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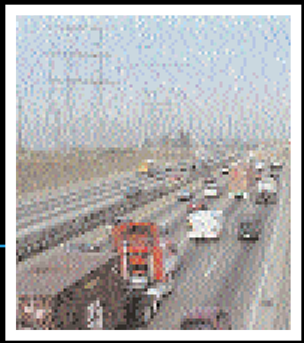

PROCEEDINGS OF THE WORKSHOP ON PAVEMENT RENEWAL FOR URBAN FREEWAYS

February 16–19, 1998
The Beckman Center
Irvine, California

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Sponsored by:

FEDERAL HIGHWAY ADMINISTRATION
CALIFORNIA DEPARTMENT OF TRANSPORTATION
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Acknowledgments

The Workshop on Pavement Renewal for Urban Freeways was sponsored by the Federal Highway Administration (FHWA) with the cooperation of the California Department of Transportation (Caltrans). Funding for the workshop was provided to TRB by the FHWA.

To organize and conduct the conference, the TRB Strategic Highway Research Program Committee established a Workshop Steering Group, chaired by Richard P. Weaver, P.E. Mr. Weaver and his steering group members deserve special recognition for leadership and practical enthusiasm that overcame all obstacles in the initiation of this workshop.

The complex and innovative nature of the workshop required extraordinary coordination efforts among TRB, FHWA, and Caltrans. David O. Cox, P.E., Senior Engineer with the FHWA in Washington, DC, and Steve Healow, Transportation Engineer with the FHWA California Division Office in Sacramento, were the principal coordinators for the FHWA. For Caltrans, Douglas R. Failing, P.E., District 7 Design Chief, Los Angeles, and Kevin M. Herritt, Structural Section and Design Standards Specialist in the Caltrans Headquarters in Sacramento, were the principal coordinators. Douglas Shaffer, P.E., and Bruce Green, P.E., provided staff coordination for TRB. Mr. Green was on loan from the Missouri Department of Transportation especially to assist in this activity for which MODOT is gratefully acknowledged.

The Caltrans District 7 Office staff in Los Angeles, under the guidance of Mr. Tony Harris, P.E., District Director, and Mr. Failing, developed the detailed technical background regarding the Long Beach Freeway (I-710). These staff also arranged for the field view of the project and prepared the engineering drawings and cost estimates for the proposals developed at the workshop. The following staff members provided special services on behalf of the workshop: Coordination–William H. Reagan, Mario A. Gutierrez, Peter Lin; Design and Estimates–Simon Quo, David Huang, Renhe Yin, Giap Hoang, Le Nguyen, David Wang, Sonny Poolsawat, Carlos Tong S. Drawings–Tim Baker; Video Services–Steve DeVorking.

This report was prepared by the Workshop Steering Group and reviewed and approved by its parent committee, the TRB SHRP Committee. The report was then reviewed by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Research Council's Report Review Committee. The purpose of this independent review was to provide candid and critical comments to assist in making the published report as sound as possible and to ensure that it has met institutional standards for objectivity, evidence, and responsiveness to its charge. The review comments and draft manuscript remain confidential to protect the integrity of the process.

Thanks are due to Lester A. Hoel of the University of Virginia, Gary L. Hoffman of the Pennsylvania Department of Transportation, Gary D. Taylor of the Michigan Department of Transportation, and David K. Willis of the AAA Foundation for Traffic Safety for their participation in the review of this report. Although the reviewers provided constructive comments and suggestions, responsibility for the content of the report rests with the authoring committee and the institution.

The Workshop was conducted under the general supervision of Neil F. Hawks, P.E., Director of Special Programs for TRB. Linda Mason, Communications Manager of the Special Programs Division, managed the editing and production of these Proceedings. Kathryn Harrington-Hughes of Harrington-Hughes and Associates provided editorial services. Special thanks are due to Cynthia M. Baker for meeting arrangements and word processing.

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Introduction

Pavement renewal on urban Interstate highways and other urban freeways and expressways is a growing national concern as more and more of the 113,000 lane miles[1] of this critical network exceed the pavement design life. Increasingly, transportation agency budgets are directed toward these very expensive renewal projects. Pavement renewal and related costs are at the core of "billion dollar" projects under construction or on the drawing board, such as the reconstruction of Interstate 15 in Salt Lake City, Utah and I-25 in Denver, Colorado. Because of the disruption these projects may cause, the initial costs to highway users and local communities often dwarf the capital cost of renewal. Can urban freeway renewal be accomplished through innovations that limit traffic and community disruption, control agency costs, and yield long-lived pavements? The question has been discussed among transportation agencies for some time. Considerable research and technology can be brought to bear on this issue. Both transportation agencies and the construction industry have introduced effective new technologies and techniques

[1] Highway Statistics 1996, *US Dept. of Transportation, Federal Highway Administration, Table HM-60*

on a local or regional basis and can envision still other innovations to better manage and execute such projects and to improve the durability of the resultant product.

The Federal Highway Administration (FHWA), the California Department of Transportation, and the Transportation Research Board jointly sponsored a workshop designed to focus on the introduction of innovation to urban freeway pavement renewal.

The concept of the Workshop on Pavement Renewal for Urban Freeways emerged from discussions of a number of TRB committees. Among these are the TRB Strategic Highway Research Program (SHRP) Committee, the TRB Research and Technology Coordinating Committee, and the TRB Long Term Pavement Performance (LTPP) Committee. These three committees, whose members include senior transportation officials and industry leaders, have been advising the FHWA and the American Association of State Highway and Transportation Officials (AASHTO) on aspects of research and technology deployment related to pavements.[2] In their discussions, several themes recurred:

- Although there is considerable pavement research now under way or recently completed, and significant new materials, technologies, and procedures are emerging, there has been insufficient focus on the application of this research to the renewal of the vast inventory of urban freeway pavements.
- The private sector of the highway community, specifically construction contractors and others concerned with the design and construction of such projects, has not been effectively involved in the introduction and transfer of innovation.
- The long-term reliability and durability of "renewed" pavements must be substantially improved so that the emerging crisis is not repeated in the near future.
- In general, insufficient attention is paid to user costs and other external impacts in the development of typical urban freeway pavement renewal projects.
- The current need is not exclusively a pavement issue but one that involves challenges to general highway design, construction management, work zone safety, highway maintenance, and traffic management. Solutions will also demand innovation and flexibility in the acquisition of construction services and materials and in the introduction of time- and money-saving nonstandard technology.

The TRB SHRP Committee took the lead in organizing the workshop and created a subcommittee to serve as the steering group. The membership of the steering group was drawn from all three of the interested TRB committees. The steering group invited a national panel of public- and private-sector specialists to study a specific segment of urban expressway under conditions resembling those of an actual design and construction project. The panel was asked to propose innovative approaches for the speedy, long-lived renewal of the pavement while minimizing adverse traffic and community impacts. The goal of this workshop was to highlight recent innovations immediately applicable and to define the agenda for needed research and technology development in this interdisciplinary arena. By focusing on a specific highway corridor, the Long Beach Freeway (Interstate 710) in southern California, realism and practicality were enforced in the workshop deliberations. This approach was also intended to demonstrate that

[2] Developing Long-Lasting, Lower-Maintenance Highway Pavement: Research Needs, *Transportation Research Board, National Academy Press, Washington, D.C. 1997*

technologies, designs, and management procedures introduced in one locale can be transferred to other places and projects, even though the character of every urban pavement renewal project is unique.

Objectives of the Workshop

In addressing the urgent need to renew vast sections of urban roadways, the workshop was designed to provide a forum where experienced agency and private-sector engineers and constructors would work together to bring definition to the issues involved in a realistic but non-competitive environment. The workshop objectives were to:

1. synthesize and publicize effective solutions drawn from the mutual experience of the participants;

2. highlight the existence of available but underused technologies and research results, as well as innovative approaches to project management and contract administration;

3. point out barriers, both technical and procedural, to cost-effective and time-efficient designs and construction approaches;

4. identify pressing needs to be addressed in local and national research agendas;

5. identify needed technologies.

Workshop Program

The proposed workshop was intended to be exactly that: a *work*shop. Each of the participants was expected to play an active role and to share his or her experience, expertise, thoughts, and opinions with the entire group. To encourage this, the group was kept small, with only 44 invited panelists.

The panelists were all experienced in the renewal of urban expressways and brought both general and special expertise to the workshop. Designers, contractors, construction managers, maintenance engineers, traffic managers, and senior engineering officials were represented. Academic and professional specialists were also invited. The panelists were divided into four teams, which were to independently develop schemes for renewal of the study segment pavement. To encourage cross-fertilization of ideas, no two members of the same team were from the same state. A typical team composition was:

- One highway designer (agency or consultant)
- One construction manager (agency or consultant)
- Two construction contractors
- One state DOT chief engineering officer
- One FHWA Division Administrator or Assistant Administrator
- One highway maintenance engineer
- One academic or consultant specialist.

Team members are identified in the list of participants provided in Appendix A.

The task for each of these teams was to propose design and project management “solutions” to the problems presented by the study segment. These solutions were expected to:

- provide a renewed pavement with a long service life;
- minimize traffic disruption;
- provide a safer environment for workers and highway users;
- minimize short- and long-term user costs;

- minimize project life-cycle costs to the agency;
- minimize community and environmental impacts;
- identify research and technology development needs.

To encourage diversity and creativity in the array of solutions, each team of panelists worked independently. Near the close of the 4-day workshop, all teams met together to compare and analyze the solutions developed by each team.

Each team was supported by a California DOT staff member who provided local knowledge of the study segment. A technology specialist from the FHWA also supported each team. This specialist brought information about recent research and technology developments and, on behalf of the team, compiled statements of additional research and technology needs identified during construction.

To set the stage for the workshop deliberations and to aid the panelists, the steering group also invited local speakers directly involved in or affected by renewal of the study project to describe the local conditions, constraints, and expectations. This included California DOT staff to describe segment conditions and environs, community and environmental constraints, and project expectations. Nationally prominent speakers were invited to highlight the national significance of the issues and to generally identify new technologies and management approaches applicable to urban freeway pavement renewal.

The workshop program describes the daily activities scheduled for participants.

Interstate 710 Project

To ensure that the workshop would be more than a theoretical exercise, the participants focused on an anticipated but as yet undesigned Caltrans project to reconstruct a 15.7-mile (25 km) portion of Interstate 710, also known as the Long Beach Freeway. Located in a mixed use corridor, the freeway provides access to the bustling Port of Long Beach, to the area's tourist attractions, and to numerous employment sites along the corridor. It is also the major north-south thoroughfare between the cities of Long Beach and Los Angeles and passes through nine municipalities **(Plate 1)**. Constructed in the late 1950s, the freeway carries as many as 218,000 vehicles per day—well above what anyone would have predicted during the planning and design phase. More than 30,000 of those vehicles are trucks laden with goods on the way to market either here in the United States or abroad.

The existing pavement consists of 200 mm (8 in.) of portland cement concrete pavement over a 200-mm (8 in.) cement-treated base lying atop a 200-mm (8 in.) imported subbase. The highway measures 38.4 m (126.5 ft) across and carries eight lanes of traffic, with a narrow (2.4-m [8 ft]) outside shoulder in each direction. A metal barrier sits in the middle of the 4.8-m (15.75 ft) median **(Plate 2)**. Appendix B is a fact sheet that provides more detail about the study corridor.

WORKSHOP ON PAVEMENT RENEWAL FOR URBAN FREEWAYS

Program

Day 1 *Morning* **Field View**

Workshop Team Members and other participants viewed the study segment in the field in the company of California DOT officials familiar with the segment and its environs. The first day of the conference was Monday, February 16th, 1998, which was "President's Day." The national holiday was selected specifically because traffic volume would be lower, permitting panelists to observe conditions of the study segment in somewhat greater safety.

Day 1 *Afternoon* **Plenary Session**

Invited speakers reviewed the objectives of the workshop, framed the national issues, and elaborated on the unique local scene of the study segment and expectations of the renewal project.

Day 2 *Morning and Afternoon* **Team Discussions**

The workshop teams independently discussed potential solutions to the engineering, management, and community issues presented by the study segment.

Day 3 *Morning* **Team Discussions**

Teams finalized their proposals and identified research and technological developments needed to improve procedures and techniques for renewal of urban freeway pavements.

Day 3 *Afternoon* **All-Team Discussions**

Each team informally presented its proposal to the other teams and solicited comment and feedback from all participants. Team technology specialists presented findings of individual teams regarding needed research and technological developments.

Day 4 *Morning* **Team Discussions**

Day 5 *Late Morning* **Presentation of Team Findings**

Workshop Format

The workshop was preceded by a tour of I-710, which gave participants a first-hand look at the project corridor. The workshop then opened with a number of presentations from representatives of the local community, state departments of transportation (DOTs), contractors/consultants, and FHWA; the presentations, which focused on expectations and needs, rather than pavement design and materials, set the stage for the week's discussions and deliberations.

Participants were grouped into four teams of a dozen or so members. Each team included at least one chief engineer or administrator of a state DOT, an FHWA division administrator, a contractor, a design engineer, a construction engineer, a traffic engineer, a materials supplier, an equipment supplier, a member of FHWA's technical staff, and a Caltrans engineer.

The workshop participants were instructed to develop a solution that would meet the long service life goal identified by the workshop steering committee:

> *The renewed pavement shall serve for 40 years without need for structural repair. Surface maintenance and ride restoration interventions are permissible. The nature, timing, and associated traffic disruption of such interventions should be identified in the proposal. "Full depth" repairs are not permitted, nor is any "surface repair" that requires geometric adjustment to guardrail, median barriers, drainage features, structures, or other highway elements.*

Each team was challenged to come up with solutions to the problems presented in the I-710 project corridor. Two teams were charged with producing an asphalt pavement design, and the other two a portland cement concrete pavement design. The teams were given the following objectives in developing a solution:

- Provide a renewed pavement with a service life of at least 40 years (twice that of a typical pavement)
- Minimize traffic disruptions
- Provide a safe environment for workers and highway users
- Minimize short- and long-term user costs
- Minimize agency life-cycle costs
- Minimize community and environmental impacts.

Setting the Stage

Without understanding the physical setting and economic and social context, the best engineers and planners may fail to develop the best solutions for projects like the reconstruction of I-710. If the specific expectations of local communities, government officials, and highway users are not similarly understood, the most elegant designs will not find public support. Following the field tour of the Long Beach Freeway, a series of speakers were invited to define the context and expectations for the study project. The initial presenters spoke from broad national or statewide views; each succeeding speaker narrowed the view and was increasingly explicit in defining expectations for this project and others like it.

Dr. Anthony Kane, Executive Director of the Federal Highway Administration, defined the national expectation and context for projects like this. Mr. Carlson and Mr. van Loben Sels, both directors of state departments of transportation, provided statewide views. Mr. Tony Harris, the Los Angeles division director for the California DOT relayed expectations from a regional perspective. Mr. Douglas Failing, the chief of design in Mr. Harris' division, described the specific physical characteristics of the freeway, the problems it presents, and the manner in which the California DOT would traditionally approach such a project.

Mr. Daniel Beal of the Automobile Club of Southern California and Ms. Candice Traeger of the United Parcel Service offered expectations from the private and commercial highway users' perspectives. Mr. Kerry Cartwright spoke on behalf of the Port of Long Beach, the largest shipper using I-710. Ms. Jenny Oropeza, Councilmember for the City of Long Beach spoke of the expectations of the local community.

The final two speakers, Mr. Charles Miller and Mr. Charles Nemmers, challenged the workshop teams to find innovative solutions to the problems posed by the need to reconstruct I-710 but reiterated that the needs and expectations of a diverse set of customers must not be forgotten.

The Federal View

ANTHONY KANE

Executive Director of the Federal Highway Administration

As we look at the country, we see that what is happening here in California is a microcosm of what is happening nationwide. And as we take a look at what FHWA's niche is for the future, I think it will be far more one of trying to find the good and praise it, find the good practices, share good ideas, convene workshops, and package up case studies. It's not going to be about individual project approvals. It's not about the kind of oversight that we started out with in our earlier days. It's really about finding solutions, reaching out wherever we can. I applaud Caltrans for this workshop because it ties to FHWA's mission as well: namely, to look at innovations and new ideas and to share best practices.

Some 7,000 urban freeway miles have pavement that needs to be replaced within the next 2 years. Another 11,000 or so will need to be replaced by the year 2005. It's clearly a large national issue.

Each year, slightly more than $100 billion is spent by all levels of government on highway operations, maintenance, and capital expenditures. The split is probably 60 percent in urban areas and 40 percent in rural areas. The amount being spent on freeway rehabilitation projects in this country is about $12 billion per year. It is important that we spend that money wisely, that we take a look at the best ways to rehabilitate and reconstruct roadways in this country.

Underpinnings of Quality

Customer satisfaction, continuous improvement, and employee involvement are the three underpinnings of quality in any organization. A couple of years ago, to assess our customers' satisfaction with the highway system, the National Quality Initiative conducted a nationwide survey of the public—our ultimate customers.[3] Two very strong comments came out of that survey. "Pavement condition" rated the highest priority in terms of needing improvement, and the lowest overall rating, in terms of satisfaction, had to do with delays caused by construction.

In the 50 largest urban areas in this country, delays caused by projects to improve pavement condition are estimated to cost $4 billion a year.[4] Congestion in metropolitan areas overall costs some $50 billion a year in lost mobility.[5]

There were more than 650 fatalities in work zones in 1997, including both motorists and workers.[6] In the coming years, there will be far more urban reconstruction projects underway, all involving traffic and work zones. Clearly, we need to focus on the mobility needs in those corridors, as time is certainly of the essence in terms of user satisfaction.

Continuous improvement is a goal of any work we're involved with. In materials and design, there's fast-setting concrete, high-strength concrete, different kinds of steel, and composite materials. There are smart technologies, including sensors in pavements and structures, to provide real-time information useful in asset management and traffic mobility. If a highway agency is not already incorporating intelligent transportation system technologies in pavement reconstruction projects, it should be planning to do so, as ITS technologies can greatly improve traffic management and control.

Innovative contracting methods, including A+B contracting, lane rentals, warranties, design-build prequalifications, and ISO 9000 concepts, can and should be looked at. The full range of construction methods and practices, including everything from traffic management schemes to off-site construction, should be considered to minimize the amount of time a facility must be closed.

