place.

What are the properties that a fast-assembly bridge must have to meet the requirements just stated? The bridge must be designed on the sectional principle so that it can be put together from a few different standardized components. By means of jigs and fixtures the components must have been manufactured so accurately that they can be assembled without reaming of fitted holes and, therefore, can be interchanged. Components have to be connected and disconnected in the simplest way. Connection of the components is mostly made by fitted bolts. Because friction faces would require special treatment, there is no advantage in using high-strength friction grip bolts. Riveting and welding also do not offer any advantage because they do not permit an easy disassembly. In order to make the equipment versatile, the bridge must be variable in its cross-sectional width and span lengths. For the same reason, it should be possible to locate the main girder supports at any point on the main girder. The bridge may have to be curved in both its vertical and horizontal planes, the curvature being variable. Previous experience in building the bridges shows the necessity for having wide variations in the bridge layout because of factors, such as traffic areas below the bridge, utility lines, trees, and the like, that must be considered when the bridge is erected. The fast-assembly bridge systems of the Rheinhausen type, used for the bridge across the Aegidientorplatz in Hannover, fulfills all of these conditions.

The basic elements of the fast-assembly bridge of the Rheinhausen type are the main girders (Fig. 1). These main girders are designed with an open cross section and consist of the upper roadway plate with transverse roadway ribs, web plates, lower flanges, and welded-in cross girders in the main girder center. Four alternatives are manufactured: 2-web, 12 m long; 1-web, 12 m long; and 2-web and 1-web, 6 m long.

Main girders 6 m long will mostly be assembled at the bridge ends. They can be supplied with a uniform web height and with a raised web. The height of web plate is

Presented at the 50th Annual Meeting.

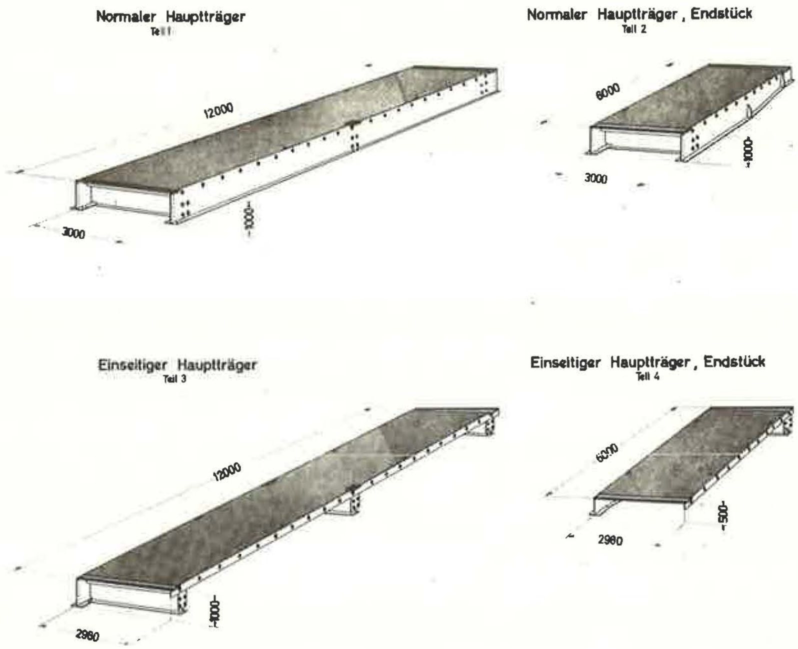

Figure 1. Main girders.

uniformly 1 m for all main girder types. Variation in the design of the bridge cross section is possible with the use of these main girder components. The variation is shown in Figure 2. For the 1-lane bridge cross section, a 2-web main girder component is used. Should the useful lane width of 3 m be insufficient, the roadway width could be increased up to about 3.20 m, as has been done in Hannover, by enlarging the component, or up to about 3.80 m by arranging a special curb. Two-lane and multilane bridge cross sections can be obtained by combining the required number of 1-web main girders with the 2-web main girder component. In this way useful roadway widths of 3, 6, 9, or 12 m are reached.

