201

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SUMMARY: BRIDGE ENGINEERING CONFERENCE

modes

1 highway transportation
3 rail transportation

subject areas

22 hydrology and hydraulics
25 structures design and performance
33 construction
34 general materials
40 maintenance
62 soil foundations
63 soil and rock mechanics

FOREWORD

The Bridge Engineering Conference held in St. Louis, Missouri, September 25-27, 1978, was conducted in order to facilitate an interchange of information on all aspects of design, construction, rehabilitation, and maintenance of vehicular bridges with specific emphasis on problems and solutions of interest to highway, railroad, and transit bridge engineers, administrators, and managers. Proceedings of the Conference were published in Transportation Research Records 664 and 665. This circular contains summaries of reports and discussions presented at the conference and not included in the proceedings.

Part 1 of the circular contains introductory remarks by the Conference Chairman along with the keynote address and three of the presentations delivered at the plenary session. Part 2 includes the substance of a panel discussion at the conclusion of Session 12 on the future of bridge loadings. Part 3 reflects some opinions solicited by interviews with selected attendees. Part 4 is a list of corrections to papers appearing in Transportation Research Records 664 and 665, and Part 5 is a list of the conference participants and the sponsoring committee.

PART 1
PRESENTATIONS

Ivan M. Viest, Bethlehem Steel Corporation

This Bridge Engineering Conference will facilitate an information interchange on all aspects of design, construction, rehabilitation and maintenance of bridges.

During the past several decades, an impressive amount of research has been conducted on developing new materials and technology to design, construct and maintain bridges. Much has been learned and should be conveyed to the user. Much remains to be learned: the practitioners should play a part in guiding future research.

A continuing trend toward heavier loads and increasing traffic volumes, combined with adverse environmental conditions, has resulted in rapid deterioration of existing bridges. The U.S. Department of Transportation's comprehensive review of the national bridge inventory concluded that over 40,000 bridges on the Federal Aid Highway System are either structurally deficient or functionally obsolete. The National Association of County Engineers has estimated that over 160,000 county bridges are in a similar predicament. Bridge problems faced by railroad and transit agencies are much the same.

The problem is widely recognized. Appropriations for bridge construction and maintenance are continually increasing. But funds provided thus far are insufficient! An even larger effort must be made if the nation's surface transportation system is to function efficiently. A careful evaluation should be made of all available methodology and needed research to insure the optimum use of resources.

During recent Transportation Research Board annual meetings, 2 sessions on bridge research needs were held: January 1976 on steel bridges and January 1977 on concrete bridges. Ideas presented at these conferences were worked into a set of research needs statements that will be a part of the 1978 collection of transportation research needs.

The Federal Highway Administration's federally coordinated program of research and development encompasses many bridge research projects. Some are reviewed on an annual basis; the review serves to point out further research needs. Last June, the American Iron and Steel Institute held a 2½ day meeting discussing the needs for future research on steel bridges.

From all this work, as well as from frequent discussions with both practitioners and researchers, I concluded that there is a substantial back log of research needs.

To illustrate, I will discuss 5 topics: (1) bridge loading, (2) safety, (3) serviceability and maintenance, (4) structural design specifications, and (5) prefabrication and construction.

Perhaps the one most urgently in need of further work concerns all aspects of bridge loading. Highway bridge design loads haven't changed since 1944, more than one full generation ago. And those for railroad bridges are even older. Their relationship to actual loads is tenuous at best. Considerable attention has already been given to this problem as you can see from the conference program, but the solution is certainly not on hand.

Ivan M. Viest

Bridge loading is complicated by 2 factors: state-to-state variations of legal limits, and changes that are taking place with time. This second point was extremely well demonstrated in Canada, where Ontario carried out a substantial sampling of actual traffic in the early 1970's. Input was converted into a new design loading forming part of the new Ontario bridge design specifications about to be issued. A more recent check on loads indicated that significant changes have already taken place.

How can we handle such a situation? A paper, touching on predicting future loads, will be presented by Fred Moses at a session on probabilistic design for bridges at the TRB Annual Meeting next January. Research in this area is in its infancy.

Most past research on materials, members, connections and bridge systems was concerned principally with bridge safety. A substantial contribution to this aspect of design was made by the AASHO Road Test in Ottawa, Illinois. While the tests showed a considerable strength reserve in slab and stringer bridges, they also demonstrated conclusively something that those of you who are railraod bridge engineers have had to live with for some time - the possibility of fatigue failures. Since that time, a major research program on fatigue of structural bridge members has been carried out as a part of the National Cooperative Highway Research Program. Largely thanks to these studies, the profession is ready to deal with fatigue problems encountered as a result of increasing magnitude and load density on the highway system.

These and other studies are now leading to consideration of bridge redundancy in design. A session on redundancy will be held at the 1979 TRB Annual Meeting in January. Here is another area in which relatively little work has been done in the past, at least in a form for use today.

Past practice for determining safety factors was purely empirical. However, during the past 50 years, substantial progress has been made in the probabilistic determination of safety. Today, the mathematics of probability can be used by code writing authorities to achieve more uniform levels of safety, thus decreasing the cost of bridges. State-of-the-art on this subject will also be discussed at the forthcoming January TRB meeting; those presentations will outline steps for further progress.

My next subject is serviceability and maintenance. The trend toward development of load factor-type design methods focused past research particularly on the question of strength. Now that the AASHTO Specifications include load factor design, everyday design practice is showing that it is not enough to consider strength alone. Bridge performance - day in and day out, such as response to overloads - is often the limiting design factor rather than strength. While this isn't new to you, it's a point neglected by researchers in the past. In future, a considerable research effort must be devoted to questions of bridge serviceability. This will automatically lead to research on bridge maintenance. Inspection, evaluation, repair and replacement of existing bridges are other areas that urgently need attention from our research community.