An effective communications strategy is important for the facility owner as well as the construction contractor. State surveys have found that television, radio, and newspaper announcements, as well as changeable message signs, tend to have the highest payoff, probably because that's what people are used to, but as we advance into other areas, such as the Internet, the range of communications strategies will become even broader.

Employee involvement is another cornerstone of quality. In situations such as freeway reconstruction, where you really have to act and think and respond quickly, you have to empower employees on both the owner side and the contractor side. This presents a real opportunity for partnering. Partnering is only effective when the partners are empowered to make decisions.

The Challenge

Our challenge is to consider the needs of our customers—the highway owner, the highway users, and the neighboring communities—in our communication plans and our business plans.

As we strive to minimize life-cycle costs, it would be great if we could finally get political support for the concept that spending more *government* money saves *private* money. As agencies construct or reconstruct roads, they often forget about the private costs, despite the fact that the basic reason for building facilities where transportation is a derived demand is to minimize user costs.

[3] *National Quality Initiative Steering Committee.* National Highway User Survey. *May 1996.*
[4] Special Report 212: *Proceedings of the National Conference on Corridor Traffic Management for Major Highway Reconstruction, held Sept. 28-Oct.1, 1986 in Chicago, Illinois. Transportation Research Board, National Research Council, Washington, D.C. NOTE: Current data are available from Texas Transportation Institute's data base on the Internet at: http://www.mobility@tamu.edu.*
[5] *Urban Roadway Congestion, Annual Report, 1996, TTI, College Station. Current reports available at: http://www.mobility@tamu.edu.*
[6] Traffic Safety Facts 1997: A Compilation of Motor Vehicle Crash Data from the Fatality Analysis Reporting System and the General Estimates System, *National Highway Traffic Safety Administration, Washington, DC, 1998, 218 pp.*

The State DOT View

E. DEAN CARLSON

Executive Director of the Kansas Department of Transportation and former Executive Director of the Federal Highway Administration

The biggest problem in conducting highway projects in Kansas is making sure that everybody works together to minimize inconvenience to the traveling public and emergency service providers, local business interests, government entities, and others affected by highway reconstruction. In the past 10 to 15 years, we've come to realize that we have customers out there, and that we ought to do what they want us to do. Newer and bigger highways aren't always better in their eyes, and trying to detour traffic while work is in progress often is just not acceptable.

My first experience with innovative customer service was in 1972, when FHWA decided states could reconstruct certain urban freeways using Interstate Highway funds. A regional administrator told his staff to approve rebuilding all the Atlanta-area freeways with Interstate Highway funding, and that the number of lanes would not be reduced during reconstruction. That decision, while very receptive to the customers' needs, led to a 40 or 50 percent increase in construction costs.

It is nearly impossible for Kansas DOT to acquire highway rights of way, because urban development has consumed all the large tracts. Our politicians are not ready to spend billions for new urban highways, knowing that the voters will not support a tax increase to pay for those highways.

It's clear that we have to find ways to provide better transportation using existing facilities. In Kansas, we approach major reconstruction projects on urban freeways and expressways from several different points of view. We work with local government units, as well as emergency service providers, planning agencies, economic development groups, and businesses in the area. We make sure that everybody knows what we are doing and that they are part of the process by providing them access to information and an opportunity to provide input.

For example, for one large Kansas City metropolitan project, Interstate 635, we held a series of meetings that gave us a chance to describe exactly what we were trying to do. The meetings also allowed us to develop contacts so that, down the line, people knew whom to call if there was a problem. The publicity that resulted from these meetings was a side benefit that might help us get new money and new programs in the future.

We have found that if there is enough advance publicity about the construction, the traffic tends to melt away; in fact, sometimes traffic moves better during construction than before or after construction. Obviously, if you warn or "scare" people enough, they'll choose another route.

Kansas DOT is starting a public involvement program that will be taken to every DOT employee. A snowplow operator, for example, will have the tools to convey the mission and message of the DOT to a variety of audiences in his community and to the public. We're also going to make use of public meetings, interviews, brochures, flyers, videotapes, billboards, and so forth to keep motorists aware of projects and changes that could affect their travel. These publicity tools are easier to use in an urban setting than in a rural setting because the population is concentrated, there are more media outlets in urban areas, and more people turn out for meetings in urban areas.

It's crucial to ensure that everything is coordinated. Design, traffic engineering, and construction personnel have to work together. The major goal is to keep construction time to a minimum. It's important that the public understands that you are striving to finish construction as fast as you possibly can. Kansas DOT uses disincentive/incentive clauses in contracts to encourage the contractor to accelerate construction. For example, the contractor for a new interchange in Topeka was paid $1.2 million to finish the project almost a year ahead of schedule. Another contractor, on a pavement reconstruction project on Interstate 35, collected $1.25 million by finishing a 2-year job in 20 months. If you accurately calculate the user costs, money spent to reward a contractor for finishing a project ahead of schedule is the best money you can spend. The contractor had crews working on site 18 hours per day, 6 days a week, but the public was grateful that they didn't have to deal with 4 more months of construction zones.

Some states have successfully used lane rentals to encourage accelerated construction. For example, after the Northridge earthquake, FHWA worked with Caltrans to come up with a $250,000 per day incentive for early completion of the Santa Monica reconstruction project. The contractor earned $14 million for coming in ahead of schedule. When you evaluate that cost in light of user delays, however, the actual cost of the incentive was far less than $250,000 per day.

To maintain an adequate level of service for commuters and other travelers in urban areas, it's critical that an incident management plan be developed. This involves close coordination with emergency medical services, fire services, and law enforcement services. For example, Kansas DOT has arranged with the Kansas Highway Patrol to allow tow trucks to travel against traffic on exit ramps, in order to get the trucks to the incident faster.

When we have to change traffic patterns in work zones, we work closely with the Kansas Highway Patrol to minimize motorist confusion and inconvenience. We use cellular phones and radios to communicate quickly among the DOT staff and with the emergency services staff. On most projects, we also deploy roving vehicles to evaluate traffic flow. Incident prevention and management ought to become less cumbersome once we have an integrated intelligent transportation system on our roadways.

The decision to reconstruct a pavement is usually made on the basis of the remaining life of the existing pavement and its capacity, geometric conditions, projected traffic, and so forth. The additional capacity needed and the right of way available determines the number of lanes that will be added. On some projects, we close the median and construct lanes on the inside; in others, we build retaining walls to eliminate backslopes that previously occupied space. Determining which type of pavement—asphalt concrete or portland cement concrete (PCC)—to build is largely driven by traffic. We can probably build an asphalt pavement inside of an urban beltway that will last fairly long. But most of the asphalt designs will need a resurfacing or rehabilitation every 15 or so years. A PCC pavement, on the other hand, can last 30 to 40 years, with just a little grinding.

We have endured 3 years of pretty heavy construction in Kansas, and our citizens—even though they like the highways they get—are tired of orange barrels; if we can keep the barrels off urban freeways, we will have accomplished what we set out to do.

Kansas has a smoothness specification for new pavements that sets a goal of zero blanking band. A lot of states still use the 0.2 inches blanking band, but at that level our motorists complain about roughness. Several paving companies in Kansas have won national awards for smooth urban and rural pavements. It's interesting how they use the incentives to improve quality. On the back of each paving machine hangs a sign that announces the amount of incentive funds they've won because of the smoothness of their pavement. Every worker on that job can figure out how much of that will go in his or her pocket at the end of the week. That's an incentive that works from a quality standpoint.

All told, the new technology, better planning, and the willingness to keep the public informed will allow us to serve our customers better. Our primary interest is to rebuild what we own rather than build new, but sometimes others have other ideas. For example, business owners clamor for us to build new interchanges that will enhance their businesses. But because too many interchanges can interfere with efficient traffic flow, we try not to add interchanges as part of our urban reconstruction projects.

We get a lot of letters from the public, griping that this curve is too sharp or this grade is too steep or the pavement is too rough. Rarely do they praise us. But in a random survey of 1,800 people in Kansas, more than 90 percent of the respondents said that the state DOT was doing a good job. Judging by the way California DOT is proceeding with this project and by the experience level of the workshop participants, the California DOT will likely find a similar level of positive customer feedback.

The Challenge of Urban Freeway Renewal

JAMES VAN LOBEN SELS
former Director of the California Department of Transportation

By California law, safety needs come first, followed by maintenance and care and rehabilitation of existing facilities; the lowest priority is accorded to new capital projects, such as new interchanges and freeways. Politicians and executives focus on the new capital projects because they can tell the constituents at home that they did wonderful things—that they are dealing with the future and growth of California, the quality of life, and the economic vitality of the state.

We who own and operate the state highway system truly believe that safety, maintenance, and rehabilitation of the system are our most important responsibilities—that we must be good stewards of what we own. About 15,000 of the 45,000 or so lane miles in California are in need of work. Previously the funds that have been available caused us to concentrate on the worst first—that is, only when a pavement was failing, or about to fail, did we fix it. We put overlays on the pavement, trying to find 4- or 5-year solutions.

Much of our freeway system, which is a signature for California, still looks new. But portions of it are 30 or 40 years old. It was designed for a 20-year life, and it has exceeded that not only in time, but also in terms of traffic and loads.

Our challenge now is to fix the highway before it fails. We want to go from a program of fixing the worst first to a program of preventive maintenance—to preserving our pavement by fixing it before it fails. The difficulty is determining when to fix it. There is no formula.

The people of California, like people everywhere, judge highways by ride quality, not engineering concepts. They are not satisfied with what they have, and we are concerned that the highways will fail before we get a chance to fix them. We are convinced that we must invest in rehabilitation—and we are going to invest heavily in rehabilitation. We have decided that at the end of 10 years, only 5,500 miles of California's highways will be showing signs of distress—a significant improvement from the 15,000 distressed miles today. As much as we would like to zero out the number of distressed lanes, we realize that it is just not affordable. We are not sure if 5,500 lane-miles is the right target number, but it is certainly much better than what we currently have.

With the cooperation of the state legislature, we have persuaded the transportation commission to increase investment in pavement and bridge rehabilitation by one-third over the next 10 years (at the expense of new capital projects).

In urban areas, we face operational as well as engineering challenges. We have to engineer the section, but we also need to get in there and get out as rapidly as we can because of the impact on the traveling public. We can't just go in and take a couple of lanes out of service for rehabilitation for a year, 6 months, or even 1 month. We're looking at how we can do this piecemeal over weekends, even at an increased cost. We calculate that the increased construction cost will be more than offset by the savings, in terms of delay, to the traveling public. We're looking for technical solutions, such as rapid-setting concrete, that will give us a renewed highway that will last for 40 or so years.

Of course, if we're going to use long-life pavement in rehabilitation projects, shouldn't we also be using it in new construction in urban areas? California tried to change the specifications for two projects in the queue to include long-life pavement. Together, the two projects totaled between $10 and $15 million. The projects made the first cut, but not the second cut. It's awfully hard in the march of new things to ratchet up the cost of doing business, particularly when your project is competing against somebody else's freeway or interchange.

If we can establish the case for long-life pavement in rehabilitation projects, we can begin to address it in our basic standards for bridge decks and urban heavy-duty pavements. We can then design and build bridges and pavements the way Europeans do, and build them right the first time.

Urban Freeway Renewal in Southern California

TONY HARRIS
District 7 Director (Los Angeles and Ventura Counties) for the California Department of Transportation, and previously with the Federal Highway Administration

Before he retired, Caltrans chief engineer Dick Weaver approached me with a vision. He wanted to get a group of people together to start tackling how we deal with urban freeway renewal. In investigating the size of the problem and the issues I would face here in Los Angeles County and in Ventura County, I realized that we would have a great opportunity to get input on how to shift emphasis from building new roadways to renewing and refreshing the system facilities we have out there now. What better test case to start with than the existing portion of I-710.

One of the problems we face on a regular basis in southern California is the weather. We have great weather, but when it's bad, it's bad. And it is bad over a very short period of time. That affects pavement design, traffic operations, and the expectations of the traveling public. They're not used to being inconvenienced, and they're very vocal about that.

We have one of the more extensive freeway systems in the country. It is mainly built out, except for a smaller piece at the north end of I-710. The level of traffic we are carrying on this freeway system is way above what anyone ever projected during the planning and design phase.

The Southern California Association of Governments predicts that a population twice the size of Chicago will move into this area over the next 20 years. This will only add to the congestion and reinforce the need to rehabilitate our freeways, most of which were built in the early 1950s and the mid-1960s. The freeways were designed for a service life of 20 years, and we are pleased that they have been functioning very well for 30 to 45 years. But we are concerned about the future.

The California Transportation Commission has made a commitment to provide additional funding toward the rehabilitation of our freeway system. As they put together their regional transportation plan, the California Transportation Commission and the Southern California Association of Governments are proposing to commit $3 billion over the next 20 years to rehabilitate our roadways. That's over and beyond any amount that had previously been in our interregional transportation plan, and it is a strong recognition of the importance of rehabilitating the roadway in addressing the issues of mobility and service.

As we get into these projects, we are finding that they are more and more expensive. You have to take into account the user's expectations, traffic management, the cost of materials, and various other concepts. But it's very important to find a way for these projects to successfully compete for funding with new capital improvements projects.

In Los Angeles County, there are approximately 153 miles of pavement in need of rehabilitation. That's miles of freeway, not lane miles. Taking into account that most of those freeway miles have at least eight lanes, well over 1,000 lane miles in Los Angeles County alone need rehabilitation.

In addition, approximately 33 lane miles of candidate projects have been identified for consideration for long-life pavement strategies—and that's just the beginning. Another 55 lane miles need moderate rehabilitation. The majority of the freeway system here is in need of some type of rehabilitation.

I spend a lot of my time visiting and working with elected officials in Los Angeles and Ventura Counties. Some of the expectations they routinely communicate to me are: "I want a smooth ride; I want a timely ride; I want to be able to plan my trips and know that I can make those trips on a timely and regular basis—and by the way, I want you to fix this roadway tomorrow, as soon as possible, but while you're fixing it, don't inconvenience my commute or my travel at other times of the day either."

We have to try to balance those needs. Safety is also important to the county officials. They are very supportive of projects that will help improve conditions out there, as long as safety is not compromised. They're willing to support and make adjustments if they can fully understand what is proposed, how it will benefit them, and how it can be done in a timely manner.

The bottom line is, they want a fully maintained facility that operates at peak performance, but that does not inconvenience them during improvements.

You've already heard what is needed on urban freeway renewal nationally and in other state DOTs. I'm going to address some of our other ongoing projects.

Ongoing Projects

We have been spending time and effort investigating other forms of long-life pavement, and we have worked on several different phases of a concept. Earlier this summer, for a carpool lane project under construction on I-605, we worked with the contractor to initiate a change order. We wanted to determine the production rate of a contractor using fast-setting hydraulic concrete.

Not only did we work with the contractor, but we also approached the press, whom we invited to come out and spend some time with us on site one summer night. The contractor placed approximately 1,300 linear feet in one lane over an 8-hour time period.

The importance of that was twofold: first, we were able to determine the production rate for placing fast-setting concrete pavement. Second, we were able to introduce the public and the press to this concept, especially since we were going to do more and more work in this manner. We wanted their support and understanding.

We got a lot of positive reaction and a lot of positive press, and we didn't have to close a lane. It was all done within an existing construction project. The real challenge will come when we start having actual traffic impacts.

Next, we initiated another project in northern Los Angeles County, in the Antelope Valley area on Route 14. For that project, we wanted to place a fast-setting concrete structural section and then come in and test it. We are going to use the heavy vehicle simulator we purchased from South Africa to test the structural section 24 hours a day, 7 days a week, until failure. The idea behind the test is to determine exactly what is the life of that structural section. Construction is underway, and we're planning to start the heavy vehicle simulation tests in spring 1999.

On a section of roadway on I-10, which stretches from the I-210 interchange to Gary Avenue, we are planning not only to test the pavement, but also to determine how much a contractor can produce in an actual project.

We have initiated a public awareness campaign. We started off by holding meetings with members of the local media to educate them about upcoming projects. We will be meeting with representatives and officials of local cities in the project area to set up the detour plans and to help them understand what's going on with the project. We will be distributing regular project updates to the community.

Why is this important? We want to take on the challenge of actually closing two lanes of a four-lane freeway for an entire weekend—we want to close two lanes from the end of commute hours on Friday until 5 a.m. on Monday morning.

We want to tell the public: If you'll allow us to close the two lanes for an entire weekend, when we open them back up, you'll have a new structural section to ride on.

Our goal is to rebuild the freeway in 2-mile segments. All our interchanges are spaced 2 miles apart, which allows us to go in, set up operations, and minimize the impact between various interchanges.

As you can see, we're trying some things, but it's not enough. The challenge we have in Los Angeles County is to get outside the box—to think of new ways of doing things—if we want to provide a quality product to our customers, the traveling public.

I'm looking for ideas, and all ideas are welcome. What we learn with this project will be beneficial not only here in Los Angeles County, but also throughout the state of California and the nation.

The bottom line is, we want a renewed freeway system that provides a smooth ride, one we can reconstruct with minimal traffic impact.

Project Overview

DOUGLAS FAILING
Division Chief of Design for the California Department of Transportation, District 7, Los Angeles

I'd like to provide a brief summary of the key issues with the I-710 project, followed by my own perspectives and a bit of additional data.

Some of the key sections of I-710 now carry close to 220,000 vehicles per day. Over the next 20 years, the traffic volume is projected to increase only about 1 to 2 percent per year on this particular route. Although we're looking at an overall traffic increase of 20 to 40 percent—a relatively small increase for an urbanized area—we are also looking at a huge increase in the volume of truck traffic that's projected to result from port growth.

In the Alameda Corridor, 20- and 30-year projections indicate that truck traffic from the ports will grow to two-and-a-half times today's volume. We're looking at 2 million equivalent single-axle loads (ESALs) per lane per year in the outside lanes, or about 4 million ESALs over the two outside lanes per year in a 40-year growth projection. For a 40-year pavement design, we're dealing with numbers on the order of 164 million ESALs for that particular roadway.

Now compare that with the truck traffic that these roads were originally designed to handle. The freeway was designed in the late 1950s for a 20-year life. Today's traffic far exceeds those original projections. The freeway was built basically of unreinforced portland cement concrete pavement. There are no tie bars for load transfer across longitudinal joints. There are no dowels across transverse joints. Yet the pavement has served close to, and in some cases more than, 40 years. It's done yeoman's work. It's provided everything we could ask of it and more.