Roadway widths in between these figures are also feasible. For the fast-assembly bridge of Hannover, for instance, it was necessary to have 2-lane roadway widths of 7.50 m (Fig. 3). They were formed by arranging two 2-web main girders of 3.20 m each on the outer edges of the cross section and installing an intermediate plate of 1.10-m width. This cross section design also offers the advantage that the 7.50-m wide 2-lane cross section can be split up into 2 separate 1-lane roadways of 3.20 m each.

As a rule, the main girder components are completely welded ready-made units of the stated sizes. They can be transported on trucks or by rail without complications. For transport to very distant places, say, overseas countries, however, they should be sent in smaller shipping units. In such a case, the fast-assembly bridge system offers the possibility of disassembling the main girder into the individual elements: roadway plate, cross girder, and main girder web with lower flange. These can be shipped separately and assembled in the field by means of fitted bolts into 1-web or 2-web main girder components.

Of the cross girders spaced 6 m apart, every second cross girder is securely shop-welded into the main girder elements at the main girder center. The cross girders located at the joints are delivered as separate units and assembled when the main girder transverse joint is closed. All field connections are made by fitted bolts of 40-mm diameter and material quality 5 D. They are galvanized.

The bridge when fully completed forms a longitudinally and transversely continuous, flexurally rigid beam grillage. Under service conditions, a jointless roadway deck over the whole bridge area is thus obtained. The static computation is based on Bridge

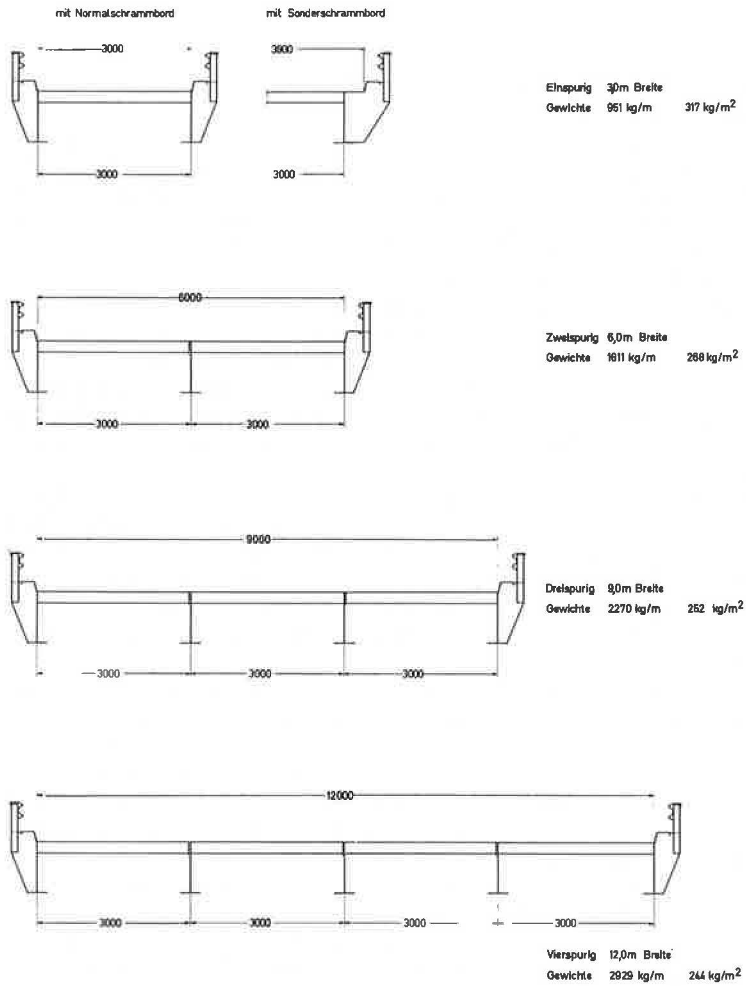

Figure 2. Variation in design.