Let's spend a minute or two on the question of structural design specifications for bridges. The principal criteria used today in the United States are the AREA Specifications for Railroad Bridges and the AASHTO Specifications for Highway Bridges. Both have been around for some time; both have grown substantially as knowledge regarding bridge behavior has expanded. While both specifications originally included only allowable stress designs, the first load factor type procedures were introduced during the last decade. I can see 3 areas of structural design that would benefit from specification research: (1) logical rearrangement of the specification format to simplify its use, (2) elimination of duplicate design methods and, (3) incorporation of probabilistically derived strengths and load factors.

Finally, I'll make a few remarks on prefabrication and construction. As a steel industry employee, I've been following with interest and dismay the growth of imports of steel bridges. In 1976 and 1977 several major steel bridges were awarded to foreign fabricators. The 20,000-ton Luling Bridge over the Mississippi, now under construction in Louisiana, is the prime example. While this general topic is outside our Conference's scope, at least one of its aspects has a direct bearing: research on advanced fabricating methods leading to greater productivity.

Let me cite the aircraft industry as an example. Some 20 years ago, under the Department of Defense's leadership, the industry conducted a major project on automated detailing and fabrication of aircraft parts. The result was an early use of computers and a substantial increase in productivity. Although bridge fabricators have accomplished similar steps on their own, it's my belief that any expanded bridge research program must include studies of manufacturing and construction problems, including those of standardization and mass production. A rapid replacement of obsolete bridges with prefabricated units would be of particular benefit to the county systems.

Moving now to the bridge rehabilitation and replacement programs, initial steps have been taken for both railroad and highway bridges. The Northeast Corrdior railway improvements, to be discussed later in this program, include over $300 million for bridge rehabilitation and replacement. Special bridge replacement funds have been authorized for the Federal Aid Highway System in the total amount of $835 million for the period 1972 through 1978. This year, the administration recommended to Congress that the authorization for this program be increased substantially.

These bridge replacement funds are included in the upcoming Highway Act. The House bill allows $2 billion for this purpose at a matching ratio of 80% federal and 20% local funding. The Senate bill, including a recent amendment, would authorize $525 million at a 70/30 ratio. Current versions of both proposals include a provision that 15 to 30% of the funds be spent on bridges not on the Federal Aid Highway System.

The total cost of rehabilitating highway bridges alone has been estimated at well in excess of $25 billion. Thus, even with increased funds, the replacement problem promises to be with us for some time.

In view of this long-term timetable and accumulated backlog of bridge research needs, it appears to me that the bridge rehabilitation and replacement program could derive substantial benefits from stepped-up bridge research. Indeed, we would be remiss if we would not take advantage of the economies that can be gained through better knowledge.

Many of the problems are common to all bridges. Many of the solutions are also common to all bridges. Accordingly, I want to complete my remarks with a call, a call for substantially increased bridge research to be accomplished through a Joint Transportation Bridge Research Program. This program should include both highway and railway bridges and should involve all sectors of the bridge fraternity. Such joint Transportation Bridge Research Programs will maximize this needed effort and bring our best resources to bear on the needed solutions.

KEYNOTE ADDRESS

A. Scheffer Lang, Association of American Railroads

I am not usually given to quoting people, but I ran across a quotation the other day that struck me immediately, because it sums up so well what the Transportation Research Board is all about. The quote is attributed to a Dr. Thomas Arnold, who said: "...it is clear that in whatever it is our duty to act, those matters also it is our duty to study." It seems to me that admonition is what a conference like this is all about: people who design and build and maintain bridges, studying them.

A. Scheffer Lang

But there is a larger lesson that can be learned here, one that goes more directly to what research is all about. I want to tell you what I think that larger lesson is.

A few years back I became involved with the program of "high speed ground transportation" research and development in the Deaprtment of Commerce. It was an unusual program, and one that caused us to ask ourselves a lot of questions about "research" and what it really is. We found that for starters one has to make some sort of distinction between "basic" and "applied research." Our interests were pretty clearly in applied research; and that is the interest of most of you here at this conference, too.

"Applied research", we decided, was nothing more than part of a structured problem-solving process. Well, a problem is something we have when we think there is a better way; a way to do things or a better state in which things might exist. "Problem solving" is the process of finding and implementing that better way. Applied research is the "finding" part of that problem-solving process.

I was involved with the High Speed Ground Transportation Research and Development Program for three-and-one-half years. I learned a lot more about applied research before I was through. The most important thing I learned was that just knowing how to look for better ways to do things and looking for them was not enough. You have to know what you are looking for.

We had all sorts of whiz-bang researchers working on our problems (and offering to work on our problems) who, it turned out, produced little or nothing of any use to us. They produced little or nothing of use, because they never understood what they were looking for, even though they were skilled "lookers".

I am sure that all of you can cite similar experiences. There is a lesson in those experiences.

Finding a better way requires knowing what "better" is when you see it. It is not enough to be looking. Only people who really know what "better" looks like will (1) find it themselves, (2) recognize when someone else has found it, or (3) recognize that no one has yet found it.

What all that says is that the people who have the problems are the people who should do applied research on them; if, that is, you want that applied research to be effective. That does not suggest that each one of us should personally do all of his own applied research. What it does suggest is that each one of us should be involved in the process of looking for better ways to do our job.

It also suggests that no one should be doing applied research unless there are people who have the problems directly involved in the specification and management of that research. Again, you need people who really know what "better" looks like.

Another way to put this is, "You cannot let someone else do your applied research for you."