The Port of Los Angeles and the Port of Long Beach are lined up at the southern end of the corridor; the intermodal rail yards—Union Pacific, Burlington Northern, Santa Fe—are at the northern end, near I-5. The rest of the traffic up to the northern district is heading for the east-west distribution centers, I-10, SR-60, I-105, and SR-91, and into the Inland Empire, one of the most booming areas in the nation right now, as well as I-405, which serves coastal areas to the north and south.

Straw Proposal

The standard rehabilitation design we are proposing—our straw proposal, if you will—is a one-size-fits-all public works project that involves a total replacement of the two outside lanes—that is, full-depth replacement of the top 8 inches of pavement.

The basic assumption is that the rest of the structural section, the cement-treated base, is still good and still has a lot of service life in it. But when we replace the pavement, we are going to tie across the longitudinal joints, dowel into the existing pavement in the number one and two lanes, and then put back in the dowels across the transverse joints. This will provide better load-carrying capability in the future.

The number one and two lanes have relatively little pavement breakage in them, although there are some areas, particularly in one stretch between 105 and Route 5 in an over-crossing structure, where some random slab replacement will be necessary in lanes one and two. We plan to replace those slabs, including inserting longitudinal ties and dowels in those particular slabs; we do not, however, intend to come back to put in longitudinal ties and dowels in a retrofit pattern in the rest of the roadway.

The reconstruction estimates are based on all work being done during off-peak night hours. We do a lot of weekend work in urban areas, and that will also be a strategy on this project. Using conventional methods and practices, we are looking at probably 3 years of construction for this 15.7-mile section.

This project does raise special issues. The roadway was built at a time when we had different standards. It was not built to current Interstate Highway standards. The vertical clearances specified then do not comply with today's standards. There are a few stretches of roadway with vertical clearance problems, which pose a challenge in rehabilitating this roadway. There are a lot of areas, though, where vertical clearance isn't a problem, and that provides some opportunities that we might not normally have with our run-of-the-mill approach.

We do a lot of night construction here, although we avoid it where we can, for safety reasons. We're looking for innovative ideas that will allow us to meet production goals while avoiding use of night construction. That's good for quality, it's good for the traveling public, and it's good for safety overall.

We are starting to use more and more enhanced highway patrol protection in our construction zones. Officers will routinely patrol the site and have a visible presence. This helps reduce instances of road rage and keeps our customers—the portion using the roadway at that particular time—focused on the need to pay attention to what's going on out there.

I've read estimates that, at any particular time out on the roadway, anywhere from 15 to 25 percent of drivers are impaired in some way. The percentage does not just include drivers who have been drinking; it also includes people who have dust in their eyes or who are taking legal prescriptions that affect their driving ability. Our work crews are out there working in close proximity with those impaired drivers, trying to stay alive day in and day out, and still get the job done for our customers.

Our highway maintenance crews often don't have the luxury of working behind protective barriers. We routinely strive to restore full-width shoulders—10 feet at least on the right-hand side—so that maintenance crews will have a safe place to pull over and perform their maintenance tasks. In those areas where we don't have right-hand shoulders—and there are many in this corridor—we try to design the roadway to reduce the need for our maintenance crews to close lanes.

By not closing lanes, we keep our people off the road, thus reducing their exposure to hazardous working conditions. Capacity is maintained, and traffic doesn't back up. Whenever possible, we look for ways in which our maintenance crews can access the work area from other than the freeway. For example, parallel city streets can sometimes provide access to the work area, without having to have trucks out on the freeway or having to close a lane of the freeway. After all, anything that's sitting out there is just another target for the 200,000 people driving by—of whom 50,000 or so are impaired.

Traffic Management

The biggest problem for us in the urban area is incident management. Traffic in Los Angeles runs fairly well as long as there are no incidents. We are all too familiar with those situations where a motorist is looking off to the shoulder, watching the guy in the orange truck, and then crashes into the car in front of him. We are continually seeking ways to reduce our presence on the roadway; not only will this reduce incidents, but it will improve the movement of traffic overall.

Local User Views and Expectations

DANIEL BEAL
Manager for Technical Resources and Policy Development, Automobile Club of Southern California

The Automobile Club of Southern California has 4.5 million members in the southern half of the state. Started in 1900, it is the oldest and largest affiliate of the American Automobile Association (AAA). The Auto Club helped lay out the roads in California and helped invent the art and science of traffic engineering and road design. So we naturally have a historic as well as current interest in better pavement design, in better maintenance and funding of our highways, and in the tasks we're taking on in this workshop.

I know I'm preaching to the choir here, but on a national basis, we are not spending enough money on our transportation system. This nation is absolutely dependent on an uninterrupted flow of people, goods, and services, and probably more than 99 percent of the time, a trip or a delivery involves travel on a road. And those roads are wearing out.

Between 1960 and 1993, inflation-adjusted total spending on the nation's highways declined 50 percent, and capital spending declined 60 percent. Highway and bridge capital needs are $53 billion a year just to maintain current conditions, or $73 billion a year to make things better; the current spending level is only $35 billion, and it's not going to get any better in the near term.

One reason may be evident in a comment made by a colleague of mine. We were talking about this workshop, and he said, "Dan, you'll get 40-year pavement when elected officials get 20-year terms." I'm not sure he's right, but I'm not sure he's wrong either. I think that points out that we need to do a very good job of selling the benefits of this kind of project to the people who have to pay for it.

Do users know the system has severe problems? Yes, we think they do. In a 1996 poll conducted by AAA, more than two-thirds of our members nationwide described the condition of roads in their states as fair, poor, or very poor.

According to The Road Information Project (TRIP), we're wasting $23 billion—$125 a person—in this country on vehicle and tire repairs and extra fuel needed as a result of poor pavement conditions.[7] The Surface Transportation Policy Project (STPP) recently floated a much higher number than that,[8] and FHWA Executive Director Anthony Kane has pointed out that traffic delays cost us $4 billion each year.

Fix the Roads

AAA takes this situation so seriously that in 1996 we began a campaign called "Crisis Ahead: America's Aging Highways and Airways." It's our association's number-one priority. And that leads me to my first user-side observation. We'd like you to fix the roads. We'd like you to fix them as economically as you can, as quickly as you can, as safely as you can, and we'd like you to fix them so they stay fixed. That's a very simple request, but it's obviously not simple to accomplish.

There are some very complex issues behind a request like that. Some of them may be beyond the immediate scope of this workshop, but I think they all bear on it.

Probably a half-million of our 4.5 million members are directly or indirectly affected by the existing conditions of I-710 and would be further affected by an extended construction project on that roadway.

The state of California has designated I-710 as a statewide corridor of economic significance, which means it is bearing a great deal of the goods movement for this region. What happens in this corridor and with this project affects not just southern California; it affects businesses and people and economies far beyond Los Angeles.

A key issue will be determining how much of I-710 can be taken out of service to make capacity improvements that will mean decades of relatively trouble-free operation. My suggestion would be to do what you have to do to give us a first-class facility that will perform its crucial job for many years to come. But I suspect a great many people would not entirely agree—they would rather not have their routines disrupted.

[7] Key Facts about America's Road and Bridge Conditions and Federal Funding. *Washington, D.C., The Road Information Program (TRIP). Updated 1999.*
[8] Potholes and Politics 1998. *Washington, DC., Surface Transportation Policy Project, 1998.*

Be Inventive and Involve All Users

As we begin this project, we ought to keep in mind that in some respects it will resemble new construction more than what is typically considered rehabilitation and maintenance work. This requires that you be as inventive as you possibly can in developing means of mitigating the effects on traffic, the community, and businesses. You will need to review every aspect of this project—not just the operations aspect, but also materials, design, and construction—to minimize the impact.

You need to involve all of us who will be affected by this project. That's a lot of people, including motorists, the business community, and local communities.

In an article for *Better Roads*, Clyde Walton of the Maine DOT wrote, "Somewhere in this process there has to be continuous feedback between us and our highway users. In public works, a better-informed public is a willing contributor to the success of the project. Let the design sell itself to them by listening and by valuing their input. Show it in the design. Consider them as part of the team."[9]

That's what we'd like you to do. We all need to be part of the solution. It will be much easier for motorists to put up with the inevitable detours and delays of this project if they think that other system users are also contributing to the solution. For example, I-710 is a key truck route. The Southern California Association of Governments is actually considering truck-only lanes on this corridor. So goods movement will be affected by the project and thus must be part of the solution. A lot of the warehouses in the Ports of Los Angeles and Long Beach operate only during daytime hours and have a huge effect on traffic during peak hours. One of the things you might consider is developing a working partnership with the warehouse operators to see if some of their operations can be moved out of the peak hours.

Another thought would be bringing in the large trucking firms, such as UPS, to the early design discussions. Talk to them and see how they can best cope with the delays and disruptions wrought by this project.

A key issue in designing the pavement for this project is the potential for this pavement to carry loads as much as 50 percent higher than are legal in other states. That's a policy question for California.

If the Alameda Corridor project is completed by the time this project begins, then you might want to see how much freight can be transferred from I-710 during construction. If, however, the Alameda Corridor is not finished in time, you might want to reconsider the timing of the I-710 project.

Users of I-710 will have to be given as many alternatives as possible. There are two parallel freeway corridors about 5 miles on either side of I-710—the 110 and I-605. They already take a great deal of the load of north-south movement in that corridor. They'll be asked to take even more.

This project will likely affect a constituency within about a 10-mile band, and the arterial roads in that band will have to carry heavier loads. This provides another opportunity for a strategic partnership. There is a very large backlog of signal synchronization and arterial improvement projects in this county. Partnering with the cities and agencies responsible for those improvement projects might be a good way to help them accomplish their goals, while ensuring that the roads will be ready to accommodate the traffic that will be rerouted as a result of the I-710 project.

These cities also have terrific access channels to their citizens, including community newspapers, cable televi-

[9] *Walton, C.D. "Why You Should Involve Drivers in Roadside Design,"* Better Roads, *Vol. 68 No. 2, Park Ridge, Illinois (Feb 1998) pp. 23-24.*

sion, and community meetings. Talk to them about piggybacking onto their activities. They can help.

We can also help. The Auto Club has nine district offices that are in reasonable proximity to this corridor. We can give out information. We can work with the cities. We can work with Caltrans, and sometimes we have an idea or two about innovative traffic approaches that we might be able to offer, too.

This corridor is very diverse in terms of land use. That gives you some opportunities. In those parts of the corridor that are not residential in nature, 24-hour-a-day work might be acceptable, as you won't be bothering anyone. Many of the other, residential parts of the corridor are home to low-income families that, frankly, do not have warm-and-fuzzy memories of past freeway construction projects. You need to work with them, and you need to make the impact on them as low as possible.

And finally, public transportation has a great role to play here. The good news is that the region's most popular rail transit line runs parallel to this project. The bad news is that it is operating near capacity, and its expansion potentials are limited. But there are a variety of other options. For example, people are talking about smart shuttles. This project could offer a great opportunity to field test and evaluate an innovative shuttle system. Long-distance commuter buses are another option.

Transit approaches, like everything else, are going to take a lot of careful planning and market research. We had an interesting experience after the Northridge earthquake in 1994. I was with the City of Los Angeles then, and we thought it would be wonderful to implement subsidized bus service on the west Los Angeles commuter route that bypassed the downed bridge on the Santa Monica Freeway. It saved a half-hour. The parking was free, and the bus was nice and new. It was a complete flop. Nobody took it. And we still, to this day, don't quite understand why. It seemed like a good idea.

Technology Showcase

This project may lend itself to being a terrific technology showcase. ITS applications are coming on line all the time. Think about making this corridor a test case for traveler information and advanced traffic management systems. It would serve two purposes: First, it would demonstrate to the public that this stuff—ITS—really works, and it works under a difficult and challenging environment; and second, it's a great test bed to try out different approaches to ITS, again under a challenging situation.

Conclusion

I haven't mentioned the system users' preferences in terms of paving material and design, and frankly, I don't have a clue as to what their preferences are. I am not sure if they care, as long as several basic criteria are met: the road gives a good ride, it is constructed quickly and safely, and it holds up well over the long term. We leave the debate and decision on materials and design up to you.

But there's a great deal more than just materials and design involved in this project. I hope you take every opportunity as you work through this workshop to take those issues and the opportunities they present into consideration. We, the system users, will work with you. If you give us a solid and meaningful program, we'll be there with you, and we'll cooperate in implementing it.

The Commercial Users' View

CANDICE TREAGER
Public Affairs Manager, Pacific Region, United Parcel Service

It's heartening to hear the kind of things we've been discussing in the private sector, such as customers and quality, now being discussed in the public sector. The United Parcel Service (UPS), with a fleet of 90,000 vehicles, is dependent on the highway system to meet its customers needs.

Customer involvement and participation is very important to UPS. For example, we developed a motor carrier advisory board, which includes a number of representatives from the private sector. We ask their opinions and confront their concerns about large trucks. We listen, and we take their concerns to heart.

On an ongoing basis, we hold monthly meetings where the public can talk with UPS staff. We also communicate with the public via faxes and newsletter updates, which help us keep our customers informed about our operations and thus engender their support for our operations. By providing these forums on an ongoing basis, we avoid a lot of gripes and complaints from citizens when our trucks have to be rerouted because of construction.

What Highway Agencies Can Do

Highway surveillance cameras combined with variable message signs and other technologies can be important real-time tools for informing motorists and shippers about traffic jams or incidents.

The number of freeway closures should be kept to a minimum. We realize that agencies sometimes have to completely close a roadway for construction purposes, but such closures should be restricted to off-peak hours. At most other times, at least two lanes of travel should be maintained in each direction.

When a primary route is scheduled to undergo maintenance or construction activities, highway agencies need to ensure that the nearby secondary routes can handle the traffic that will be detoured on to them. State highway agencies should closely coordinate their work with nearby cities and counties to ensure that the intended detour is not under construction at the same time as the primary route.

A concerted public relations program to inform the public about what is to come is essential. If it is effective, it will cause many people to seek out and use alternative routes. A wide variety of outreach media should be used, because people don't communicate in just one way anymore; you have to use many different types of media to get the word out about a project and to encourage motorists to rearrange their daily activities and look for alternative routes.

You don't expect an industry advocate to say "you need to decrease the speed limits," but we know from our experience that speed limits need to be decreased in construction areas. People will not necessarily slow down just because the number of lanes is reduced from four to two in a construction zone. As traffic is funneled into fewer lanes, the probability of accidents goes up. We strongly recommend that traffic be slowed *before* entering the work zone, which will make travel through the work zone safer, smoother, and more efficient.

It is not easy for motor carriers to reroute their delivery and pick-up paths. But if the carriers are involved up front, when planning a project, they can point out the most heavily used routes and help map more efficient detours. For example, UPS tries to route its drivers in loops, which are very efficient. A truck travels in one direction on the loop to make deliveries, and then it turns around and travels in the other direction to make its pickups. The route starts and ends at the same place. If a construction project cuts through the middle of the loop, the truck has to now make several smaller, less efficient loops. But if we know about this ahead of time, we can deal with it and take steps to mitigate the effects.

One of the first things that comes to people's minds when they think of trucks on congested highways is that perhaps our trucks don't really need to be out there on the road during the day—that we should schedule deliveries and pickups between one and four in the morning, when there isn't much traffic. Obviously, however, we are customer-service oriented, and our customers have their own schedules; to get them to accept deliveries and pickups in the middle of the night would require a major behavioral change—and I have never seen that kind of behavioral change effectively implemented. Maybe someday this will be possible, but until then, we are going to have to serve our customers during their business hours.

Problems

When motor carriers are forced to change the configurations of their vehicles, that can cause problems. For example, when lanes are narrowed and re-striped because of construction, triple trailers have to be broken down into different configurations, and this is very inefficient.

Part of the issue with reduced lane widths is perception, and we all know that perception is, in fact, reality. For example, narrower lanes make everything else look larger in comparison, and a lot of the negative attitudes that people have toward trucks are because of this. We need to educate people that trucks serve a good—without trucks, how will we provide goods and essential services?

Re-striping can cause other problems for truckers, particularly when construction sequences necessitate that the stripes be repositioned from one day to another. Our drivers have had some real difficulties in some areas where the pavement has been milled and the stripes are not very visible, particularly in the rain. This is causing some major safety problems.

Another problem can be caused by construction vehicles. Construction vehicles, be they gravel trucks or whatever, tend to leave debris on the road. Agencies should require that they clean their tires off or wipe their tires down when they exit the construction area. Again, dealing with public perception, a cracked or pitted windshield can turn people against a project, the department of transportation, and trucks in general.

Additional Business Costs

What are we really talking about in terms of highway construction projects affecting the cost of doing business? In a word—personnel. And personnel costs are very expensive. With a major highway construction project such as the I-15 project, UPS has to hire additional personnel. It's not just because of the additional delivery loops. They are also needed because the construction makes it a hassle for workers to get to their jobs. The UPS workforce includes a large number of part-timers, but if construction delays make it too difficult for them to get to work on time, they're just not going to come in anymore. We then need to hire additional personnel, and with these new workers come additional training costs, additional equipment, and so forth.

Absentee and tardy rates also increase as commuting to work gets more difficult. Our shipments are time sensitive, but it is hard to operate in a time sensitive manner if our workers can't get to work on time. As a result, overtime hours go up, which drives payroll costs up. And of course, if businesses move out because of the construction and stores and offices sit vacant, UPS also loses business.

Local Business Impacts

KERRY CARTWRIGHT

Manager of Transportation Planning for the Port of Long Beach

I am going to talk about the amount of trade that passes through the Ports of Long Beach and Los Angeles, to give you an idea of the impact on the I-710. Long Beach is the number-one container port in the United States, and number seven in the world. Combined, the Ports of Long Beach and Los Angeles are number three in the world. This gives you an idea of the significance and prominence of both port facilities and the importance of I-710 to the ports.

In 1998, 4.1 million TEUs (20-foot equivalent units) were shipped through the Port of Long Beach—the only port in the world to handle that many shipments. The Port of Los Angeles handled 3.4 million TEUs that year.

The I-710 is the gateway into the Port of Long Beach. Over the next 20 years, a considerable number of acres on Terminal Island, site of the port, will undergo tremendous development, to accommodate expanded and new terminals. The number of TEUs forecast by 2020 through the Ports of Long Beach and Los Angeles combined is estimated at 23 million. The estimated number of trucks generated by both ports today is 17,000 to 20,000; 70% of these travel I-710. When we estimate the number of additional trucks at 9,000 per day, we consider that anywhere from 20 to 40 percent of the goods will move by rail. Right now, we have a number of facilities that have on-dock rail, which allows cargo to be transferred directly from ship to rail, and that number will also increase.