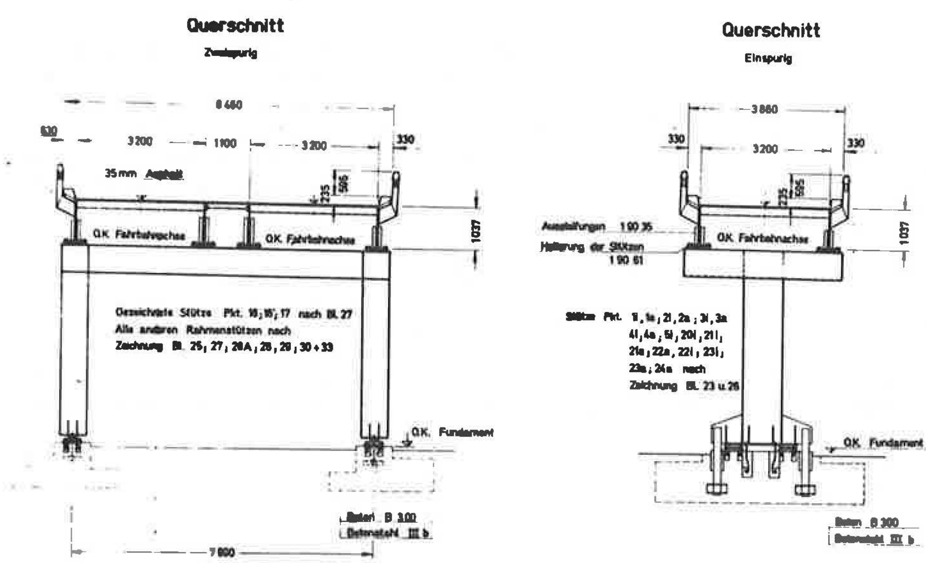

Figure 3. Design of fast-assembly bridge in Hannover.

Class 30 of the German DIN 1072. With variable bearing positions, the standard type permits span lengths up to about 30 m.

The main girder elements normally are fabricated as straight units. If bridges are to be curved in their plan view or elevation, a curvature is sufficiently approximated for practical use by a broken polygon course with breaks at the joints at intervals of 12 m. Vertical curves have large radii of curvature, and the breaks at the joints can be achieved by a wedge type of drilled-web splice plates. Plan view curves, however, can have very small radii. In those cases, a wedge type of drilled splice plate arrangement generally will not do. Special wedge plates have to be provided at distances of 12 m to form the curvature required. The wedge plates are variably dimensioned and can be suited to any curve. As compared with the design for a continuous curve, this design with a polygon-shaped approximation of curvature offers the great benefit that, on reuse of this bridging equipment, splice plates and wedge plates need only be exchanged to overcome curves of great variety and all main girder elements and cross girders need have no modification.

In addition, the design of the main girder units allows giving the completed bridge any one-sided crossfall. If necessary, this can be changed in longitudinal direction of the bridge in accordance with the horizontal curvature. The one-sided crossfall is achieved by appropriately inclining the support points of the main girder webs. Because the completed bridge structure represents a torsion-soft structure, transverse inclination is possible by twisting the bridge while it is being erected, without appreciable additional stresses.

Within the limits of the maximum span lengths the fast-assembly bridge system of the Rheinhausen type largely grants freedom with regard to the arrangement of bearings. Bearings can be provided at any point on the main girder web or below the cross girders. The axes of the support frames need not be at right angles to the longitudinal bridge axis but may be set in oblique-angled arrangement. When the bridge is being erected on the site, bearing stiffeners are mounted by way of additional bores for force transmission purposes. When the equipment is used at several places, the same main girders allow different positions of bearings. It is also not necessary that, on a support frame, all main girder webs be supported on the bearings directly. If it is required by traffic below the bridge, outside main girder webs can be supported indirectly by additional cross girders within the superstructure, whereas the inside webs arranged over bearings directly transmit their forces to the support frame. Tie rods can be installed easily.

At the ramp ends, the bearing bodies are designed as fixed, knife-edge, rocker type of bearings or roller bearings moving on one side and made of steel. Bearings provided between superstructure and steel rocker posts are fixed, knife-edge rocker type of bearings made of steel or reinforced neoprene. Because of impact and noise suppression, softer supports are preferred.