I have to tell you that there are a lot of folks in Washington who have not yet gotten that message. They want to do your research for you. And there are folks outside of Washington who are willing to sit back and let the folks in Washington try to do their research for them.

It does not work very well, if it works at all.

It is worth noting that the National Cooperative Highway Research Program, probably the most effective research program in any area of transportation, avoids this mistake pretty well. The NCHRP program puts the researchers (that is, the professional "lookers") together with the people who have the problems (in this case, the state highway departments). It works; as it should.

Well, all of that is what this meeting is about. All of that is what the Transportation Research Board is about.

"....in whatever it is our duty to act, those matters it is also our duty to study".

AASHTO SUBCOMMITTEE ON BRIDGE AND STRUCTURES: PAST, PRESENT AND FUTURE

Sidney L. Poleynard, Louisiana State Department of Transportation and Development

Many of you have expressed a desire to participate in a national bridge conference of this type for several years. We, the members of the Operating Subcommittee on Bridges and Structures of AASHTO have certainly been in agreement with the idea. And we are pleased to take an active part in the program.

Sidney L. Poleynard

I have been asked to make a few comments about our bridge committee, past, present and future. Little explanation is needed as to the make-up and purpose of the committee, since most of you, including our friends from abroad, are familiar with the AASHTO Specifications for Highway Bridges. Briefly, the membership is composed of a representative from each state, District of Columbia, Puerto Rico, the U.S. Department of Transportation and some provinces of Canada. The committee meets in 4 regional meetings each year at various locations in the country. All interested individuals, industries, associations and societies are invited to attend.

Now, where did all this begin? As most of you know, the early highway bridge engineer either had worked for a railroad or was greatly influenced by professors who had designed or constructed bridges for railroads. Certainly, because of need, the railroads in the name of the American Railway Engineering Association (AREA) had a beginning that predated AASHTO by many years. This was fortunate because both the engineers involved and their specification experience, particularly on steel bridges, was a great help to the early highway bridge engineer-and still is, I might add.

Although the Office of Public Roads, the predecessor of the Bureau of Public Roads and, now the Federal Highway Administration (FHWA), had prepared "Typical Specification for the Fabrication and Erection of Steel Highway Bridges" in 1913, the development of the country and the rapid increase in the numbers of trucks and automobiles after World War I gave the bridge engineer a mission we have been working at ever since, -- namely to cooperate with the different states and federal departments and other associations, societies and institutions with a view to assisting in establishing uniform standard methods of design, construction and maintenance and in standardizing as much as possible the various kinds of construction used in connection with highway development.

Starting in 1921 with this as an objective, several outstanding engineers, either involved or interested in highway bridges, believed we needed standard specifications for our bridges -- not only in steel, but in timber and concrete. Various specification bulletins were published during the twenties, but the truely first AASHTO bridge specification appeared in 1931. This has been constantly changed, revised, and added to until we have the recently published 1977 edition. The increased size represents much hard work over the years by many including the members and their staffs, industry, academia, and consultants. It truely has been a cooperative effort.

We today are still active with 19 agenda items ready for balloting this year. Of particular importance is a proposal for a fracture control plan for steel bridge design and construction. We hope this plan will greatly improve our quality control and quality assurance programs, especially for welded fracture critical members. We have also completed metricating our specifications for soft conversion, a first step to the eventual hard conversion.

We have several items pending for future agendas and discussions. An important one is a problem that has been around for a long time -- and one that perplexed the organizers of the Bridge Committee -- that of design loading. At first, just after World War I, it was military loading, steam rollers and logging donkeys -- now it is the ever increasing size and frequency of truck loading. What are adequate design loadings and geometrics for a bridge today -- and tomorrow? What will eventually be the "ideal" size of a truck and how will increased loads and numbers affect the thousands of bridges we have already built? The solution will not be easy.

Another immediate problem facing the committee is that of hard conversion to metrication. The impact on the designer is probably of the least concern since most of us had a taste of metric units in college physics and we lived through that. But we must remember the craftsmen and industry. The crafts and the workers involved are not as receptive to training, and industry is worried about the economics of the change. This task will not be easy, but the committee is committed to go forward in this effort before the printing of the next edition of the specification in 1981.

Although the future's not our's to see we must prepare for the future. It is comforting to know that the committee is well structured to keep its finger on the pulse of change.

COUNTY BRIDGE PROBLEMS AND NEEDS

Howard E. Schwark, Kankakee County, Illinois

Since the tragic collapse of the Silver Bridge over the Ohio River near Point Pleasant, West Virginia, on December 17, 1967, the public has been reminded through the news media, trade publications, congressional reports and surveys made by many highway related agencies, to name a few, that America faces a serious problem with its highway bridges. To better understand county bridge problems and needs perhaps we should begin our discussion before the Silver Bridge collapse, even though this tragedy was largely responsible for the extensive bridge inspection program which so clearly pointed out the seriousness of structurally deficient or functionally obsolete bridges that were on the federal aid system.

Howard E. Schwark

Most of the structurally deficient or functionally obsolete bridges on the county road systems were constructed in the first few decades of this century. A few may bear plates dating back to the later part of the last century. Considering that these structures, in the main, were designed for horse and wagon loads and their widths were limited to one lane of traffic it hardly seems possible with today's traffic that any of them are still standing. It is further difficult to understand this phenomena when we consider the evolutionary changes which have taken place in the number, size and weight of vehicles traveling over these bridges. I can recall several years back when our threshing crew would disconnect the threshing machine from the steam engine, plank the bridge floor with runners for load distribution, cross the bridge first with the steam engine, then pull the threshing machine across with a heavy log chain. Today loads much heavier than either of those machines cross the same bridge at high speeds building up an impact factor resulting, in some instances, in a higher stress than the combined load of engine and thresher. In my opinion these seemingly indestructible structures designed so well by our early bridge engineers fostered the apathy which has existed in the minds of the public that these bridges would last forever and, as a result, we are faced with today's national bridge crisis.