Most terminals are going to become more advanced and more efficient in their throughput, with the result that more cargo will be processed through the port, and hence more trucks will be needed. For that reason, truck traffic is expected to grow much more than the overall vehicle traffic.

The expected 25,000-vehicle increase from all sources will equate to one lane total, half a lane in each direction, because the truck directional split is about 50/50 on I-710 in this section. This is to give you an idea of the peak hour volumes as well. The freeway in this section is six lanes, so it is basically at or near capacity right now at peak hour on a daily basis, and it's certainly going to increase dramatically under future conditions.

So something is going to have to give over time, and you're going to probably see different things happening to adjust to the increased traffic on I-710, because obviously the six lanes are not going to be able to adequately accommodate all that increased traffic.

You may see a shift to the I-110, but existing data show that the use of the I-110 is minimal because of where the trucks are going. There's simply no need for them to use the I-110 because the regional destinations are more to the northeast than the downtown rail yards and the rail yards farther to the east.

There may be a shift to the Terminal Island Freeway, but that only represents a short leg of the trip and would avoid some of the severe congestion down around the port. The next choice may be the Alameda Corridor. There is a myth that the Alameda Corridor is, in fact, a truck facility. The Alameda Corridor is really a consolidation of three or four rail lines into two mainline tracks, grade-separated throughout the entire corridor from the ports to downtown. It is not a truck expressway facility.

Separate from the Alameda Corridor program is a project by the City of Los Angeles and the County of Los Angeles to widen Alameda Street from the existing four lanes to six lanes, with the aim of increasing capacity and helping to meet the overall travel demand. Any expectation that the widened roadway will carry a lot of the port-generated truck traffic is a fallacy because the route will not represent a significant time savings for trucks, even with the congestion on I-710.

The hope is there will be some shift to alleviate traffic on I-710 so as not to overburden it and cause severe gridlock almost 24 hours a day. The significant fact is that 70 percent of trucks in the future will have five axles.

As most of the container trucks generated by the port move farther north on I-710, the trucks disperse to distribution centers or warehouses, where the goods are repackaged as cargo on typical semitrailer trucks. You see fewer and fewer container trucks as you go farther north because the goods have been distributed onto other trucks.

What does this all mean as far as not only pavement management, but also long-range planning for overall demand and needs along this corridor? The Southern California Association of Governments' regional transportation plan is now considering truck lanes throughout the region, on SR-60, I-5, and I-710. Unfortunately, in the regional plan right now, the proposed truck lanes would start at SR-91. It doesn't help a lot for the port-generated trucks. They still have to work their way up to that point.

In addition, as the City of Long Beach undergoes a lot of development, especially in Shoreline Village and Queens Way Bay, the additional truck traffic will cause a perception problem, particularly with some users of that facility who are destined for points of interest in the City of Long Beach.

We certainly have a daunting task to determine or develop a solution to the problem of the increased truck traffic, and there's no stopping this because of the burgeoning trade with Asia. We will have to grapple with these issues and come up with an effective near-term and long-term solution.

There's hope that the Alameda Corridor can alleviate some of the burden on I-710, but only a small percentage of the truck traffic will be able to shift to this corridor. The fact of the matter is that truck traffic on I-710 will continue to increase just because of the increased trade.

Another thing that we're considering in our new strategic planning process at the Port of Long Beach is the concept of inland ports. This simply means that we haul the containers or cargo by train through the Alameda Corridor to redistribution centers or ports inland. Obviously, this would reduce truck trips on all the freeways in the region.

The Alameda Corridor will help maximize the use of rail. There's a mistaken belief that the Alameda Corridor will generate increased trade. In reality, the Alameda Corridor is going to allow us to handle the increased trade that's going to occur regardless. Both the Port of Long Beach and the Port of Los Angeles are maximizing the use of rail, and will continue to do so.

The Community View

JENNY OROPEZA

Councilmember for the City of Long Beach, representing the city's downtown area

As a native-born southern Californian, I have a love-hate relationship with freeways. I love them because they get me from point A to point B, and I hate them because they keep me waiting to get from point A to point B.

I'm concerned with the needs and priorities of my own district, which is the downtown area of Long Beach, as well as our entire city, which is 420,000 people plus. But as a board member for the Metropolitan Transportation Authority (MTA), I also have to consider the transportation needs of the broader region.

In Los Angeles County, the MTA is responsible not only for regional transit operations, which comprise the bus operation and also our much beleaguered and maligned rail construction projects, but also for planning and funding a wide range of regional transportation improvements, from freeway and rail transit expansion to ITS, sound walls, buses, and local arterial streets.

As a result, and in light of our limited resources, we have to make tough trade-offs and tough decisions that affect what the 21st century is going to look like for those of us who live and work in Southern California.

I also serve on the Southern California Association of Governments (SCAG), which is in the throes of developing and marketing a regional transportation plan that will take us to the year 2020. It involves a lot of controversial suggestions, a lot of out-of-the-box suggestions and ideas to grapple with the projected phenomenal growth over the next 20 years.

I also serve as the chair of the Goods Movement Advisory Group of SCAG. That's a collaborative effort involving the private sector and elected officials representing the county and the cities. Our mission is to focus on the movement of goods throughout the region, which is a major component of our future. We look at this not only from the perspective of moving freight through the region so that it can reach all corners of the country, but also from the perspective of the economy of Southern California, which is becoming more and more dependent on international trade.

These interesting and challenging hats that I wear give me an opportunity to learn a great deal and to share a local perspective, because I am a local elected official in these decision-making arenas.

I was also recently elected to the National League of Cities' Board of Directors, so I hope to bring the agenda and perspective of Southern California to the national scene as we advocate for funding sources for our projects.

I would like to share a little bit about the local communities' perspective on I-710, particularly how it relates to rehabilitation and renewal.

Let me say up front and very clearly that I-710 is absolutely critical to the City of Long Beach. We are in the throes of a revitalization. The economy of the city used to be primarily based on the defense industry. We have, however, redefined the city as a major tourist destination and a major import-export hub. We are developing a number of venues, including a state-of-the-art aquarium; a major project called the Queens Way Bay, which has a number of water elements along our coastline; and our convention center. We are home to the *Queen Mary*. In short, there are a lot of reasons for people to come to our community, and they come by way of I-710.

Because I-710 basically brings the greater Los Angeles area right down into all of these venues, it is critical to us, not only in terms of how it flows and rides, but also it terms of how it looks.

Focus on Aesthetics

The public's perception of I-710 is frankly not a positive one. They see it as a scary place because of all the trucks. They see it as a filthy, dirty place because it is old and the infrastructure is worn. I'm not only talking about what they ride on, which is ridged and uncomfortable, but also what they see as they travel down the road. They see medians that are banged up and filthy, they see no, or very little, greenery along major portions of the freeway **(Plate 3)**. They feel like second-class travelers compared with travel on other freeways in the region that look much better, that ride much better, and that are much more comfortable and safe.

I'm being as candid and direct with you as I can because, as you grapple with the design questions, I would urge that you also concern yourselves with the aesthetics.

Safety should be the number-one concern as you implement a project like this. Safety for the folks who drive the freeway. Safety for the folks in the surrounding neighborhoods who will be affected by rerouted or detoured traffic. Safety for the highway workers themselves.

Issues of noise are also very critical, particularly in those areas along I-710 where there are no sound walls. This poses some conflicting agendas. People don't need to drive on the freeway at night, so it's a good time for construction. But people do need to sleep, and highway construction makes a lot of noise.

The traffic congestion that comes with any closure of lanes is also an issue. As someone who travels I-710 several times a week into downtown Los Angeles, I will tell you that it is scary to be in a car on that freeway because you are much smaller than a lot of the trucks. And there are many, many times during the day when you are stopped in traffic. Any kind of little incident, even in the opposing direction of traffic, can bring traffic on the freeway to a screeching halt.

One of the reasons we are moving so much freight and moving it so far on highways is that we don't use warehousing as much as we used to because folks want products delivered just in time—not yesterday, and not tomorrow. This saves money, but it also means that more trucks are moving along the roads, making more deliveries.

Workers also want to get to their jobs just in time. With the added congestion that comes with the lane closures, particularly during commute time, there frankly is no good time on I-710. Congestion is a traffic problem and a public relations problem. It is a real problem for people with real lives, who have to commute to real jobs.

Most communities in Southern California have come to expect congestion. They can live with some of that. But their patience will wear thin if it really gets bad, especially if it is the result of roadway improvement projects that they don't understand and that they don't see as benefiting them. This is the public relations challenge of the project.

And remember, people are concerned not only with a roadway's ride quality, but also with how it looks. They are concerned about what the median looks like. They are concerned about having green along this cement jungle, which these freeways often are. They also compare I-710 with other state highways in Southern California. Today, it does not measure up. This is one of the ugliest of freeways. Because motorists spend so much time on it, especially with added congestion, it is very important to have some greenery along the road, and Caltrans and others must make a commitment to maintain it.

Folks hate seeing garbage and trash. They hate seeing burned up bushes or nothing but dirt along the sides of these freeways and in the median. There is not much space for greenery in the I-710 median, so I don't know if we can aspire to a green median, such as the much-admired roadway to Santa Barbara, but I hope that you are mindful of the aesthetics as you work on your designs.

The Importance of Communications

As elected officials, we expect Caltrans to keep us informed, to keep our concerns in mind, and to work with us during the major construction. This is where we, the local communities and governments, can assist, because we have the connection to the people. My phone rings off the hook when there is a construction project going on. People want to know why they are being rerouted, why there is a detour, why they can't get off at their usual exit, and so forth.

Communication is critical to making this project work and is very important in getting the public to buy into the project. The folks at the local government level all up and down that corridor are also critical to the project's success, as are the elected officials, who hear from folks in the supermarket or in late night calls to their house. If you develop well-tuned systems that communicate with the public-agency employees and officials every step of the way, you will be well served.

When problems do arise during construction, as they often do, be up front, prompt, honest, and direct in your communications. If the road is going to be closed for 3 weeks or whatever, tell us. It is better than getting half the news followed by countless delays.

These are the challenges we face, as seen from the local perspective. The public's expectations are very high and may even sometimes be unattainable. But by thinking outside the box, you can attain many more public objectives. And I do hope that you, as you work through this, will use the local resources and heed local input, particularly in the implementation phase of your designs.

The pending reauthorization of the Intermodal Surface Transportation Efficiency Act (ISTEA) is, of course, an important opportunity to make progress in this and other efforts. I am confident that the residents of the local communities along this corridor will be very supportive of additional resources for rehabilitation if they believe that those funds are being spent effectively and responsively to meet their needs and concerns.

Clearly, there are many challenges, but I am encouraged to know that great minds are working and thinking about these things. Working together, we will be able to continue to revitalize the urban infrastructure of Southern California and allow people to move in the 21st century.

Meeting the Challenge through Innovation

CHARLES MILLER
Director of Operations Management Services with Michael Baker Inc. and previously Secretary of Transportation for the West Virginia Department of Transportation, Director of Transportation for the Arizona Department of Transportation, and Associate Director of Research for the Federal Highway Administration.

When we talk about meeting the challenge through innovation, the first thing that comes to mind is the engineering aspect—namely, how to design something that's going to last for 40 years, and be cost effective. We also obviously have to ask and answer the question, "What and where are the innovations?"

First, let's focus on the challenge itself. Many times, the challenge itself gets hidden in the clouds. One key challenge in this workshop is to keep our eye on the ball. When we were kids learning to play baseball, what did they teach us? Whether we were catching or batting, it was always the same: Keep your eye on the ball.

The challenge we face is a varied one. Our goal is to produce a rehabilitation project that optimizes the total long-range societal cost. What is the optimal societal cost? It's really a whole host of things, none of which is new to us. As contractors, consultants, and engineers, we know about construction costs. We can figure them out pretty quickly and easily. We can also turn our attention to the cost of administration. The I-710 project has a certain administrative cost, a little higher than most projects probably because of its complexity, but it's something we can certainly estimate and control. I suspect that we'll find that the cost of traffic management is probably a little higher than normal, but that's okay. We can factor that into the overall process.

If you take a look at examples of successful public participation, you'll find that the most successful projects have had a public information and public involvement cost of one percent or less. That's a slight price to pay for the impact that it has.

Microsocietal Costs

There are other costs that are not so well known to us—namely, the microsocietal costs involved. For example, time delays; if something is delayed, it's a significant cost. Time is money, and time delays cost money. Another cost is based on increased numbers of accidents, which incur significant costs in terms of loss of life and loss of human resources, as well as damages.

We hear about increased violence—road rage—on our highways every day. Road rage is a recent term, but one that is now becoming commonplace. Where do you hear about most of these incidents? In construction work zones. Someone decides to follow the posted speed limit, and it makes everyone following him angry. They blow their horns, give him the finger, shake their fist.

Microsocietal costs also include effects on local businesses. For example, a mom-and-pop local hardware store is situated on a side street. The business operates on a very thin margin, competing with WalMart and K-Mart and a host of megastores. If construction causes a 1 or 2 percent cut in customers who can reach the door with ease, the business is on the verge of going out of business. What can you do for the business owners? Can you do something in the overall traffic management plan?

A lot of local politicians live or die on how well things are perceived in their particular ward, borough, or county. They might not have any control over the project; maybe no one ever asked them how the project might affect their political subdivision or local political efforts. If they are left with a bad taste in their mouth from the last project, do you think they will support a new project? Probably not.

Macrosocietal Costs

What about the macrosocietal costs involved? Many of us grew up professionally in a time when the United States had a great edge in terms of technological and transportation advantages over the rest of the world, and that's not necessarily true anymore. Frankly, in the past we never thought about whether the doors needed for an automotive assembly line got to the plant on time. Thirty years ago, we had never heard about just-in-time delivery. Materials and parts were stored in warehouses, where they were readily available whenever they were needed. But the world has profoundly changed, to the point that it is "live or die" in terms of being able to deliver goods and services on time.

The macro-scale effects are significant. Certainly, the emphasis on just-in-time deliveries, which make up a big portion of the materials and supplies that come through the Port of Los Angeles and the Port of Long Beach, has major impacts. If a truck of widgets is delayed, the cost of the widget goes up, causing a profound societal effect in the long term. This is something we need to think about in our business, as we go about rehabilitating expressways. The I-710 project will have an effect on the regional economy. Delays on the project will be felt in Phoenix and Scottsdale.

Remember, we need to keep our eye on the ball. We can't let concern over voids in the mineral aggregate, for example, cloud out some of these other, societal effects, because they are every bit as important as the technical issues.

Innovation

What are the areas of opportunity for innovation? Think hybrids—that is, about putting elements together in new ways to overcome obstacles to implementation. One example might be portland cement concrete thin overlays. Some say they can't use overlays because of bridge clearance problems. Well, maybe there's a solution to that—grind down the pavement, or remove some slabs.

What about precast slabs? Many say precast slabs can't be used in pavements. The old pavement has to be sawed and then lifted out. Can you lift the new slab back in, quickly grout it, and get on down the road? Maybe.

Think about these things from an administrative standpoint. Lane rental. Design build. Incentive/disincentive clauses. They work.

Let's take a look at traffic management. I understand that on the I-710 project, we are not blessed with a great differential between directional peaks. I wish we were, because then we would have reversible lane capability. Obviously, no one likes to work at night. Accidents go up, and safety is a bigger concern. Night work costs more, and the quality sometimes suffers. But sometimes it's the only way. Particularly in a situation like we have with the I-710, where we don't have room to add lanes by using the shoulder, it may just be a lifesaver.

A construction project that stretches 10 to 15 miles, with the entire stretch torn up at one time never gives the public a break. In designing a project, think about the optimum segment length, as well as where you start and end those segments, particularly as it relates to vertical geometry.

There are a lot of trucks in the traffic mix on I-710. A project or segment terminus in the middle of a 1- or 2-percent grade where trucks are slowed to 10 or 15 mph and then have to get back up to speed can create a queue from here to San Diego that will drive the traveling public nuts.

Communications—Hire an Expert

Communicate with the traveling public. Technology unheard of 10 years ago is at your disposal today, including variable message signs and highway advisory radio. Use it. It's the best communication tool that you have on site.

Another area that you really want to pay attention to is, of course, public involvement. Focus groups, local business groups, and public meetings are great ways to reach the public. Getting the local media involved in all groups is an absolute must.

In the mid-1980s, we were preparing to construct I-10 through downtown Phoenix. It was going to intersect with the Black Canyon Freeway that ran north-south (I-17). The project called for a major reconstruction of I-17 through the area where the interchange was to be constructed. A group of representatives from local businesses, civic groups, and media outlets was formed. The group became so heavily involved in the process that they even made a group of local spot announcements, prepared and coordinated with the Arizona DOT. The department's message was delivered, but in the voice of the local television anchor, who was extremely well liked in the community. The public loved getting the information from their local broadcaster, making the announcements successful beyond any doubt.

Local focus groups with local media participation really do work. In another instance, in downtown Charleston, West Virginia, the concrete pavement at the junction of three Interstate Highways (I-64, I-77, and I-79) had deteriorated to the point where it had to be replaced. We had worked out a plan to rehabilitate the pavement rather than replace it, and we were ready to start the project. We put together a public information campaign with the local media, using press conferences, press packets, all the normal tools. We started the project, and all the work was done at night; no lanes were taken away during the day or during peak hours.

Two days into the project, I received a call from the local television broadcaster, raising all kinds of thunder for scaring the traveling public with warnings of how bad traffic would be, yet there hadn't been a traffic disruption yet. I thought, boy, that's as good as it gets.

The local media are absolutely essential. Keep in mind, however, that although you might be able to get free airtime, don't be afraid to pay for it; after all, if you pay for it, you control the message.

And one final recommendation: Hire an expert. To quote from the 1986 TRB National Conference on Highway Reconstruction, "Public information is by far the most critical ingredient in a successful major construction project. The public information aspects of major reconstruction projects are too critical to assign to an engineer, no matter how skilled.[10]

After all, would you ask a public relations person to prepare shear diagrams or draw influence lines? Of course not. That's engineer's work. Conversely, should we expect ourselves to be experts in getting information to the public? Of course not. Hire an expert. Make no mistake about it, it's money well spent.