For roadway transitions subject to major movements, finger-grip constructions have successfully been applied. At the bridge end with fixed bearing, a simple edge protection is sufficient.

Depending on local conditions, the fast-assembly bridge of the Rheinhausen type can be delivered with longitudinal continuous drainage piping or individual downpipes along the whole bridge. The gap approximately 10 mm wide arising between the individual main girder elements is suitably sealed off by a permanently flexible synthetic cement so that the decking is made completely watertight.

As a standard feature, the fast-assembly bridge of the Rheinhausen type is provided with guiding devices that consist of about 12-cm high curbs and crash barriers of cap section opened downward and that were made especially for this bridge type. The crash barriers are supported at intervals of 3 or 6 m. At the crash barrier posts and, if existing, on the footpath brackets, provision has been made for the attachment of light poles. When there are sidewalks or bus stops below the fast-assembly bridge, it is recommended that special splash protection be provided. It consists of a sheeting arranged between curb and crash barriers and prevents pedestrians from being splashed by water from the roadway surface.

Great flexibility and variability are demanded of the fast-assembly bridge. This condition especially applies to the supports of a fast-assembly bridge. Normally the support arrangement consists of 1-leg or multileg steel frame structures. Their shape greatly depends on different local conditions so that standardization does not offer any benefit; it is better to study and redesign the support frames for every new requirement. For intermediate supports of the fast-assembly bridge in longitudinal direction, the frames are designed as rocker frames with a point rocker type of bearing at the frame bases. Where traffic areas below the bridge have to be kept clear of bridge structures, it is often necessary to provide frame legs not only below the bridge but far outside of the bridge by using large transom span lengths or frames with cantilevering transoms.

Because the traffic conditions in the vicinity of a fast-assembly bridge seldom allow sand-blast derusting and painting work to be done at the site, anticorrosion work must be carried out as far as possible in the fabrication shops and any field work must be limited to a minimum. The extent of the corrosion protection largely depends on the local circumstances. Basically, however, paint materials should dry and harden quickly. Only in this way can damage to the shop coats during transport and erection be reduced to the unavoidable minimum. Two-component resin paints with zinc chromate and iron mica nearly comply with those requirements.

Surfacing work, too, must in many cases be done in the shops. Under design aspects of the steel structure, both thin plastic surfacing with minerals sprinkled in and asphalt surfacing in thicknesses ranging between 3 and 6 cm are suitable for the fast-assembly bridge of the Rheinhausen type. The choice of roadway surfacing depends on the time the bridge is to be in service. For a short use of 1 to 2 years, synthetic surfacing offers the advantage that it can be applied under controlled working conditions in the steel fabricating shops and requires little site work afterward. Because these surfaces are wear-prone, especially when spiked tires are frequently used, and can be repaired only in favorable weather, this surfacing should be adopted for short-term use only. For long-term use, an asphalt surfacing is recommended. In this case, too, an essential portion of the surfacing work, i.e., derusting and application of the adhesive primer, can be done in the fabricating shops. On the other hand, the mastic layer and asphalt should preferably be applied on the site, although, in principle, it is technically possible to apply asphalt surfacing on the main girder units prior to erection work. Apart from a better and less weather-dependent repair possibility, asphalt surfacing offers the advantage of impact cushioning and noise suppression.

The fast-assembly bridge system of the Rheinhausen type has been built by Krupp several times. Bridging equipment of this kind was delivered to Barcelona, Caracas, Rotterdam, Hannover, and Duisburg. The installations in Essen, Duisburg, and Caracas are shown in Figures 4, 5, and 6. The best example of the versatility in design is the bridge across the Aegidientorplatz in Hannover. This installation is shown in Figure 7.

Figure 4. Fast-assembly bridge in Essen where, because of traffic areas underneath, supports are located away from bridge.