Instead of local agencies funding a realistic bridge replacement program when the character and type of traffic changed from horse and buggy to mechanized vehicles that continued to grow in numbers and size, most highway agencies spent their highway dollars on building a road system and replaced only those bridges that were absolutely necessary. The rest were kept in service with occasional maintenance being the only attention they received. The reason for this, I feel, can be attributed to several factors. One factor was that counties could build a lot of road for the price of a bridge spanning only a few feet, and the public was demanding from all highway agencies better roads which resulted in local agencies giving priority to roads rather than bridges from the monies available for highway purposes. Another factor was psychological. As long as a bridge was still standing the average driver assumed it was safe to cross irrespective of the load he was taking across and as a result the public never became excited about the need to finance a bridge replacement program. Everybody went over the bridge; seldom did anyone go underneath to see what was holding it up. If they had, we may have replaced more bridges than we have to date. Another factor was that by and large counties did not have professional services available to them for rating bridge capacities. About the only guidelines many counties had for bridge replacement were outright failures and an obvious need to replace due to heavy loads and high volumes of traffic. As a result the bridge crisis did not materialize into national proportions until the rating of structures on the federal aid system was mandated by the federal highway administration, a fallout from the Silver Bridge tragedy, and it was estimated that replacement costs for deficient bridges on the Federal system alone would cost approximately $12.5 billion. The number of bridges on the off-system in need of replacement has been estimated to be 5 times more than the number of bridges on the on-system. A complete report of the off-system bridges is not available because the rating of these structures nationwide is incomplete.

Why should counties be concerned about this bridge problem now when for many years they were able to get by with a comparatively modest bridge program and the remainder of these old bridges are still standing and most are still carrying traffic? They haven't been hit by vehicles in spite of their narrow widths. They haven't been collapsed by overloads as they seemingly should be so why get excited at this time. I believe it is because we are now faced with the truth. We know factually the conditions that exist on a national basis that we have known to exist in each of our jurisdictions for some time. We also know that more and more school busses of increasing size and capacity are using the rural roads today than ever before. A failure of a bridge with a loaded school bus on it would be a national tradedy. We are also faced with more and more railroads being abandoned with heavy trucks taking their place which are appearing in ever increasing numbers on our rural highways. The bottom line, however, is that we know these bridges must be replaced to meet today's traffic needs and that counties do not have the funds to get the job done.

Perhaps to better illustrate the point made on counties' concerns over funding problems I would like to use as an example our experience in Kankakee County, Illinois. In 1961 we conducted a survey of all bridges requiring replacement on the local system of highways. A total of 381 were located and inspected which included three river bridges and 111 under twenty feet in length. At that time we had a very modest bridge replacement program using Federal Aid secondary funds or motor fuel tax funds for bridge construction work. In 1963 we started a tax levy of five cents per $100 assessed valuation levied on real and personal property for a county bridge matching fund. Each of the seventeen townships could also levy a like amount to match county funds on a fifty-fifty basis for joint bridge construction in its township. Several did not levy at first but by 1969 all were eligible for matching funds. However, in 1965 we began an ongoing program of bridge replacement at which time we estimated our bridge needs to be $8,000,000 county wide. In 1971, after spending $1,600,000 on the bridge replacement program, a revised estimate of our needs was $8,300,000. Today, 1978, after spending $5,733,250 constructing 85 bridges over 20 feet in length and replacing 80 other structures with pipe, pipe arches, box culverts, etc., we estimate our needs in 1978 dollars to be $5,300,000 to construct 100 remaining structures, a somewhat disappointing progress report. The continued increase in costs of labor, wages, and material has resulted in an approximate 55% increase in our construction costs over the past 13 years with the largest increase taking place within the last 6 years. We have used every available source of funding including Federal Aid Secondary, Federal Bridge Replacement, Revenue Sharing, Joint Bridge, Motor Fuel Tax, County Highway, Road and Bridge, Safer Off System, and the State Local Bridge Fund and still find ourselves further behind in our bridge replacement program than we would like to be. I am sure that some counties have progressed better than we have in their bridge replacement program, and others may not have done as well. A county with a high assessed valuation and one which began early in the bridge replacement program is not quite as badly off as smaller counties or less affluent counties who do not have the advantages of a high-assessed valuation and sufficient staff. Judging from the results of surveys conducted by the National Association of Counties (NACO) there is still a large number of bridges needing replacing nationwide. I feel those counties with these deficient bridges share some of the same problems Kankakee County has--with insufficient available funds to meet the replacement costs leading the list.

Up until now our county has used relatively few federal dollars in our bridge program other than a bridge replacement project presently underway involving the replacing of a river bridge at a cost of a little over a million dollars. I can see this changing rather rapidly, especially in light of the concern Congress is expressing over the local bridge crisis across the nation. We will more likely be using a share of our local bridge funds for matching federal dollars depending upon the matching ratio set forth in the proposed new highway bill. Congress and highway related associations have placed a great deal of emphasis upon the size of the federal appropriation for on-system and off-system bridge replacement. Little has been reported on how capable the local agencies will be in matching these funds especially if the funding reaches the billion dollar mark. Many counties in Illinois, I have been told, will find it difficult, if not in some cases impossible, to match these funds if they do become available. I believe that many counties throughout the nation will not have sufficient matching funds if the matching ratio is set at a given figure and consideration is not given to using a sliding ratio based upon a county's ability to raise the matching funds.