Conclusion

Our challenge is more than pavement thickness, white pavement, black pavement, hybrid pavement, and so forth. It is to provide mobility and serve the public, while keeping in mind the societal costs of our work.

We need to think outside of the box. We can't be afraid to change the way we think about what it is we're going to do. Think innovation.

[10] *1986 TRB National Conference on Highway Reconstruction report, page 44.*

[11] *Michael Hammer and James Champy,* Reengineering the Corporation: A Manifesto for Business Revolution, Harperbusiness, 1994.

Charge to the Workshop Participants

CHARLES NEMMERS
Director of the Office of Engineering Research and Development, Federal Highway Administration

In the words of Mike Hammer, one of the gurus of corporate reengineering,[11] we have to think bigger if we are really going to get something big done. We have to set some unreasonable goals. Because if we set very reasonable goals, we are not going to get things done any differently than we did before. We have to strive to uncover possibilities.

We have to think about accomplishing the I-710 project almost overnight. About building a bridge in a month. We pick the low-hanging fruit when we suggest ideas like working double shifts, working at night, A+B bidding, lane rental, partnering, and incentives; these are all good things, but we've got to think larger than that.

Today's best practices are behind us. Our charge this week is to look forward, to think of the possibilities. We have to think big, to think outside the box.

We don't want a synthesis of best practices from this workshop. We want a list of great ideas. As Einstein said, the significant problems we face can't be solved by the same level of thinking that created them.

To begin with, we need to quit thinking like civil engineers. I would submit that the first thing we ought to do is digitize the corridor, using satellite technologies and global positioning systems, and then make this digitized corridor available to everybody—cities, counties, trucking agencies, utilities, emergency management teams—everybody.

We ought to think about satellite control of all the construction equipment and materials on the job. For example, for a little over a dollar, you can buy a microchip to put on your truck or car or equipment, and you are then able to track where that vehicle or equipment is at all times. This is how the Army tracked its materials that were shipped back from the Persian Gulf.

We ought to explore different traffic control algorithms. For example, real-time traffic adaptive control systems, which are computer algorithms for traffic management, can be used in a digitized corridor to evaluate "what if" scenarios.

We then ought to move to the next level of thinking, which involves expert systems technology. We can use these systems for a lot of things, including environmental compliance and for quick decision making.

We've talked about communications—publications, hot lines, highway advisory radio, changeable message signs, and so forth. But that's only half of the equation. It leaves out the *listening* half of the equation. As Stephen Covey says in *The 7 Habits of Highly Effective People*, we must first seek to understand, before we can be understood.[12] If we are going to be effective in communicating, then we have to listen first. And we have to start listening to each other, to contractors and designers. After all, contractors probably know more about building highways than public agencies do.

Let's learn some lessons before we build the whole project. Let's pilot test different options to see what works and what does not.

In addition, we need to develop better civil engineering technologies. If we are going to be civil engineers, let's be better civil engineers. If we're going to try to place a new pavement overnight and then open it the next day, we need a better way of accelerated testing.

Considering the vertical clearance problems in the corridor, some have suggested milling and replacing the pavement. But mindful of Einstein's admonition, maybe we ought to instead replace the bridges that span I-710. If a bridge has only 10 years of life left, why fix the pavement underneath and leave a worn-out bridge above it? Maybe we need to think about what is on top instead of what is underneath.

We've talked about keeping the same number of lanes open during construction as we had before construction. Maybe we ought to think about this a bit differently—to put ourselves to the challenge of having uninterruptable travel; that is, your trip will never be interrupted once you are on I-710.

We estimated it would take about 2 years to rebuild a 10-mile highway. Do you know what that means? It means that for the rest of our lives, every 38 miles we travel on the national highway system, we will come across a construction work zone. Now, if we can get that project built in 1 year instead of 2, there will be at least a 76-mile gap before we come to another work zone.

[12] *Stephen R. Covey,* The 7 Habits of Highly Effective People. *Simon & Schuster, 1989.*

That same project had an estimated construction cost of $5 million per mile. But the user cost is about $295 million—that's a 60 to 1 ratio of user cost to construction cost. A lot of you might say that the construction cost is "real" money, and the user cost is "impact" money. Well, I say that the $295 million is real to our users. If we are going to be pavement engineers, we ought to put down good, hard pavement, but that's not enough. We need to figure out how to cut the user costs. If we completed the project in 6 months and detoured all traffic, for example, the user costs are about $140 million—a 27 to 1 ratio. If we are really concerned about user costs, we need to put it into our mindset, into our thinking, because we have to get to better than a 60 to 1 ratio.

This is no time for pedestrian thinking. We don't want to be bound by our civil engineering mindset. Think about using expert systems, information technologies. Think about listening to determine what is really needed. Use new, better civil engineering technology. And think about the user costs.

Workshop Team Findings

Beginning on the morning of the second day, the workshop teams began their efforts to develop solutions to the problems presented in the I-710 project corridor. Each of the four teams was denoted by the color of the members' name badges: Green Team, Yellow Team, Blue Team, and Brown Team. These highly original names are used to distinguish the findings of each team in the report.

The raw materials available to the teams included:

- Engineering drawings and aerial photographs of the existing highway
- Reports on preliminary engineering investigations
- Extensive engineering and geographic information about the corridor and its environs
- Traffic volume and loading information including videotapes of peak and off-peak traffic flow.

Coupled with observations made during the field view and information and expectations presented at the plenary session, the teams were well prepared to undertake their assignment. California DOT staff familiar with the I-710 were on hand to answer specific questions about the corridor and the existing facility.

The team deliberations continued for two and one-half days. Toward the end of the second day, time was provided for informal exchange of views and ideas among the four teams. Team solutions were finalized on the morning of the final day and presented at a closing summary session.

Subsequent to the workshop, the team findings were reviewed by the California DOT staff, which prepared preliminary drawings and cost estimates, the DOT staff met with representatives of each team to make sure the DOT had accurately captured the team proposals. After this meeting, estimates and drawings were further refined. Final adjustments were made as the California DOT completed a subsurface investigation, evaluated potential detours, and developed bridge repair and replacement estimates. Final estimates and drawings were completed early in 1999.

The plans developed by the workshop teams were only intended to be illustrative and were not "official" in any sense. Nonetheless, the California DOT is committed to moving beyond the "standard" approach and is giving serious consideration to various suggestions from the workshop. The degree to which any of the team findings will be adapted by the department remains to be seen, but some suggestions are being applied on a trial basis on other projects in Southern California.

In February 2000, Mr. Doug Failing, the Chief of Design for District 7 of the DOT, reported that 2000 meters of one lane of Interstate 10 in Los Angeles County was removed and replaced in a 55-hour weekend window. Essentially this was a trial version of the reconstruction option suggested by the Yellow Team. The pavement design called for a rapid strength gain hydraulic cement and the construction contract included strong quality control requirements and an incentive/disincentive clause for on-time re-opening of the roadway. The reconstruction was completed and traffic was restored on time.

Mr. Failing also reported that design for reconstruction of a six-lane portion of the I-710 immediately south of the study area is nearly complete and is scheduled for construction in 2001. This project adapts many of the suggestions of the four workshop teams. For example, instead of rehabilitating only the truck lanes, the project will overlay all of the travel lanes with a robust asphalt concrete overlay topped by an open-graded surface course as suggested by both the Blue and Brown Teams. The minimum thickness of the overlay will be 225 mm (8.88 in). Again, the design envisions construction during 55-hour weekend windows. To enable full-width paving, the construction sequence will call for reconstruction of the shoulders first so they can serve as temporary traffic lanes. During the weekend construction periods, all traffic will be diverted onto a single carriageway carrying two lanes of traffic in each direction. The opposing lanes will be separated by movable barriers. The existing steel guardrail median barrier will be replaced with a modern concrete barrier. Where necessary, the mainline grade will be adjusted to restore minimum vertical clearances at overpassing structures.

A separate contract will be let for landscaping improvements and upgrading roadside appurtenances such as signs, bridge rail, and lighting to modern standards. It is the department's intent to make this project an aesthetic "showcase."

Although design decisions have not yet been made for the portion of I-710 studied by the workshop, Mr. Failing indicated that similar efforts to improve longevity, accelerate construction, and enhance aesthetics and the environment will be features of that work.

Of more importance, perhaps, the California DOT is considering the broad community and economic context of this project and is not treating it as a "standard" pavement repair project.

Standard Design and Construction

To provide a baseline against which the teams' proposals could be measured, the Caltrans staff prepared a straw proposal based on their customary practices and recent experiences. As proposed, this standard approach would involve total replacement of the two outside lanes in each direction with 200-mm (8-in.) high-performance concrete pavement **(Plate 4)**. Slabs on the inside lanes would be replaced only as necessary. Drainage would be improved in spots. Existing substandard vertical and horizontal clearance problems at bridges would remain. The median and the shoulders would be rebuilt. To improve the load-carrying capability of the pavement, tiebars would be added across the longitudinal joints, and dowel bars would be added across the transverse joints. At locations of spot repairs, load transfer to the existing pavement would be established with the use of dowel bars. Outside shoulders would be widened to 3.9 m (12 ft) where feasible or as wide as possible in all cases.

Sound walls and landscaping were not included in the straw proposal.

With this plan, construction would take 3 years using standard methods, work would take place at night and on weekends, and the project would cost $63 million.

Summary of Team Reports

The reconstruction strategies developed by the four teams for the renewal of the Route I-710 corridor shared a number of the common objectives despite their unique approaches to the solution. Among these, the most prevalent was providing a safe and efficient facility while at the same time minimizing community impacts, maintenance costs, and construction time.

Because of the extremely high volumes of truck traffic on Route I-710, the majority of the teams' innovative spirit was shown in their methods of traffic control, which made extensive use of ITS technologies. All teams agreed that careful analyses of traffic patterns through the corridor and surrounding arteries would be essential in developing a good traffic management plan. In addition, an intensive public information campaign, begun in the early stages of project design and continuing through project completion, would be mandatory.

All teams understood the basis for Councilmember Oropeza's comments that the present facility is "scary" to drive on because of a large volume of heavy trucks and is certainly not appealing for tourists heading for Long Beach. Everyone also agreed that the full width of the Route I-710 freeway should be reconstructed now, and that addressing only the two outside lanes at this time would require rehabilitation of the remainder within the next 10 years.

All four teams developed solutions that provide for

Table 1
PROPOSAL COST ESTIMATES

Green Team-Proposal replaces all lanes and includes replacing or widening 25 bridges
$191,520,000

Yellow Team-Proposal replaces all lanes and schedules completed pavement construction in 16 weeks
$87,580,000

Brown Team-Proposal replaces all lanes and addresses noise and safety issues
$64,940,000

Blue Team-Proposal replaces all lanes and addresses noise and safety issues
$72,330,000

Standard-Proposal replaces only 4 lanes, does not address safety or environmental concerns, or provide a predictably long-lived solution.
$62,820,000

Table 2
COMPARISON OF TEAM PLANS TO STANDARD DESIGN AND CONSTRUCTION OPTION

Expectations	*Standard Options*	*Green Team*	*Yellow Team*	*Brown Team*	*Blue Team*
Critical					
Long-lived pavement renewal	Renews 4 or 8 lanes	Yes	Yes	Yes	Yes
Replace median guard rail w/ concrete barrier	Yes	Yes	Yes	Yes	Yes
Widen outside shoulders to 3.6 m	Somewhat	Yes	Somewhat	Somewhat	Somewhat
Replace rolled curb and drainage at E.P.	Yes	Yes	Yes	Yes	Yes
Accelerated schedule	No	Yes	Yes	Yes	Yes
Desirable					
Vertical clearance correction	No	Yes	Yes	Yes	Yes
Horizontal clearance corrections	No	Yes	No	Somewhat	Somewhat
Potential for capacity increase	No	Yes	No	No	No
Truck volume increase	No	Yes	No	No	No
Congestion related accident relief	Somewhat	Yes	Somewhat	Somewhat	Somewhat
Enhanced appearance	Somewhat	Yes	Somewhat	Yes	Yes
Widen inside shoulders	No	Yes	No	No	No
Noise reduction	No	Somewhat	Somewhat	Yes	Somewhat
Innovative Features					
High-performance materials	Yes	Yes	Yes	Yes	Yes
Innovative design	Somewhat	Yes	Yes	Yes	Yes
ITS (ATIS, Incident management)	No	Yes	Yes	Yes	Yes
Incentive/disincentive contracts	Possibly	Yes	Yes	Yes	Yes
Concrete recycling or reuse	No	Yes	Yes	Yes	Yes
Rubblization	No	No	No	Yes	No
Traffic control devices	No	Yes	No	No	No
Innovative finance potential	No	Yes	No	No	Yes
River traffic	No	No	No	No	Yes
Heavy-duty truck lanes	No	Yes	Yes	No	No

recycling nearly all potential waste materials from the construction back into the project. Also, a complete incident management program was considered important for mitigating potential traffic snarls in the event of an incident or stalled vehicle during construction.

All groups believed this particular project would lend itself well to the use of incentive/disincentive provisions within the contract. Offering bonuses for expeditious project completion would inspire creativity and ingenuity on the contractor's part and benefit the traveling public in the form of reduced delays.

Table 1 compares the estimated construction cost of each team's proposal to the cost of the Caltrans "standard" design. Table 2 compares the features of each of the plans proposed by the workshop teams to the standard design and construction option. The following sections describe the details of each team's plan.

Green Team

The Green Team adopted an ambitious "Get in, get out, stay out" philosophy, preferring to not only meet the immediate needs, but also those that would likely arise in the next 10 to 20 years. They proposed replacing all traffic lanes and most bridges now to avoid more reconstruction in 5 or 10 years.

They eliminated life-cycle costing from up-front consideration, so that they would not be constrained by budget targets and could truly think "outside the box." Their proposal is, however, expected to bring significant user savings, which will more than offset the cost of construction.

Overview

The Green Team envisioned a "Teflon corridor" that would be completely free of hazards such as guardrails and barrels. This would provide a safer corridor and a great deal of flexibility for rerouting traffic as necessary. The highway cross section would be expanded slightly, to 40.2 m (132 ft), allowing a full-width shoulder that could serve as an extra lane in an emergency **(Plate 5)**.

Before pavement reconstruction could begin, all overpassing structures would be replaced with clearspan bridges, thus obviating the need for center piers. Stub abutments are well out of the way of any run-off-road vehicle. Bridge construction is estimated to take 35 weeks.

Because the roadway carries a significant number of overweight loads—and the load limits will likely go up as a result of the anticipated growth in international trade—the team felt strongly that the project should "not be rebuilt to old standards." As allowable loads go up, the number of trucks would be expected to go down, which would reduce traffic, increase efficiency, and decrease cost.

The team sees several advantages to this project:

- Minimal disruption to traffic and to adjacent neighborhoods
- Work crews and motorists separated and protected by barriers
- Elimination of fixed objects in the roadway
- Shoulders wide enough at 3.9-m (12-ft) to serve as operational traffic lanes in emergencies
- Avoidance of costs and disruptions caused by bridge maintenance in the future
- No "tunnel" effect during or after construction, which will make the roadway less threatening to motorists
- Lower total life-cycle costs as a result of savings caused by fewer user delays (a savings of 15 minutes per day would equate to about $600 million).

The portion of the project that would affect mainline traffic could also be completed in one-third of the time estimated for the standard option (i.e., 1 year versus 3 years).

Pavement Design

The Green Team's plan would use the existing 200-mm (8-in.) imported subbase, which would support a much heftier, more durable pavement composed of 300 mm (12 in.) of new portland cement concrete resting atop 355 mm (14 in.) of a new lean concrete base. The materials removed from the existing subbase would be incorporated into the new subbase.

All materials would be recycled, thus avoiding disposal problems. The objective would be "zero flow" of material off the project.

By replacing the existing overpasses with single-span overpasses, the team would eliminate possible hazards, as well as the need to shield bridge abutments and piers from motorists. No geometric changes would be necessary, except to meet new roadway grades (the roadway would be raised approximately 256 mm (10 in.)).

Traffic Control

A moveable precast concrete barrier would be used during construction to route traffic through the workzone. This would serve two purposes: it would separate the two flows of traffic, and it could be put back into service as a moveable barrier for later changes in lane configurations if necessary. During construction, four lanes of traffic would be maintained in each direction. Individual lanes would be quickly delineated by screw-in reflectors, which also could remain as permanent lane markers.

Construction would proceed in 5 stages **(Plates 6a-6d)**. The mainline structure would be widened to reestablish a 3.6-m (12-ft) outside shoulder/emergency lane. A temporary median barrier would be used to separate the work zone from traffic. The barrier would make it possible to smoothly shift traffic as needed during construction, while maintaining four lanes of traffic in each direction. The barrier would be left in the median once construction was completed. One of the advantages to this plan is that traffic capacity is maintained, and traffic does not have to be rerouted.

The median would be strengthened and paved to carry traffic, and a moveable concrete barrier would be installed.

1. The barrier would be moved to the outside of one side of the median, and the four lanes of traffic would then be shifted so that the inside lane would be on the median. Another barrier system would be installed along the edge of the travel lanes, creating a 6-m (20-ft) work area, where a temporary lane would be constructed.

2. Once the temporary lane was constructed, the traffic and the median barrier would again be shifted so that the new lane would become a travel lane. This would free up lanes 3 and 4, as well as the shoulder, in the opposing travel lanes for reconstruction.

3. Once lanes 3 and 4 and the shoulder were reconstructed, traffic would be routed onto the new pavement, and traffic in the opposing lanes would then be shifted onto the median. This would allow reconstruction to proceed on lanes 3 and 4 in the opposite direction.

4. After the reconstruction of lanes 3 and 4 was completed, traffic would be shifted so that work could begin on the inside lanes.

With this plan, disruption to traffic would be minimal, as four lanes of traffic would be maintained in both directions during construction. Construction would be expected to take 200 days, a tight but realistic schedule.

The team did foresee a problem with the ramps in this proposal, however. Two solutions were proposed: paving 1.6 to 3.2 km (1 to 2 m) a day, which would require lane closures in 4.8-km (3-m) increments; or opening each section to traffic as soon as possible. The latter could be accomplished through paving with high early strength concrete, which would allow traffic to be carried in 4 to 8 hours, or through use of a temporary slip ramp.

Schedule and Cost

Cost for the project was $191.5 million ($122.6 million for roadway improvements, $65.2 million for structural improvements, and $3.7 million for right-of-way).