The Aegidientorplatz is an important traffic center in the city of Hannover. Altogether, 7 streets converge into the roundabout. Two of these are 1-way streets; the remaining five have 2-way traffic. Five 2-way tram lines pass to and from the Aegidientorplatz. The trams run for long distances below the fast-assembly bridge parallel to the longitudinal bridge axis and also in the zones of the end ramps. Therefore, the end ramps had to be split into 4 separate branches to provide passages for the trams. The fast-assembly bridge crosses 4 motor roads and 3 tram lines and has to allow for

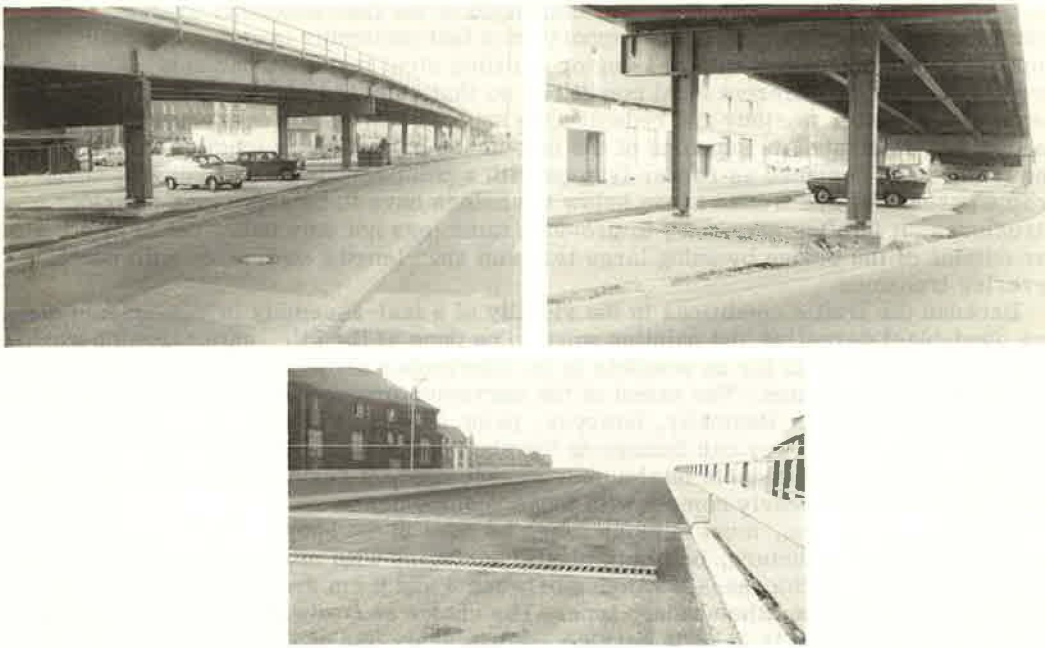

Figure 5. Fast-assembly bridge in Duisburg.

2 thread-outs of tram lines at the bridge axis. In addition, urban utility lines and old trees represent other factors that had to be considered in the design.

The fast-assembly bridge was built to create a relief roadway for one of the main traffic flows. Streets at the ground level remained unchanged. A subway construction site is expected to appear in the area of the Aegidientorplatz in the near future. The bridge is scheduled for 10 years' use at this location.

The fast-assembly bridge is composed of a 2-lane central portion having a travel way 7.50 m wide and four 1-lane descent branches 3.20 m wide each. The 2-lane central roadway is 222 m long, and the total length of the 1-lane descent branches is twice 253 or 506 m; the length of the fast-assembly bridge is thus 728 m. The 1-lane concrete ramps are 2 by 106 or 212 m long. The span lengths are between 11 and 28.5 m. The structure consists of 78 two-web main girders, 18 intermediate plates,