Matching federal dollars is only the beginning of the problems facing counties in an accelerated federal bridge replacement program. The Congress and FHWA have been busy for over twenty years building the interstate highway. Due to the nature of this immense project and the fact that it was built almost entirely on new location, laws were passed and policies developed which in no way fit local highways. Yet counties must, when using federal funds, comply with these laws and policies. To replace a bridge that has been in the same location for over 50 years and address its impact on the environment is rather redundant. To be required to obtain a permit for construction to replace a bridge from the Army Corps of Engineers when on the same stream a landowner is dredging the streambed, straightening nature's meanders and destroying the integrity of the watershed, all of which is being done without a permit because agriculture is exempted from the law, is not in the best interest of the country. This is certainly an example of how a discriminatory law can result in unnecessary public expense and, because of exemptions, does not do the job for which it was intended.

Other items such as archaeological finds, historic structures, endangered species all take time and are costly items to administer. In almost all cases counties are going to construct bridges replacing bridges which have been in the same place for many, many years. If we as counties are going to have a successful federal bridge replacement program I feel that Congress must acknowledge the fact that our bridge replacement program is far different from that of the interstate highway program; at the same time they should acknowledge that the counties and their respective states have proven their ability to get a job done. Out of the 3.1 million miles of rural roads in this country approximately 2.3 million miles are under the control of local agencies. That figure represents a lot of responsibility.

If an accelerated program does become a fact I feel that the obligating of allocated funds the federal way will also be a problem. First of all, prepared plans for a project are necessary before work can be placed under contract. Relatively few counties will have sufficient plans "on the shelf" to be ready for a large program. Most counties needed their construction dollars for the few bridges they have been building, and their county boards were reluctant to invest in plans based on an insecure hope for more money for bridge construction. Because of this there more than likely will be a time lag which will hard press counties to obligate their allocated funds within the time alloted. By the time a county has designed plans for the structure and processed it through the red tape factories, considerable calendar time will have lapsed. I believe this problem must be addressed on a national basis. The term "obligated" should be redefined or the period for obligating funds should be extended to allow counties to get their programs underway. A large number of counties nationwide do not have the staff to cope with the paper work involved in using federal funds. Often times we overlook this because we have assumed that counties are no different from the state and federal government who add or transfer staff when the need arises. I can assure you that there is a difference.

I feel counties need substantial financial assistance in coping with their bridge problems. Along with that need is a need for Congress to recognize that the counties on a nationwide basis are very dissimilar in many respects, such as topography, traffic requirements, climate, type of traffic, economy of the area, whether they are industrial, agricultural, residential or wide open spaces. Each characteristic requires certain considerations to be made during the design of a structure. For instance, in an agricultural area with super-wide farming equipment the guardrail treatment should be different from the guardrail treatment in a congested residential area. A bridge in rough topography should be considered differently in width and approach grade from one located in the flat plains where its length may be extended many more feet to provide the necessary waterway opening. Many variables exist in as diverse a land as ours. The point I wish to make is that we are no longer talking about a program to which we can apply uniform standards nationwide when we discuss rural local bridges. We are instead in need of addressing each bridge as an independent structure to fit specific requirements if we are to obtain the most value from the construction dollar. It is, therefore, essential that full consideration be given to allowing sufficient latitude in standards if we are going to invest the taxpayers money wisely and, most of all, eliminate these old structures as quickly as possible before another tragedy occurs. Let us not impede safety by making one bridge super safe and allowing others to collapse because we did not have the time or money to replace them.

To briefly summarize, the county bridge problem is critical nationwide and the needs are in excess of the present available funds which counties can generate for bridge replacement purposes. It has become a habit in so many instances for local governments to turn to the federal government for help when their needs exceed their available funding sources. The county off-system bridges seem to be no exception. I support the use of federal funds with reservations. After more than twenty-five years as a county superintendent of highways, I have observed the growing dependency of counties for federal dollars to get the job done. I have also seen the cost of projects increase when using federal dollars to get the job done. I have also seen the cost of projects increase when using federal dollars due to certain requirements which are applied across the board just because federal dollars were used. Red tape, environmental concerns, A-95 Review, Uniform Act on Acquiring Right-of-Way to name a few, all take time, and time is money!

The same taxpayer who sent his dollar to Washington also paid his local and state taxes. His interest in the bridge program is to be able to cross a bridge safely and he doesn't care which level of goverment is paying for it because he has paid his taxes. My point is: Why should there be a difference in how his dollar is spent? Why can't state and local governments continue the work they have done together for so many years? Why should Congress attempt to set apart federal funds as something holier than local and state funds with an ever-increasing loss in purchase power due to unnecessary regulations spawned chiefly by a National System of Highways which bears no resemblance whatsoever to local highway systems?

The tenor today, as expressed through California "Proposition 13", is that local governments will have a difficult time in raising local revenues to meet their needs. Let us not betray the conscientious taxpayer who is watching his tax dollar locally by wasting his federal dollar nationally. The ultimate answer to these concerns, I feel, is for Congress to appropriate directly to the states sufficient revenues over a period of time from the Trust Fund to meet the needs of the bridge crisis in their respective state and allow each state to proceed as they do now when they administer their local and state road funds. I think we owe this to the taxpayer, and I feel he in turn trusts us in county government to be able to do the job with his safety and welfare in mind.

TWO SIDES TO A CONSULTANT

George Andrews, Sverdrup & Parcel Associates, Inc.

The purpose of this bridge engineering conference is to facilitate an interchange of information on all aspects of design, construction, rehabilitation and maintenance of vehicular bridges with specific emphasis on problems and solutions of interest to bridge engineers and administrators of highway, railroad, and transit agencies.