The team also put forth several other options to consider:

- Plan and construct a dedicated container truck operation in the median between the port and the railroad terminus; allow heavier and longer trucks on this dedicated roadway, but collect a fee from users.
- Use the median as a value-pricing lane; motorists could opt to use this lane, rather than the conventional lanes, to avoid congestion, but would pay a price for the privilege.
- Put the outside shoulder lane to use as a travel lane during peak periods.

The team recommended a 5-month lag between when the contract is awarded and when construction starts, to allow for proper planning, design, and equipment modifications. They also believed that the schedule should accommodate at least 60 days of plans review before the bid date. A fully empowered conflict resolution team, available 24 hours a day, 7 days a week, is also recommended.

Yellow Team

Adopting the slogan, “Give us your weekend and we’ll give you 40 years,” the Yellow Team proposed that all eight lanes be reconstructed and that all construction be done on weekends, posing minimal disruption to travelers during rush hours and weekdays **(Plate 7)**.

Two options were proposed: a full-depth recycle, and an unbonded concrete overlay. These options could be used independently or in tandem, depending on the outcome of a subsurface investigation. Preliminary indications are that the unbonded concrete could be used over 90 percent of the project.

The team proposed closing down one section of the road each weekend, while the shoulders were repaired, the median rebuilt, and the roadway repaved. Only one direction of travel—a 4.8- to 8-km (3- to 5-m) section—would be closed at a time. When the rebuilt section is opened to traffic on Monday, all four lanes would be operational and all work would be complete. The new pavement would be 200 mm (8 in.) thicker than the existing pavement, which will require that the roadway grade be adjusted at some overpassing bridges to maintain vertical clearance.

Substantial surface maintenance would probably be required at about 25 years, if the pavement is to last 40 years.

Pavement Design

One option was to recycle the existing 200 mm (8 in.) of PCC pavement and the existing 200 mm (8 in.) of cement-treated base. The existing pavement and base would be milled out, crushed, and stablized with cement and replaced on subgrade at a varying thickness. The base thickness would vary from 300 to 450 mm (12 to 18 in.) across the template from the median to the edge of the travel way. This variance would allow for a heavier truck design in the two outside lanes while maintaining standard pavement cross-slopes. PCCP slab thickness would measure 300 mm (12 in.) at the inside lanes and 355 mm (14 in.) at the two outside (truck) lanes.

In areas where the existing subgrade was considered sound, an unbonded PCC overlay would be used. A 50-mm (2-in.) lift of hot-mix asphalt pavement would initially be placed on the existing PCC pavement as a bond breaker. A 300-mm (12-in.) PCC overlay would be placed on top, covering the full width of the facility. In areas where vertical clearance is a problem, the existing slabs could be removed and the grade sufficiently lowered to maintain required vertical clearances.

With the exception of the cast-in-place PCC traffic barrier and shoulder widening, the existing geometrics of I-710 would not be changed. Intelligent transportation system (ITS) devices would be installed, and some aesthetic improvements would be made to the corridor. This proposal could be implemented without adjusting the existing bridge structures.

Traffic Control

As each segment is closed for reconstruction, traffic will be rerouted onto the adjacent Interstate highways (I-110 and I-605) or onto surface streets. The impact is expected to be minimal in the long run, as each segment will be closed only once. A variety of diversionary routes are available, so that the traffic can spread out onto alternate paths. Accurate, multimedia communications with the public are imperative, because of the changing work zones and detours. Variable message signs, Web sites, hotlines, public involvement techniques, and various other methods of communication will be used to let travelers know when and where the construction is and what the alternatives are.

The team believed that if they could effectively communicate with the public and provide options before and during the quick-hitting weekend work, traffic would disperse.

Schedule and Cost

The team estimated that the project could be completed in less than 9 weekends, by using two concrete plants with dual 8.2-m^3 (9-yd^3) drums, which could produce 1377 m^3 (1,800 yd^3) of concrete an hour.

Incentive-disincentive clauses could be effective in cutting construction time and lessening delays and inconvenience to motorists. For example, a $50,000 per minute penalty could be a very effective means of stressing that the contractor must be off the road and the road must be open to traffic by 5 a.m. on Monday.

To resolve any disputes and answer any questions, a conflict resolution team would be available around the clock.

Because there is no cost of on-site traffic control with this scenario, the team proposed that the savings be used on incident management; for example, by situating tow trucks at intersections along the detour route, for rapid response to breakdowns or crashes.

The estimated cost would be $87.5 million ($87.4 million for roadway improvements and $100,000 for structural improvements). The project could be completed in 4 months.

Brown Team

Like the other teams, the Brown Team set out to find the optimum plan for rehabilitating the pavement to serve for 40 years, while minimizing construction time, user costs and delays, and the effect on the environment. They determined that all four lanes needed rehabilitation. The median and shoulder would be replaced and designed for the same conditions as the mainline section.

Rather than replacing the full depth of the pavement, however, they opted to recycle the existing pavement into the base and to then overlay it with 200 mm (8 in.) of high-quality, polymer-modified hot-mix asphalt, designed using the Superpave system **(Plates 8a-8d)**.

The first phase of the project would be to improve the outside drainage and reconstruct the shoulders to meet necessary structural values. During the second phase, traffic would be shifted onto the shoulders so that the median could be constructed to proper structural values and the guardrail would be replaced. During the third phase, the two inside lanes of traffic would be closed on weekends only, leaving two lanes of traffic open. In the fourth phase, weekend traffic would be shifted to the two inside lanes so that work could proceed on the outside lanes.

Because the new pavement would be 200 mm (8 in.) higher than the existing pavement, adjustments would have to be made for vertical clearance at bridges. The team proposed replacing the Claire Street bridge so that full vertical and horizontal clearance could be attained.

The Firestone and Artesia bridges would be jacked up, and the approaches would be rebuilt as necessary. The bridge clearance work is expected to take about 6 months and should be completed prior to repaving the roadway.

To meet the 40-year design life goal, the project should include whatever repairs and reconstruction are necessary to ensure that the mainline bridges would last 40 years.

Construction

The new pavement would consist of a 30-mm (1-in.) wearing course of new porous hot-mix asphalt on top of a 170-mm (6.5-in.) lift of new polymer-based hot-mix asphalt. Hot-mix asphalt was chosen over portland cement concrete so that the roadway could be opened up to traffic more quickly.

The existing portland cement concrete pavement and cement-treated base would be rubblized into 5- to 10-mm (2- to 4-in.) pieces. These pieces would then be compacted to provide a firm, durable, 400-mm (15-in.) base for the asphalt overlay. This in-place recycling of materials is more efficient than off-site recycling, and rubblizing the existing concrete pavement would minimize reflection cracking on the new asphalt pavement.

Traffic Control

Because a full shutdown of the roadway for any time would be impractical, paving would be done at night. One lane could be shut down from 9 p.m. to 6 a.m., and a second lane could be shut down from 11 p.m. to 5 a.m. But if two lanes could be completely shut down for an entire weekend at a time, allowing for 56 hours of work, it would boost contractor production and improve safety. Alternative contracting procedures, such as A+B bidding or lane rentals, could be used to facilitate this. The team believed that the discretionary nature of most weekend trips would mitigate any delays and congestion. This would not only facilitate more efficient construction, but it would also ensure that capacity was maintained because four lanes would be open in each direction during peak periods.

A public information campaign would be needed to get communities to accept increased traffic on parallel streets during construction and to advise motorists of the project and their options.

ITS technologies, such as variable message signs and video cameras, would be installed and used for monitoring traffic and communicating with the public.

Sound walls should be installed wherever necessary as soon as possible to block construction noise from neighborhoods.

Schedule and Cost

Using night paving, the project would take about 35 or 40 weeks. But if several lanes could be closed for a full weekend at a stretch, the schedule could be cut to 30 weeks or less.

The cost is estimated to be about the same as the standard design and construction proposal put forth by Caltrans—$64.9 million, without considering the cost to reconstruct the three bridges. Most of the costs would be attributed to roadway improvements, with about $2.6 million for structure items.

The team also recommended that the walls and bridges be aesthetically improved.

Blue Team

Because the existing pavement showed little sign of distress, the Blue Team based their project on using the existing pavement and base, but repairing and patching it as necessary.

Pavement Design

The team proposed an 200-mm (8-in.) hot-mix asphalt overlay, composed of 154 mm (6 in.) of coarse-graded stone matrix asphalt and 50 mm (2 in.) of a fine-graded hot-mix asphalt wearing course. The Georgia DOT has successfully used this combination of mixes for 5 years now, and found it capable of bridging the joints, broken slabs, and transverse longitudinal joints in the pavement where natural faulting occurs with no evidence of reflection cracking.

An open-graded friction course was proposed as an optional surface course because it is quieter, results in less traffic spray during wet weather, and improves safety by draining water off the pavement surface. However, the performance of open-graded friction courses would need to be enhanced for this project, particularly in the areas of stripping and oxidation.

The proposal calls for one direction of travel in each section of I-710 to be closed at a time. The sections would stretch from one interchange to the next, and most would be about 4.8 km (3 mi) long **(Plate 9)**.

Construction would proceed in the following stages:

- Replace the median barrier and strengthen and improve the shoulder lanes.
- Shut down one direction of travel
- Restripe the lanes in the opposite direction of travel, making the lanes slightly narrower so that four lanes become five. A pre-cast temporary barrier would be used to separate the two directions of travel.
- Once the closed section was rebuilt, traffic would be moved over to that side, and the process would repeat.

Traffic Control

The Blue Team's traffic management plan is similar to that proposed by the Yellow Team, but it adds diverting trucks onto the Los Angeles riverbed, which is dry half of the year. The riverbed is accessible at both the port and the rail yard, but access ramps would have to be built. With truck traffic between the port and rail yard representing about 40 percent of the total truck traffic in this corridor, significant capacity and safety improvements could result from diverting those trucks onto the riverbed. The riverbed is wide enough to carry four lanes of traffic.

Milling-and-resurfacing would likely be necessary twice during the pavement's 40-year life to renew the wearing surface.

Schedule and Costs

The project is estimated at $72.3 million, which includes the bridge work, barriers, drainage, and improving the riverbed. The work can be done in 10 months, but this might have to be stretched out over 2 years, to avoid the rainy season.

Review of Proposed Pavement Designs

Pavement design was a critical component of the reconstruction schemes proposed by the four teams. One of the workshop objectives was to provide a renewed pavement with an anticipated service life of 40 years. The overall structure of this new pavement and the manner in which it salvages or recycles the existing pavement largely drive the entire reconstruction scheme.

At the workshop, there was insufficient time to prepare and review a detailed pavement design. Consequently, the workshop steering group requested the Pavement Division of the Federal Highway Administration to review and comment on the pavement designs of the four teams. The FHWA staff members asked to review the designs are familiar with current practices and recent research and none participated in the preparation of the workshop designs. For these reasons, the steering group believed that the Pavement Division was able to provide a knowledgeable and unbiased review.

The commentary provided by the FHWA staff does not attempt to revise the pavement designs. Rather, they point out potential problems and concerns, suggest potential alternatives and offer pertinent comments relevant to pavement design in general and construction of urban freeway pavements in particular.

Comments

The current and future traffic loading on this section of freeway is extremely high (exceeding 100 million ESALs for 40 years). It is beyond that for which most existing pavement design and analysis models were developed. The final designs selected must therefore be carefully developed and evaluated by qualified pavement design, materials, and construction professionals. The following remarks are intended to provide general comments on the proposed designs and some suggestions for further consideration before the final design is selected. We have not attempted to redesign the project, only to identify some potential problems or concerns. More detailed evaluation of the condition of the existing pavement structure, materials availability, and traffic loading is needed before selecting a final design. High-quality materials and construction are essential irrespective of the pavement design selected.

The issue of vertical clearances for existing bridges is critical. Cost implications are unknown for replacing the pavement to its current grade and elevation (an alternative was not considered in this study), for accommodating the proposed 200-mm (8-in.) asphalt concrete (AC) overlay, or for the proposed 300-mm (12-in.) jointed portland cement concrete (JPCP) overlay with a 50-mm (2-in.) separation layer. To provide adequate clearance, either the bridges would have to be raised or the pavement under the structures would have to be reconstructed. It is assumed that this was considered during the development of the various options proposed and will be reflected in the cost estimate for the various options. Obviously, this has significant implications for both the cost and the time needed for construction.

Concrete Pavement Alternatives

The concrete alternatives proposed by the Yellow and Green Teams are summarized as follows:

Green Team—Total Reconstruction Option

- 300-mm (12-in.) doweled concrete pavement (concentrate dowels in wheel paths)
- 350-mm (14-in.) LCB (existing pavement recycled into base and 90 kg/m^3 (200 lb/yd^3) cement in LCB).

This pavement section will adequately serve the projected traffic for the 40-year performance period with conventional materials, based on the 1998 rigid pavement supplement to the AASHTO Guide. Important considerations of this design are

- adequate dowel bars to minimize curling/faulting,
- adequate tie bars to prevent lane separation and increase edge support,
- full 3.6-m (12-ft) width, full-depth outside shoulder to provide edge support, and
- 3.6- to 4.5-m (12- to 15-ft) joint spacing.

Careful consideration should be given before disturbing the existing 200 mm (8-in.) CTB or 200 mm (8-in.) imported subbase material, as it may increase nonuniformity or provide poor support if it becomes unstable.

Recent research with instrumented dowels in Ohio indicates that concentrating dowels in wheelpaths may not provide significant benefit. The data appear to show that the relative moment in dowel bars is greater for the built-in construction curl and moisture warping (which is even more likely in this relatively dry climate) than for dynamic (traffic) loads. This indicates that dowels serve a greater benefit in controlling undesirable curling/warping of concrete slabs than in transferring dynamic loads from one slab to the next. It is recommended that dowels be placed uniformly across the joint.

This is critical and should be carefully evaluated using instrumented dowels at the Palmdale location, which will be subjected to accelerated load testing as part of the University of California-Berkeley research effort currently underway.[13] It is unfortunate that Hveem's excellent 1949 research on this particular issue was not followed up on previously.[14] The 147- or 250-mm (5.75- or 9.75-in.) dowels tried earlier in California were not adequate to resist the combined curling/warping and load stresses as documented in Hveem's report. However, for the climate at this specific project site and the excellent performance of the existing pavement, this factor may not be as important as in a desert type climate farther away from the ocean.

While it is recognized that the estimated lean concrete base (LCB) thickness is based in part on the quantity of material anticipated to be available from the existing pavement and cement-treated base (CTB), the significant thickness of LCB in this design may not provide significant marginal benefit. According to the 1998 supplement to the AASHTO Guide, a 300-mm (12-in.) concrete pavement with a 355-mm (14-in.) LCB will perform similar to a 355-mm (14-in.) concrete pavement on a 150-mm (6-in.) LCB. Similar results can be achieved with a high strength concrete of 320-mm (12.5-in.) pavement and a 150-mm (6-in.) LCB. As noted above, these thicknesses have not previously been determined to be necessary in California. The resulting net decrease in structural section may make it possible to avoid or minimize adjusting existing substandard structures and/or provide additional vertical clearance for future rehabilitation options.

[13] *Update of Palmdale Instrumentation Plan for Palmdale Long Life Rigid Pavement Study, October 20, 1997, John Harvey, University of California, Berkeley.*

[14] *Hveem, F. N., "Slab Warping Affects Pavement Performance." In* Proceedings, *American Concrete Institute, Volume 47, 1951.*

Yellow Team—Overlay Option

- 300-mm (12-in.) concrete overlay
- 50-mm (2-in.) hot-mix asphalt bondbreaker

This overlay option is the preferred design except for sections where reconstruction is needed to match elevation of existing mainline structures or to meet minimum vertical clearances under existing overpasses. The unbonded overlay is a low-risk option that utilizes the in-place pavement structure without disturbing the existing base. The only unknown with this design is the support provided by the existing pavement section for the bondbreaker and overlay. However, the existing pavement has provided adequate service for 44 years, it should be safe to assume the existing pavement will provide firm support for the proposed overlay. Assuming the existing pavement contributes support similar to a lean concrete base, this section is considered adequate. (Note: A subsurface investigation subsequent to the workshop revealed the reliably sound subgrade support could be anticipated over 90 percent of the total project area.)

It may be possible to remove the existing 200-mm (8-in.) concrete pavement and some of the base and replace it either with a 300-mm (12-in.) doweled JPCP or a 250- or 280-mm (10- or 11-in.) jointed reinforced concrete pavement (JRCP) under the overpass structures or on approaches to existing mainline bridges if the existing CTB is in good condition. The steel content for these short reconstructed sections should be in the 0.25 to 0.40 percent range given the very heavy traffic loads expected. The slab length should be 9 m (30 ft) or less and preferably no longer than 6 m (20 ft) to reduce cracking and subsequent deterioration, which may require maintenance or rehabilitation. Higher strength concrete might also be used for these short sections to allow for early opening and/or to reduce the required thickness to meet design loading requirements.

Yellow Team—Reconstruction Option

- 300- to 350-mm (12- to 14-in.) concrete pavement
- 350-mm (14-in.) concrete pavement would be in two outside truck lanes
- 200- to 350 (8- to 12-in.) CTB (consisting of recycled existing 200-mm (8-in.) concrete and 200-mm (8-in.) CTB)

This proposed section will adequately serve the projected traffic for the 40-year performance period with conventional materials, based on the 1998 rigid pavement supplement to the AASHTO Guide.[15] However, local experience in California has failed to indicate that more than 280- to 350-mm (11- or 12-in.) thickness is needed even for the highest traffic loading with good base/subbase/subgrade support. Important considerations for design are

- adequate dowel bars (38 mm (1.5 in.) diameter) to minimize curling/faulting;
- adequate tie bars (No. 6 bars at 615 mm (24 in.)) to prevent lane separation and reduce edge loadings;
- tied, full-depth 3.6-m (12-ft) outside shoulders to provide edge support; and
- 3.6- to 4.5-m (12- to 15-ft) joint spacing (as a result of favorable climatic conditions at this specific project location).