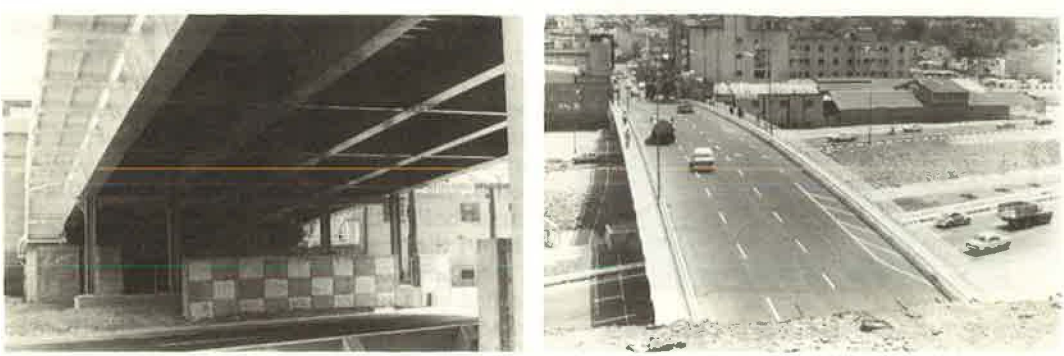

Figure 6. Fast-assembly bridge in Caracas.

Figure 7. Fast-assembly bridge in Hannover.

and about 40 wedge plates. The steel superstructure weighs about 1,023 tons corresponding to 311 kg/m^2, and the supports weigh 175 tons corresponding to 53 kg/m^2. The longitudinal grade changes from 0 to 6 percent. Maximum change in longitudinal grade at a bending point is 1 percent. Transverse grade is designed from 1 to 3 percent in accordance with the horizontal curves. In horizontal plane, the fast-assembly bridge is considerably curved. The angle at the center of the curvature circle is about 80 deg, and the curvature radius is about 90 m. Because of the length and considerable horizontal curvatures, the bridge was subdivided into 3 sections, which are separated from each other by expansion joints of a finger type of transition. Roadway surfacing consists of the adhesive primer already applied after sandblast derusting in the fabricating shops, a 1-cm thick mastic layer, and a 2-cm thick melted asphalt layer. Mastic and melted asphalt layers were applied when the bridge was erected.

The individual components of the superstructure were fabricated by Krupp in its Rheinhausen plant and by MAN in its Gustavsburg plant. By rail and road, the components were brought to a branch factory of Krupp in Hannover where the support frames were made and where the individual components were preassembled into erection units, each consisting of one 12-m long main girder with brackets, curbs, and crash barriers. As far as necessary, the intermediate plates were also attached to the main girders.

Erection at the site was completed on 5 weekends; in each case work was done from 4 o'clock on Saturdays until 3 o'clock on Mondays. A rigid time schedule was necessary, and punctual execution of the erection work could only be achieved with the extensive assistance of all municipal authorities. Subdivision of the 5 erection sections was made according to the traffic requirements so that car and tram traffic was only interrupted in the respective erection section during one weekend whereas, in the remaining sections of the Aegidientorplatz, traffic continued to run smoothly. The order was awarded to Krupp on May 17, 1968. The steel structure was erected on 5 weekends from September 21 to October 20, 1968. Prior to that time, foundations and concrete ramps were already made. The melted asphalt work was carried out from October 8 to October 30, 1968. As planned, the fast-assembly bridge was opened to traffic on November 1, 1968. There were 5½ months between order placement and opening. For fabrication and erection, about 4 months only were available.

In 1968, the contract price amounted to 1.785 million DM for the superstructure and the supports and to 285,000 DM for the foundations and concrete ramps, a total of 630 DM/m^2 of roadway area of the fast-assembly bridge. The fast-assembly bridge has been in service without interruption for 2 years. It is readily accepted by drivers, even by bus and truck drivers, although ground-level travel is still possible. Because of the melted asphalt surfacing, there is scarcely any traffic noise.

Despite the asphalt surface thickness of only 3 cm and a 6 percent longitudinal grade, the melted asphalt surfacing so far has shown only minor damage, which was easily repaired, although there were unusual climatic conditions during the winter of 1969-1970 and the summer of 1970. There have also been no difficulties with snow. At the bridge, an ice-signaling instrument has been installed; it measures the air humidity and temperature and, when the measure values are critical, signals the traffic service crew to sprinkle sand or clear the bridge.

According to the municipality's information, the fast-assembly bridge has been a success and has met all expectations. Fast-assembly bridges are a valuable help in overcoming innercity traffic problems.