I assume, therefore, that most of you in attendance are highway, railroad, and transit agency administrators or bridge engineers. Why then should I presume that you may be interested in whether or not a consultant has two sides, three sides, or for that matter, any sides?

From the introductory remarks by our Chairman, you have been advised that my previous engineering background has been as a state bridge engineer and highway administrator. Through these former positions, I have had an opportunity to develop scopes of work, prepare contracts, interview, hire, and supervise the work of many consulting engineers from the side of an employer. In my present position, I am involved with RFP's, scopes of work, interviews, and job performance from the side of a consultant.

George Andrews

In recent years, more and more public agencies are beginning to balance their workload between staff and consultant to avoid the difficult tasks of reductions in force that may develop due to uncontrollable program delays caused by funding shortfalls or by court, environmental, or other involvements. Perhaps the sharing of some of my experiences with you will aid in this transition.

As we all know, consultants can - or at least claim to be able to - solve all probelms, perform all kinds of services and, in general, remove any need to ever worry again. I am sure I don't have to caution you to take these claims with a grain of salt. But consultants can, in fact, perform a valuable service for transportation agencies of any size. This will generally be in one of two roles - either to supplement the staff you have in order to attain maximum manpower efficiency or to provide a special skill and experience that you may not have within your own organization. In either case, you should have an adequate, experienced, and professional staff to know what you need, what you want, and what you are getting.

In my former position, I was advised on several occasions by consultants that it was fundamentally wrong and against the basic precepts of free enterprise for a state agency to do any of its own design. I didn't believe it then and, more than ever, I don't believe it now. There have simply been enough shenanigans pulled over the years by a few so-called professional consultants, that I firmly believe the public is best served when the larger agencies have at the least a cadre of experienced, professional engineers to administer and perform their engineering functions. In other words, "it takes one to know one."

There are several aspects of our business which you should know about and take into consideration in your future employment of consultants. In making these comments, I am going to assume that most of you as bridge engineers and administrators represent agencies where consultants are selected on the basis of need and through a system which permits open solicitation, interviews, examination, and, finally, selection free of political pressures. To the rest of you, I extend my sympathy and my hope for a speedy change in direction.

To begin with, let us first consider the scope of work. This document should be carefully and thoroughly prepared to insure that all invited consultants are actually proposing on the same job. The size, nature, time, location of office, and degree of detail and follow-up services are all vitally important to each project and the accompanying fee that will be involved. Most of you will have a professional staff with sufficient knowledge of the proposed project to develop a scope fo work. For those who do not feel they can do the job in-house, consultants are available to assist, but I do not suggest that as a general practice the consultant who develops the scope of work then again be selected for performance. Often this is the way to go, but the practice has some inherent and obvious problems and should be carefully considered.

Next is the proposal. On a large job, a properly prepared proposal costs the consultant a lot of money, which adds to his overhead. In a few cases of which I am aware, some agencies on very large jobs have made an allowance for proposal preparation to carefully selected consultants. I do not believe this procedure is needed on most bridge or other transportation-oriented projects. I do suggest, however, that the practice employed by some agencies of pre-screening the qualifications of those consultants who have responded to an expression of interest and inviting full proposals from only a select few of those felt to be best qualified is good and I recommend it for your consideration. The preparation of proposals can cost anywhere from a few thousand to literally hundreds of thousands of dollars, adding ultimately to increased costs through increased overhead. The willy-nilly solicitation of proposals without intermediate screening is not only expensive but is unprofessional and can lead to inferior, ambiguous and ill-defined descriptions of how the work is to be performed.

Adequate proposals are essential to insure a complete and mutual understanding of the work to be done. As I indicated, however, good proposals cost money and add to overhead. Overhead then is the next item which deserves attention. Contrary to salary-related costs which reflect social security payments, annual and sick leave credits, retirement plans, and the like, overhead is a direct reflection of the consultant's modus operandi and to some extent, the type of consulting service he performs. Soils engineers, management consultants, and special services consultants, in general, for example, have a higher overhead than do consulting firms providing services employing a large number of draftsmen or subprofessionals that can be switched readily from one job to another as the needed work effort varies. The number of administrative personnel, the amount of marketing and new business effort, the style and location of office, and even the ownership of a company plane, all affect a firm's overhead. Likewise, the basic efficiency of the consultant's productive effort is critical to overhead and should be recognized.

Another important item of overhead which has grown significantly in recent years is the cost of liability insurance. All of you are no doubt painfully aware of the cost of loss of soveriegn immunity and the rapid increase in public suits. As your agent, claims for liability due to errors, omissions, and negligence are passed on the the consultants. To the extent the consultant is at fault, the payment of such claims should logically add to his overhead. But, awards for damages are frequently made by sympathetic juries or judges against big corporations and state or federal government agencies completely out of proportion to good common sense and often the consultant is caught in the middle. The common practice of insurance companies is to write their losses off against the entire industry and, therefore, consultants who have been prudent and careful in the performance of their assignment are also affected by the increased rates. As an example, I recently attended a meeting of several of the larger consulting firms to discuss the rapid escalation in costs of errors and omissions insurance. In reviewing the loss ratio of the firms represented, I found that not a single firm at the meeting had paid claims through deductibles or insurance in excess of about 15% of the amount of their premiums. Yet, such insurance is necessary, the payment of premiums is a must, and the cost becomes a part of overhead for all of us.

In employing consultants, your staff should know all about overhead, the reason for it, and what it contains. You should be prepared in your negotiations to question every item contained in overhead and agree to only those items and amounts which are pertinent. At the same time, you should be prepared to pay for all appropriate overhead. The practice now being followed by a few agencies of applying an arbitrary ceiling on overhead is unwise and unfair. Overhead varies as to the type of service and the size and nature of the consultant. Be prepared to pay what it's worth - but no more.