Because of possible exposure to saltwater resulting from the access to the port facilities and the proximity of the Pacific Ocean, Caltrans may want to investigate more positively corrosion-resistant dowels (i.e., stainless steel clad) than epoxy-coated dowels. In general, high strength concrete is not necessary, and special rapid-setting cements should be used only where essential for early opening to traffic as they are more expensive and some-

[15] *American Association of State Highway and Transportation Officials (AASHTO),* Supplement to the AASHTO Guide for Design of Pavement Structures, Part II—Rigid Pavement Design and Rigid Pavement Joint Design. *AASHTO, Washington, D.C., 1998*

times are not as durable as standard mixes. Careful consideration should be given before disturbing the existing 200 mm (8 in.) of CTB (if testing determines that it is in good condition) and the existing 200 mm (8 in.) of imported subbase material because it appears they are providing good, uniform, stable support for the portland cement concrete slab. If the existing CTB is marginal, it should probably be replaced with a lean concrete base, which has given very good performance in California and Europe under heavy traffic loading. The erodibility of the CTB is an issue, especially if disturbed. The replacement of the base may be necessary in view of limited bridge clearances available, but should be avoided if possible. If a new LCB or CTB is constructed, the base must be highly nonerodible. The World Road Association (PIARC) recommends a minimum of 8 percent cement to accomplish this.[16] Perhaps this could be reduced slightly because of the low annual rainfall. If some of the existing CTB is to remain in place, it may be possible to use a geotextile as a separator layer to minimize erodibility of the CTB surface, as has been done in Germany.[17]

While it is recognized that the estimated CTB thickness is based in part on the quantity of material anticipated to be available from the existing pavement and CTB, the significant thickness of CTB in this design may not provide significant marginal benefit. Perhaps it would be more economical to recycle the 8-in. concrete slab into the lower portion of the new concrete slab.[18] According to the 1998 supplement to the AASHTO Guide, for the outside lanes, a 350-mm (14-in.) concrete pavement with a 300-mm (12-in.) CTB will perform similar to a 400-mm (15-in.) concrete pavement on a 150-mm (6-in.) CTB. Similar results can be achieved with a high-strength concrete of 350 mm (14 in.) and a 150-mm (6-in.) CTB. As noted above, these PCC slab thicknesses have not previously been needed for California conditions. The resulting net decrease in structural section may make it possible to avoid adjusting some existing substandard structures and/or provide additional vertical clearance for future rehabilitation options. If a CTB or an LCB is used, the cement content should be about 8 percent to provide a highly nonerodible base given the very heavy truck loading expected.

Asphalt Pavement Alternatives

The asphalt alternatives proposed by the Brown and Blue Teams are summarized as follows:

Brown Team—Rubblize and Hot-Mix Asphalt Overlay Option

- 200-mm (8-in.) Superpave-design, polymer-modified hot-mix asphalt overlay
- Rubblize existing pavement in place and use as base

Blue Team—Stone Matrix Asphalt Overlay Option

- 200-mm (8-in.) stone matrix asphalt (SMA) overlay
- Localized full-depth pavement repairs as needed

Both asphalt designs are based on overlays of a thickness that require the least adjustment to bridge heights along the project. Both designs use the maximum overlay height, 200 mm (8 in.), that can be placed on the existing PCC pavement to minimize bridge clearance problems. The difference in construction cost to raise existing structures to accommodate this overlay is not

[16] *Ray, M., and Christory, J.P., "Combating Concrete Slab Pumping: State of the Art and Recommendations. In* Proceedings, 4th International Conference on Concrete Pavement Design and Rehabilitation, *Purdue University, West Lafayette, Indiana, 1989.*

[17] *Lentz, G., and Hellenbroich, T., Dynamic Deflection Measurement on Rigid Pavements, Using the Falling Weight Deflectometer,* Papers, Theme C, Volume I, 6th International Symposium on Concrete Roads, *Madrid, Spain, 1990, pp. 33-41*

[18] Summary Report, U. S. Tour of European Concrete Highways (US TECH), Follow-up Tour of Germany and Austria, *Publication No. FHWA-SA-93-080, Federal Highway Administration, Washington, D. C., 1993.*

known. Based on the method of treatment of the existing 200 mm (8 in.) of PCC pavement and combined with a 200-mm (8-in.) asphalt overlay, these designs should provide an adequate structural section for expected traffic during a 20- to 25-year period before an overlay would be needed. However, should a detailed pavement structural analysis determine that more than 200 mm (8 in.) is needed, this may still be a feasible option.

Superpave is considered the optimal selection for asphalt pavement design. The design approach and resulting asphalt pavement are especially applicable to addressing the needs of pavements subject to high traffic. As noted in the Brown Team recommendation, a polymer-modified asphalt would be used. The Superpave system of performance-graded asphalt binder provides for the selection of binder suited to the environment and traffic loading conditions. In this case it is recommended that a binder such as a PG 76-22 be used. The *Superpave Implementation Update* recommends caution because of the extrapolation made for ESALs above 30 million for a 20-year design period.[19] Also, as discussed below under the SMA comments, the high traffic levels indicate that a portion of the 200-mm (8-in.) asphalt overlay should use a larger nominal maximum size aggregate, possibly 37.5 mm (1.5 in.).

Stone matrix asphalt performance as a high-strength asphalt pavement has been proven in Europe and the United States.[20] SMA has been used in more than 100 U.S. projects since 1992 in very high traffic areas. The traditional experience is to use SMA as a surface layer of approximately 50 mm (2 in.). The Georgia DOT has expanded the SMA application and used it in multiple 50-mm (2-in.) layers for 100-mm (4-in.) total thickness. Use of SMA in multiple layers, with a total thickness of 200 mm (8 in.), has not been investigated. While the mechanical properties of a thicker SMA pavement structure may be satisfactory, the cost considerations may not be optimal. Other, larger maximum-sized aggregate mixtures could more economically be used as base mixtures under an SMA and provide equal, or possibly even greater, load-carrying capability. An excellent example of this is a recent full-depth section on I-695 in Baltimore, Maryland, (the Baltimore Beltway) that used a combination of 50 mm (2 in.) of SMA over 295 mm (11.5 in.) of Superpave 37.5-mm (1.5 in.) nominal maximum size mixture.

Rehabilitation is a recommended option to deal with the existing distressed 200 mm (8 in.) of PCC pavement. However, cracking and seating rather than rubblizing the PCC to eliminate the failed existing areas (some full-depth repairs and drainage corrections may be required) is recommended if pretreatment of the existing slabs is necessary.[21,22,23] The structural strength of the rubblized PCC would be equivalent to that of a good quality crushed rock base, which is unlikely to provide adequate support with the proposed 200-mm (8-in.) thickness given the heavy traffic loading estimated. The preferred alternative to consider is cracking and seating of the PCC rather than rubblizing. Research indicates that the structural layer coefficient of the fractured (cracked and seated) PCC would be significantly greater than that of the rubblized material. This process can be used with minimal traffic disruption and has already been widely and very effectively used in California. One report by the National Asphalt Pavement Association reflects usage on over 75 individual projects in California during the 1980s.[24] The climatic conditions in the Los Angeles area and the thicker overlay proposed would seem to make rubblization unnecessary and, if used, quite likely to reduce the service life of the proposed overlay. A fabric interlayer like that currently used on cracked and seated PCC pavements in California could also be considered to minimize reflective cracking concerns with or without any slab pretreatment.

[19] *Federal Highway Administration,* Superpave Implementation Update, *Technical Notes, Page A, Summer 1998.*

[20] *Guidelines for Materials, Production, and Placement of Stone Matrix Asphalt (SMA), IS 118, National Asphalt Pavement Association, Lanham, MD, 8/94.*

[21] *Guidelines For Use Of HMA Overlays To Rehabilitate PCC Pavements, IS 117, National Asphalt Pavement Association, Landham, MD, 9/94.*

[22] *Mahoney, J. Et al., Urban Interstate Portland Cement Concrete Pavement Rehabilitation Alternatives for Washington State, Final Report WA-RD 202.1, April 1991, 350 pages.*

[23] *AASHTO Guide for the Design of Pavement Structures, AASHTO, 1993, pp. III-79 to 158.*

[24] *Guidelines and Methodologies for the Rehabilitation of Rigid Highway Pavements Using Asphalt Concrete Overlays, PCS/Law, (Available from NAPA), June 1991.*

Community Relations and Public Information

All of the workshop teams and the invited speakers recognized that projects like that proposed for the I-710 cannot succeed in the absence of community involvement and a strong public information campaign designed to keep highway users and citizens fully informed about the project. The steering group consequently invited a task group of community relations professionals to review the overall issues related to projects like the reconstruction of the I-710 and to comment on potential public affairs approaches to the problem. This task group met several months after the workshop was held, which permitted the California DOT to complete the first set of preliminary drawings so that the task group could visualize the physical nature of the project and the alternative schemes proposed by the workshop teams.

Six public relations professionals from five states comprised the task group (see Appendix A). Two members were from the local Caltrans District 7 office and provided special knowledge about the local communities in the I-710 corridor. Douglas Failing, the Chief of Design for District 7, whose staff prepared the engineering drawings, and who participated in the workshop, was also present to provide technical information about the project. The final member of the task group was Richard P. Weaver, chairman of the TRB steering group.

The task of preparing a community relations proposal was broken down into five major headings:

- Message
- Audience
- Delivery of the message
- Community feedback
- Measuring the results.

The task force defined each subject, listed problem areas, and tried to provide answers and solutions based on their personal experiences.

The Message: Build it now, build it quickly, and build it to last.

The task force believed that the message should be positive, forthright, and early—that honest information about possible delays and inconveniences should be conveyed frankly and as early as possible. The negatives should not be sugarcoated, but they can be offset by reminding people that the agency cares about its customers and is implementing the best solution for the problem. No promises should be made unless the agency is willing to stand behind them. Motorists should be reminded that their "sacrifices" today will be paid back in the form of a new and better highway for years to come. Motorists should also be made aware that something has to be done *now*—that delaying construction will only compound the problems later.

For large projects such as the I-710, the message should be delivered to the public as early as possible, to allow time to build a working relationship with the public and to include them in all phases of project development. Community relations professionals should be involved from the earliest stages of project planning. This early involvement will foster project ownership and should make the changes wrought by the construction phase easier to "sell" to the public. For example, major changes in traffic operations and travel patterns as a result of the Olympics in Atlanta and the Northridge earthquake in California evoked a positive response from the public because the DOTs explained the changes in a way that appealed to the public's sense of reason.

The Audience

The task force identified a number of groups and organizations within the community that compose the audience for the message. Among these, commuters, community residents and businesses, and port traffic likely represent the majority of I-710 traffic. Municipalities and large employers situated along the corridor should be involved from an early stage, since changes in traffic flow will greatly affect their businesses and employees. Nonregular users would include tourists and others passing through the area.

Identifying and reaching the audience could prove difficult because of the size of the Los Angeles area and the cultural and economic diversity of the population. A thorough market research of the corridor, including field investigations and with the assistance of market research specialists, should be made.

Attempts should be made to target information to active local public interest organizations such as Concerned Citizens of South Central Los Angeles and Mothers of East Los Angeles, as well as to larger groups, such as the California Trucking Association and the Automobile Club of Southern California. These groups have proven effective networks for timely distribution of key information to their members.

Schools, religious organizations, and various ethnic groups compose a smaller, yet important, portion of the audience. Because a typical public information campaign may fail to reach them, hiring a consultant with experience in reaching these communities might be money well spent.

Many of the port-supported industries that use the I-710 corridor for transfer of goods rely on just-in-time deliveries to reduce the amount of warehouse space needed. These companies need advance information about construction delays so they can revise their delivery schedules to avoid costly manufacturing delays.

Delivery of the Message

A number of different tools for delivering a public information message were discussed by the group. Most of these will add somewhat to the overall cost of the project, but some will have a very low or no cost. Clearly, one of the crucial items affecting message delivery is the public affairs budget.

For large, complex projects such as I-710, community relations staffing requirements must be determined early on. Some highway agencies might not have a staff large enough to handle a project of this magnitude; the work could be contracted out to marketing or public relations consultants, but this would be costly and necessitate ample lead time for consultant proposals and selection.

The traditional methods of informing motorists of pending construction work cost little; these methods include press releases, open houses, and interviews. In many cases, however, these methods are inadequate to reach the members of the audience that will be most affected by the construction work. Effective options include paid commercial advertisements on drive-time radio, on television, and in local newspapers.

Changeable message signs, both portable and fixed, located near the project are preferred to billboards because they cost less and can be readily updated and revised. Portable changeable message signs, which are normally stocked by highway agencies, can be used in advance of a work zone to inform motorists of changing traffic conditions, as well as pending construction and future lane closures.

High-quality construction maps, project descriptions, and other printed material should be developed and made widely available. Distribution methods include direct mailings, inserts in utility bills and pay envelopes, handouts for school children to carry home, countertop literature displays at local businesses and information kiosks at area attractions and shopping malls.

As mentioned earlier, public meetings and open houses are one of the more popular methods DOTs use to present construction projects to, and solicit input from, the public. Another idea is to request time to speak at community events, such as meetings of parent-teacher associations and service clubs. These meetings provide an opportunity to speak to a "captive" audience, and they require little expense or preparation time. As with any public meeting, making a good appearance is crucial to the success of the message delivery. In addition, agency staff members should be prepared to answer general questions about projects such as the I-710 reconstruction, making it worthwhile to invest in media relations training and public speaking courses for agency staff.

A DOT's Web site is an excellent low-cost alternative means of disseminating project updates and construction information. For those who do not have access to the Internet, a toll-free information hotline should provide construction updates.

Other ideas include offering coupons to increase transit use, commercial tie-ins such as discounts on oil changes, video news releases for local access television and public broadcasting stations, and personal contact with local traffic reporters.

The lack of adequate internal communication about a project can pose a major stumbling block for some DOTs. During project development, the design group should request input from field personnel and keep them abreast of progress. During construction, the field engineers should keep the design office updated on project status. Local politicians, community leaders, and opinion leaders should be brought into the communication channel.

Community Feedback

Feedback, both positive and negative, is a sign that people are hearing the message. It is imperative to solicit feedback from the public; this feedback can be incorporated into project design and can be used to grade ourselves on how well we are doing our job. For these reasons, the message should not always just invite a response, but sometimes even require feedback.

Soliciting public feedback at meetings and open houses provides an opportunity to meet face-to-face with the public—our customers—and address any questions or concerns. It cuts down on the number of repetitive questions by giving the agency access to a large number of people. For those customers uncomfortable with speaking before a group, provisions should be made for written or tape-recorded questions, which could be either addressed at the meeting or answered afterwards. A toll-free telephone number should also be made available for questions that might come up later.

Although public meetings and open houses can reach large numbers of people, they sometimes do not draw the people most likely to be affected by the project. One suggestion is to take the meeting to them, if they won't come to the meeting. For example, display booths at shopping malls and community fairs is just one possibility. Such settings tend to be less formal and can be perceived as more "neutral" by the customer, thereby increasing the chance of receiving constructive comments.

Whether done by telephone, mail, or e-mail, project questionnaires can be used to solicit feedback. The questionnaires can be addressed to random sections of the public, or sequential surveys can be done with the same group of participants throughout the duration of the project. As with any survey, the questions should be kept to a minimum and worded in such a way as to encourage feedback and generate useful conclusions.

Advisory boards for the design, construction, and public information components of the project can provide timely and useful information during all phases of the project. These boards should consist of key agency staff, community leaders and legislators, and representatives of area businesses.

Measuring the Results

It's important to measure how successful a public information campaign was, as this information will inform subsequent projects. In general, it is necessary to determine how many people, comprising which sectors of the audience, were reached with the message. This requires some type of intensive follow-up survey subsequent to project construction. In most cases, agencies have not budgeted either the time or the funding for such project follow-up activities.

There are several relatively low-cost methods of tracking the success of a community relations program, including comparing corridor benchmarks before and during construction, analyzing commute times and changes in traffic volumes, and monitoring changes in public transit ridership or use of park-and-ride lots. The agency is likely already collecting much of this data on a regular basis.

Even without technical analysis of traffic data, the results of the public information campaign will be evident from the number of complaints received and the public's response during the project construction period. Comparing the actual problems with those projected could likewise indicate whether a campaign was successful. Complaints and community concerns will invariably surface during any project of this magnitude, but the objective is to reduce the number and seriousness of the complaints and concerns and to swiftly resolve them.

Conclusions

Arising from broad agreement on the urgent need to rehabilitate thousands of lane miles of urban freeways, the workshop on pavement renewal was undertaken with five objectives in mind. The measure of success is the progress that was made toward the satisfaction of each of those objectives.

The first objective, to synthesize and publicize effective solutions drawn from the mutual experience of the participants, was met to the fullest.

The workshop teams identified four distinct solutions for the reconstruction of the I-710. While each of these solutions challenges the limits of current technology and practice, the comments of the FHWA Pavement Design Division showed that none of the solutions is fanciful or improbable. Each clearly builds on the experience base of the workshop participants. Each offers anticipated advantages over the standard practices that would normally be applied on such reconstruction projects, primarily by providing a shorter construction period and extended pavement performance. Improvements to highway user and worker safety and roadway aesthetics can also be anticipated.

The mix of expertise found on each team proved to be synergistic. The construction contractors and other industry professionals brought an aggressive practicality that neatly supplemented the agency professionals' demand for safe, durable designs at reasonable cost. The transportation researchers and specialists supplied a spirit of innovation. The unvoiced, but apparent competition among the teams also provided a spur to ingenuity. The Blue Team's diversion of truck traffic to the paved bed of the Los Angeles River and the Green Team's scheme to eliminate the center piers of overpassing structures and utilize the extra mainline width gained for lane diversions are but two examples of this "out of the box" ingenuity.

The second objective, *to highlight available but underutilized technologies and research,* was also satisfied. Each team employed one or more existing technologies that are not yet commonly used throughout the country. The unbonded concrete overlay proposed by the Yellow Team, for example, is often used in the Midwest but only infrequently elsewhere. The use of stone matrix asphalt as a structural base course, as recommended by the Blue Team, is found only in Georgia. Rubblization of failed concrete pavements is another mature technology not commonly applied. The Brown Team actually put on a brief seminar at the workshop to familiarize other participants with this technology. The extensive use of movable barriers, proposed by the Green Team, is another example of a technology currently used for special situations, but not generally applied to reconstruction projects such as that proposed for the I-710.

Through their recommendations, the teams highlighted a number of *barriers to the cost-efficient and time-efficient designs and construction approaches*, effectively addressing the third objective. First and foremost was traffic management in a corridor already operating near capacity. Each team recommended innovative management practices relying on the application of intelligent transportation systems, particularly advanced traveler information systems. In general discussion, one team stated that the first notice of construction in the I-710 corridor should reach a highway user before the decision to use that corridor is made. In other words, potential users should be accurately informed of potential delay and alternative routes before leaving home or work, at the airport, at car rental agencies and, if on the highway, before entering the Los Angeles metropolitan area. While each team proposed on-site traffic management schemes, each recognized that diversion of as much traffic as possible from the I-710 corridor was essential if congestion and delay for all travelers were to be minimized.

Current contract management procedures were also recognized as a barrier. To be effective, schemes such as those proposed require more mobilization time, substantial equipment redundancy, and contractor access to extensive or numerous staging areas along the margins of the project. These needs must be reflected in the contracting documents and plans. Contracting devices to accelerate construction and minimize traffic disruption, such as early completion incentives or lane rental clauses, should be used. A+B contracting, in which awards are based on both price and elapsed time or travel restriction time, should also be considered. Because speed is essential in work of this type, several teams recommended that the project should feature a fully empowered dispute resolution team on-site. Once a work period begins, work must continue uninterrupted.

Another barrier, highlighted by the preliminary speakers and recognized by all four teams, was the potential for adverse public opinion. Because urban freeways are such an intimate part of the personal and economic lives of the users and adjoining communities, no project like this should be attempted without the cooperation and complete understanding of these groups. The preliminary speakers asked, and the teams concurred, that community and user groups be involved in the project from its earliest planning to its completion. The Task Group on Community Relations and Public Affairs has provided suggestions on how this might be accomplished. The involvement suggested by the preliminary speakers goes far beyond that commonly found on "rehabilitation" projects, but is understandable on projects with the scope and impact of the I-710.

The fourth and fifth objectives sought the *identification of pressing needs to be addressed in local and national research agendas* and the *identification of needed technologies*. To meet these objectives, the steering group asked a team of specialists to capture the research and technology needs that surfaced in the course of workshop discussions. The report of this team was considered by the members of the steering group in preparing the list of research and technology needs that is included in the following sections. There was no attempt to assign priority or dimension to the needs cited. This list should be useful to agencies funding or sponsoring research as future research programs are developed. The research needs have been categorized for convenience; the order of presentation does not imply any priority.

Highway Materials

The steering group defined a 40-year performance period for the reconstructed pavements to be recommended by the workshop teams. This necessarily carries implications for materials durability, and there is therefore a need for research on the long-term durability of the materials used in highway pavements. This is particularly true for newer materials such as modified asphalt binders, fast-setting hydraulic cements and high performance portland cement concrete where field experience is limited. Accelerated performance testing programs are needed to enable predictions about the long-term performance of such materials. In his presentation, Tony Harris of the California DOT mentioned the accelerated testing program underway in his state. Other state DOTs and universities have recently obtained accelerated performance test equipment suitable for such programs. A coordinated program among these states could rapidly investigate load-related durability questions for many pavement materials. The Long Term Pavement Performance (LTPP) Database should be mined for information on the long-term durability of more traditional asphalt and concrete paving materials. An urgency was expressed as there is precious little time remaining before a hugh effort of rehabilitation begins.

Pavement Design

In general, the teams recommended fairly conservative pavement designs that apparently have a reasonable chance of surviving the 40-year performance period. Several innovative designs, such as stone matrix asphalt

(SMA) base courses, were suggested. For other designs, non-standard or innovative design details were suggested. It would seem prudent to undertake some preliminary investigation of the potential long-term performance of these innovations. Again, accelerated pavement testing can provide indications of likely long-term performance. The Special Pavement Studies of LTPP are already investigating some of the design details discussed at the workshop and LTPP data should be analyzed as soon as it is available. Suggested research includes:

- Performance of SMA base courses
- Structural capacity of rubblized concrete base courses
- Structural capacity of cracked and seated concrete
- Impact of increasing steel percentage in continuously reinforced concrete
- Designs for "drop-in" pre-cast concrete replacement slabs
- Design standards for truck-only lanes
- Cost effectiveness of non-uniform pavement thickness
- Effectiveness of "clustering" joint dowels in the wheel path.

Traffic Management

Of the four reconstruction schemes proposed, only the Green Team's proposal will not require major traffic restrictions or detours. The Brown Team will utilize nighttime and weekend lane closures similar to those employed in current practice. The Yellow Team relies on segment closures in one direction each weekend with a new detour scheme for each segment closing. The Blue Team proposal calls for diversion of substantial truck traffic and maintaining two-way traffic in one carriageway while the opposing carriageway is reconstructed. Comparing the relative cost, safety, and impacts on users and communities of such disparate schemes on an objective basis is almost impossible. The following research is needed to improve current traffic management practices on urban rehabilitation projects:

- Advance Traveler Information System message effectiveness
- Prediction models for detour effectiveness
- Models to assess impact of short-term detours on performance of urban streets
- Prediction models for the effectiveness of non-mandatory diversions and detours in preventing or ameliorating congestion
- Creation of safety data bases for lane diversions, lane closures, and urban street detours.

Traffic Operations/Work Zone Traffic Control

Most of the traffic operations research needs identified at the workshop related to work zone traffic control. In some instances, the problem was a public perception issue, rather than one of absolute effectiveness. For example, Candace Traeger of UPS stated "narrower lanes make everything else look larger in comparison and a lot of negative attitudes that people have toward trucks are because of this." She also reported that when lanes are narrowed through work zones, typical long haul combinations might have to be broken down into smaller configurations, adding cost to carriers and shippers. "Ghost" lane stripes remaining from temporary lane markings for prior construction stages were cited as a major source of driver confusion in work zones, particularly at night and during bad weather. The Green Team even "invented" a screw-in lane delineator at the workshop. This delineator is designed to screw into fittings cast in the pavement and can be moved from place to place as lane shifts are instituted.

Listed below are traffic control needs identified at the workshop:

- Safety performance databases and syntheses of best practices for typical work zone traffic control schemes such as narrowed lanes, tapers for lane closures, lane shifts, traffic barriers, etc.
- Erasable or removable temporary pavement markings
- Unambiguous work zone signs and pavement markings
- Long-lived (20+ years) permanent pavement markings.

Economics and Finance Issues

In general, no one at the workshop debated the economic necessity of undertaking the renewal of the I-710 nor was there doubt that any of the schemes would provide positive economic benefits to the community and highway users. What most participants felt was missing were tools to discriminate among the schemes or among specific actions. For example, the California DOT standard option would not correct the vertical or horizontal bridge clearance deficiencies. The Green Team chose to correct all of them. The other schemes fell somewhere in between these two. Even if safety issues are ignored, these clearance problems have economic impact by limiting access or preventing use of the outside shoulder as an emergency or peak volume lane. The workshop participants generally felt the tools were lacking to discriminate among these choices. Given an anticipated 40-year service period for the reconstructed facility, the economic differentials among the choices could be significant.

Other financial or economic research needs identified at the workshop included:

- User cost models that include delay and detour costs and the costs associated with future maintenance interventions for major facilities
- Cost models for impacts on businesses dependent on a specific transportation facility
- Risk analysis models for contract incentives and long-term warranties.

Non-Destructive Evaluation

Just as maintenance and construction create traffic restrictions and safety hazards, so do standard practices for subsurface investigation of existing conditions. The "stop and go" nature of normal drilling and sampling and non-destructive testing techniques currently employed are poorly suited to highways such as the I-710 where even "off-peak" traffic is heavy. The workshop participants, particularly those from public agencies, saw need for a new generation of non-destructive testing techniques that do not require lane closures. An example would be a reliable, rolling deflectometer that could operate at or near highway speed. These techniques should also require less drilling and sampling to establish ground truth than current techniques. Such equipment could be employed in network-level pavement management programs as well. This would help address Mr. van Loben Sels' desire to "know when to fix it."

Those participants with construction management experience cited a need for rapid non-destructive test methods to establish when newly placed pavement is ready to open to traffic. This is especially needed for overnight or over-weekend paving operations where premature openings can seriously shorten the life expectancy of the new pavement but unnecessary delay has serious consequences to highway users.

Construction Equipment

Most construction equipment in use today was designed for construction projects far different from the I-710 and similar urban freeway reconstruction projects. This presents construction contractors with major challenges. The contractors participating in the workshop demonstrated that "contractor ingenuity" could meet many of these challenges, but construction equipment specifically designed for this construction environment would improve efficiency and reduce costs. For example, the Yellow Team called for virtually complete redundancy of equipment on the project so equipment breakdowns would not completely shutdown a weekend paving schedule. The Yellow Team proposed full weekend closures so there would be room enough to remove and replace inoperable equipment in the paving train. If full closures were not possible, however, it is problematic that such rapid replacements could be made. More reliable equipment that can be rapidly repaired within the confines of a single lane might better keep time-constrained paving operations on schedule.

Specific suggestions for needed construction equipment included:

- Flexible, easily erected conveyor systems to move materials along the project and safely across open lanes of traffic. Such systems would reduce reliance on trucks to move material off and on the work site and reduce conflicting traffic movements
- Truck "turntables" so that trucks delivering or removing material can be turned in a smaller area and in less time
- Equipment to remove concrete slabs in large sections to reduce the time needed to break up and load old concrete pavement
- "Drop-in" systems for the placement of precast, prestressed concrete paving slabs
- Recycling and paving trains for in-place recycling of concrete pavements.

Overpassing Structures

Perhaps the most perplexing technological problem confronting the workshop teams was dealing with the 17 overpassing structures that do not meet current standards for vertical and/or horizontal clearance. A number of participants pointed out that it seemed illogical to leave such structures in place if the reconstructed highway were to have a projected service life of 40 years. It seemed to many that these older structures would likely require repair or replacement during that 40-year period, thus reducing the benefits obtained from an otherwise long-lived highway.

Safety issues were also raised. Structures that encroached horizontally make the roadway appear narrower and encourage traffic in the outside lane to inadvertently encroach on the next lane to the left. These structures require installation of protective guardrail around the abutment, which further encroaches on the shoulder. Most significantly, the abutments are massive, fixed objects close to the traveled way. At one location, the concrete abutment is only 1.22 meters from the edge of pavement **(Plate 3a)**.

The four structures with nonstandard vertical clearance also present limitations to the truck traffic using the I-710. As noted earlier, nonstandard vertical clearances also restrict access for some vehicles.

Countervailing concerns included the additional cost to replace these structures, the time required to do so, and the adverse impact that concurrent bridge replacements might have on the communities that abut the I-710. California DOT staff estimated that replacement of all 17 encroaching structures would cost an additional $42.7 million and the salvage value of the current bridges, which are not structurally deficient, would be lost.

As evidenced by the disparate treatment of this issue by the four teams, no agreement emerged on what could or should be done to resolve the issue. Improvements in bridge technology can clearly help, however. The following technology needs were identified:

- Longer, lighter, less deep bridge beams of high-performance concrete, steel, or composite materials that allow removal of piers without reducing vertical clearance or creating major grade adjustments for overpassing roadways
- Guidelines and technologies for the safe and rapid removal and replacement of overpassing structures
- Innovative solutions for replacing wall abutments on existing structures to improve horizontal clearance
- New designs or construction technologies that permit rapid erection of overpassing structures with minimal traffic delay.[25]

A Final Analysis

The Workshop on Pavement Renewal for Urban Freeways succeeded on several levels. Cooperation among teams representing all parts of the industry contributed a full range of perspectives to inform discussions and decisions. More than just interdisciplinary teams, the workshop stretched the concept to include government and nongovernment interests, owners and contractors, suppliers and users, academics and project engineers and provided a climate in which innovations and solutions came to light.

With the developing interest in design/build projects, this process could prove especially useful in crafting cost-effective techniques and improved bidding practices. In fact, several individual state departments of transportation have planned or conducted similar workshops examining actual projects. The Oregon DOT and the Federal Highway Administration sponsored the first such "real project" workshop in March of 1999.

Whether or not workshops like this become commonplace tools for preliminary engineering of major reconstruction projects will be answered in the future. What was answered at this workshop is that technologies exist today that can provide long-lived reconstruction solutions for the nation's urban freeways. Cooperation among transportation agencies, the engineering and construction industries, local communities and highway users can yield innovative approaches for speedy, long-lived renewal while minimizing adverse traffic and community impacts. This promise can be met today with technologies and materials developed for an older generation of highways. With a focused program of research and technology development, the ability to deliver on this promise will be dramatically enhanced. As the motto of the Green Team has it, transportation agencies and construction contractors will be able to "Get In, Get Out, and Stay Out."

[25] *Coincidental to the workshop, Brian Addis reported just such an innovation in the February 1998 issue of* Concrete Construction. *An asymmetric, cable-stayed bridge was first constructed parallel to and then pivoted over the 10 lanes of the N12 freeway in Germiston, South Africa. Traffic was not interrupted as the new bridge was swung into place.*

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Appendix B

FACT SHEET

Pavement Rehabilitation Project—Interstate Route 710

1. Description

The Route 710 Freeway (Long Beach Freeway) is a major north-south Interstate route used for interregional and intraregional commuting and shipping through an urbanized corridor. It originates at Route 47 in the port area of the City of Long Beach and terminates at Route 210 in the City of Pasadena, spanning a total distance of 47.3 km (29.4 miles) entirely within Los Angeles County.

The existing portion of the freeway begins at Ocean Boulevard and extends northward to Valley Boulevard in the City of Alhambra, and from Del Mar Boulevard to Route 210 in the City of Pasadena, traversing several unincorporated areas of Los Angeles County, as well as the incorporated cities of Long Beach, Compton, Paramount, Lynwood, South Gate, Bell, Commerce, Monterey Park, Alhambra, and Pasadena. Plans presently exist to complete the unconstructed gap between Valley and Del Mar Boulevards 7.3 km (4.5 miles) in the cities of Los Angeles adjacent to Alhambra, South Pasadena, and Pasadena.

Route 710 serves as an intraregional commute corridor, providing access to the Los Angeles Central Business District from Long Beach and Pasadena Central Business Districts. This facility also provides access to the Catalina Island ferries, the Port of Long Beach, the Port of Los Angeles, the Long Beach Municipal Airport, the Long Beach World Trade Center, truck terminals in the vicinity of Vernon, and Cal State University, Los Angeles near Route 10. Because of the major ports and terminal, this facility serves a large volume of truck traffic.

Several recreational points of interest are also served by Route 710. These include The Lonii Beach Harbor (including sport fishing, boating, and swimming), the Long Beach Convention Center, the Queen Mary near the southern end of the corridor, and at the northern end, the Rose Bowl, Ambassador College Auditorium, Norton

Museum of Art, and the Pasadena Civic Auditorium. In addition, once a year the City of Long Beach hosts the Long Beach Grand Prix, a major car-racing event.

2. Land Use

Land use along the Route 710 corridor varies. Between the Long Beach Harbor and the City of Commerce, heavy industry predominates. Future plans for the Ports of Long Beach and Los Angeles envision expanding these facilities. According to SCAG's port access studies, by the year 2010 the projections show these facilities handling 223 million metric tons of cargo. Extensive redevelopment is taking place around the port area in anticipation of this expansion. North of the port's sphere of influence, the land use changes from industrial to commercial and residential uses. Growth forecasts indicate a substantial increase of commercial and residential infrastructure for the three areas referred to in the SCAG 1989 Mobility Plan (RMP) as subregional areas. These subregions are identified as Long Beach/Downey, Central Los Angeles, and Glendale/Pasadena. Growth of 25% in population, 29% in housing, and 32% in employment for these subregions from the base of 1984 to the year 2010 is expected.

3. Existing Facility

In 1983, the portion of this facility between Route 1 and Route 10, which is the object of this pavement rehabilitation project, became part of the Interstate system. This is an 8- to 12-lane freeway between Route 1 and Route 60 and a 6-lane freeway between Route 60 and Route 10. Much of the freeway from Route 1 to Route 5 has 8-ft outside shoulders and little or no median shoulder (the median shoulder was used for additional mixed flow lanes. Construction of this route goes back to the year 1954, with follow-up projects over the years to accommodate the traffic increasing demands in a safe and efficient manner. The structure of the pavement consists basically of three 8-inch (0.67 ft) layers, each one of imported subbase material, granular base material, in some segments stabilized with portland cement, and portland cement concrete slabs with average dimensions of 15 by 12 ft.

Deterioration of the existing PCC pavement has been evident over the last years, especially the outer lanes (lanes 3 and 4) due to the heavy axle loads they have been subjected to by a relatively high percentage of truck traffic. Slab cracking, spalling, depressions, and low-quality ride are common along this route and predominant for certain segments (Route 105 to Route 5). Improvements in recent years were made, especially along the southern portion, to improve the traffic operations of the freeway or to adopt new standards used in new projects on routes that intersect this freeway. Part of the post-construction improvements have been the replacement of the original metal beam median barrier with a PCC concrete barrier, the standarization of outside shoulders, and localized PCC slab replacement.

The subject roadway has a total of 62 on-ramps, 36 of which are metered. Of the 36 metered ramps, 15 include HOV by-pass lanes. There are 7 freeway-to-freeway interchanges and 3 conventional highway interchanges.

4. Operating Conditions

Average daily traffic volumes (ADT) for 1996 range from 130,000 to 218,000 for the segment under study for rehabilitation (Del Amo Boulevard to Route 10). The projections for a 10-year period range from 153,000 to 227,000 with percentage of trucks varying between 8 and 15 percent. Peak directional volumes vary between 10,600 and 18,800 for the same period and segment considered. Traffic projections for 20 and 40 years are under study at the present time. Accident data for this route show about 17 areas of high accident concentration, most of them traffic congestion related.

5. Proposed Improvements

The proposal includes rehabilitating the pavement structural section and metal median barrier. Existing PCC pavement for freeway lanes 3 and 4 will be replaced with long-life pavement along 22 km (13.6 mi) out of the total length of 25.2 km (15.6 mi) between Del Amo Boulevard and Route 10. Lanes 1 and 2 will be repaired at spot locations by slab replacement. Metal median barrier will be upgraded to concrete barrier and median structural section (inside shoulders) upgraded to match traffic lanes. Outside shoulders will be widened to standards. Ramps will be overlaid with 100 mm of asphalt concrete. Minor drainage and landscape work will be addressed at localized areas.

6. Funding and Scheduling

It will be proposed that this project be funded from the State Highway Operation and Protection Program (SHOPP) and construction is tentatively scheduled for the fiscal year 2000-2001 at an estimated construction cost of $60,000,000.

GO TO COLOR PLATES