The fee for services performed is the next important item to consider when employing a consultant. All of you are aware of the various types of fee arrangements being used and the reasons for the evolution from percent of construction cost to cost plus fixed fee or lump sum contracts. I will not go into the types of fees. I would, however, like to spend a few minutes on the subject of competitive bidding, a practice which is now required by a few states and some major agencies, and then add a few words about the fixed fee portion of the cost plus approach.

Competitive bidding for consulting services is getting more attention all the time. Participating recently in a panel discussion on priced proposals, I was asked if, as an ex-highway administrator, I felt there were ever any circumstances under which competitive bidding for professional services would be an advantage to the client. My answer, to the shock of the other consultants present, was a qualified "Yes." But let me hasten to clarify. From my personal experience, there are some consulting services which lend themselves to being clearly enough defined as to scope that a high-quality end product at the least cost will result through the bidding process, provided the agency or owner is totally free to solicit bids only from those firms who are known to be professionally competent. Such a practice must be restricted to those projects where the scope is not only capable of being clearly defined, but also where invitations to bid can be limited to a small number selected from a list of qualified firms with a proven performance record. You will be quick to recognize that these qualifications will restrict the application to only a few types of projects and certainly will not work when mandated by law, regulations, or influenced by outside pressures or political motives.

Even though you may be aware of the problems which will result from the indiscriminant or widespread practice of taking competitive price proposals for professional services, I don't want to miss this opportunity to highlight them once more, particularly in view of the attention being given to this subject at the present time.

When price is the principal, or worse yet, the only criterion, quality of work and amount of detail obtained will suffer. Many, if not most, engineering jobs are incapable of finite definition in advance of development. Lowest price will surely result in an inferior and inept produce with a minimum amount of detail. Detail on a bridge job, for example, can be done by the consultant designer when included in his fee or by the fabricators. But if left to the fabricators, additional cost will follow when the work is checked by the owner.

For competitive bidding, prequalification of competent engineering consultants is an absolute necessity. However, I am sure you recognize that, at best, prequalification is difficult, because of the problem of quantifying experience and performance except by judgment. Competitive bidding will result in having to accept bids from inferior and inexperienced consultants.

Even though bidding in the early rounds may lead to accepting bids from the less experienced and more poorly qualified firms, in the long run bidding gives an undue advantage to large consultants, since small consultants have no extensive past experience upon which to draw in a bidding situation. In addition, large consultants can afford to take a few losers which would drive the smaller firm out of business.

The cost of construction and maintenance will increase substantially over the life of a project for which design is cheapened by bidding. Design is a very difficult item to define. Unless specified, multiple studies on a low bid would not be made to arrive at a good economic decision. If multiple studies are required, the depth would be minimal, making them virtually worthless. There would also be a strong tendency to use previous designs and standards, even though they may not be cost effective and efficient. Even in original designs, approximate methods and simplified details would be favored. Cutting engineering costs could dramatically increase construction costs.

It has been alleged that bidding is necessary to make consultant procurement competitive. Negotiated consultant procurement is competitive, if you are willing and able to make the required reviews and investigations to insure the best quality of work for the least applicable cost and then go on to the next consultant if you are not satisfied with the negotiated results from the first.

At present, under negotiated agreements, the consultant tries his best to satisfy the client because he knows his future work depends on it. Legal actions or claims seldom occur on negotiated contracts, whereas they could become a way of life on bid contracts when the consultant knows that he only has to be low again to get the next contract.

For these reasons, among others, bidding will not necessarily stop political abuses. It will only shift any undue political influence from the selection process to contract administration. A bidder with political ties can bid low with advance assurance that he will be taken care of on contract adjustments.

To repeat, there are a few times when competitive bidding under carefully controlled and selected conditions could be an advantage to the owner. In all other cases, negotiated contracts using the principles of the Brooks Act are by far the best. Even using the negotiation approach, however, and applying the cost plus a net fixed fee means of payment, clients have placed some arbitrary limitations on the fixed fee portion which deserve mention.

Net fixed fee as defined in FHWA Policy and Procedure Memorandum 40-6 is "a dollar amount established by negotiation (and not by application of percentage factor to estimated costs) to cover the consultant's profit, miscellaneous expenses, and other factors that may be considered under the applicable regulations and that are not paid for otherwise."

I have no argument with this definition, but if it is good enough for the PPM, why isn't it good enough for FHWA and some of the states? About the first thing that FHWA did after drafting the PPM was to issue to their field offices a set of curves to be used as a guide in determining the acceptability of fixed fees. The curves have become the maximums and limited to profit - regardless of all the good words in the PPM definition.

There are several items inherent to conducting a consulting business, not the least of which is the cost of borrowing money to finance the work until progress and retained percentage payments are made, which are not allowed under the heading of overhead. These will vary with the consultant and the project. It is the obvious intent of the PPM to include these costs along with profit as a part of net fixed fee. My point here is that the client should pay no more than is proper, but at the same time he should recognize the costs of doing business as a consultant and pay accordingly.

I have already mentioned the excessive use of standards as a natural fallout of the bidding for contract process. From my experience on both sides of the table, the proliferation and indiscriminant use of standards by both in-house professional staff and consultants can be a cop-out leading to mediocrity. Standards have a definite role in engineering design to establish parameters for minimums and uniformity. But, I am sure we have all seen the results of blind application of standards to engineering solutions which have produced unsightly, inefficient, and costly end products.

The refusal of designers and FHWA reviewers to accept reasonable deviations of shoulder standards on low-volume rural roads and bridges recently led AASHTO to adopt new standards which, in turn, were rejected because of threatening safety problems. The result is a foolish application of standards which in no way can be considered cost effective or assure any significant improvement in safety.

In my home state of Washington, we have an example in the wide open eastern section of the state where the use of acceptable but minimum standards for horizontal curves at an interchange produced an unsightly result which had to be later hidden by landscaping. There was plenty of room to ease the curves and do the job right.

I understand it took seven years to obtain approval for the counterflow bus lane on the Lincoln Tunnel where "standards" were reduced to eleven-foot lanes, no shoulders, a New Jersey barrier on one side, and opposing traffic on the other. Plenty of reason to be concerned about the wisdom of the engineering judgment proposed, but the end result is a safety record better than the Shirley Highway in Virginia where all standards are by the book.

One last point that I wish to make and recommend for consideration when hiring a consultant: Be sure your scope of work requires the engineer to make and be responsible for an independent check of his work to provide a quality design -- then be sure he does it and be prepared to pay him for his efforts. It is costly and time consuming for the client to also make a detailed check of a consultant's work. The consultant must be made responsible for his work and held to it. Spot reviews by the client to be sure that scope is satisfied, progress is timely, and product is as desired are in order -- a detailed review is not.

In summary, I beleive there is a proper and useful role for competent professional consultants in the development of programs for both government and private agencies. They can efficiently supplement your own engineering staff, they can brirg new and different ideas and solutions to problems, and, when properly administered, can do so in an economical, efficient, and satisfactory manner. I do not believe, however, that you can count on it's always happening quite that easily and instead you must recognize that it takes good management on the part of both the client and the consultant to consistently achieve quality results.

PART 2

WHERE DO WE GO FROM HERE WITH BRIDGE LOADINGS? A PANEL DISCUSSION

Moderator: Heinz P. Koretzky, Pennsylvania Department of Transportation
Panelists: James W. Baldwin, Jr., University of Missouri at Columbia
Robert C. Cassano, California Department of Transportation
Paul F. Csagoly, Ontario Ministry of Transportation & Communications
Theodore H. Karasopoulos, Maine Department of Transportation
W. Jack Wilkes Federal Highway Administration

INTRODUCTION: Mr. Koretzky

When bridge engineers gather and discuss loadings and their effects upon bridges, do you ever wonder why a bridge withstands loads and overloads? Are excess safety margins and redundancy expendable?

Is structural longevity due to efforts by the designer, or improved by the quality of construction, the sophistication of inspection, the soundness of maintenance, or due to the absence of accidental natural forces or overloads? Or is the length of bridge life or probability of failure influenced by those factors?

Did engineers consider the "total life cycle", the "life span" of structures, and are they expressing thoughts using the terms "structural longevity" or structures "useful life" when assessing engineering factors?

And on the other hand, when a structure fails, do they mention structural uncertainties or accelerated deterioration?

Also, when discussing such premature structural demise, do they discuss "risk analysis techniques", or do they blame "bridge loadings"?

This panel of experts will address themselves to the bridge loading issue and give their engineering opinion or their philosophical expression to the main topic, "Where do we go from here with bridge loadings?"

I asked each panel member to express his thoughts concerning the main topic for about five minutes. After each panel member has taken his turn, I will again ask each member to amplify his statement or expand on it for about three minutes. After each panel member has taken his turn we plan to ask you gentlemen in the audience to ask questions specifically addressed to a panel member. I now ask Dr. James Baldwin to take the rostrum.

Dr. Baldwin: I claim no ceremonial powers for looking into the future in terms of where we are going. So the remarks I make will have to be based on my experience, and that experience basically limits me to making comments about what I think will happen in this country. However, I suspect that our situation here is not too different than that in many other parts of the world.

In regard to where we go from here, I think I can sum that up in one word - up. The pressure for increased allowable loads is here to stay. An 80,000 lb. gross vehicle weight is accepted in many of our states. There are a number of states that have grandfather clauses allowing 86,000 lbs. During this conference I have seen pictures on the screen of triple trailers and heard talk of 86,000 lbs. or even 106,000 lbs. However, as I look into my crystal ball I see pressures to change all of the single axles under those trailers to tandem axles. There is certainly going to be pressure for very heavy loads.

Now what we have to think about is what we are going to do about this. Whether we like it or not, if we are realistic, we will recognize that we, the engineering community, will not set the maximum load limits on our highways. Decisions of this kind are political decisions, and they will be made by politicians. It is our job to keep the political bodies informed concerning the engineering consequences and costs of those decisions and to develop ways to cope with those decisions once they are made. The interests lobbying for increased loads have valid arguments, and if we are to have a proper influence on the political decisions concerning allowable loads we must have equally valid arguments concerning the highway system costs of heavier allowable loads.

It is relatively easy for us to estimate the increased cost of constructing new bridges to carry any increased allowable load. The difficult problem is to estimate first, the effects and finally, the cost of allowing heavier loads on bridges already in existence. This is an entirely new ball game for us because it puts us in a position of trying to accurately predict failure. Unfortunately, there is a great expanse of gray area between the load or number of cycles we know a bridge will carry and the load or number of cycles we know will cause failure. In fact, this situation even puts our credibility on the line. Except for a few new bridges that have failed, we have seldom had our credibility challenged. But right now there are overloaded trucks out there on the highway testing to see whether or not the bridges will really fail at the loads we say they will.

Mr. Cassano: I think that it is obvious from discussions at this conference that the efficacy of the AASHTO HS20 vehicle is being challenged pretty strongly. For the first time in my memory we had an agenda item at last year's AASHTO Bridge meetings to consider including as AASHTO HS25 configuration in the bridge specifications. We heard a talk this morning about the Ontario code which our next speaker may cover in more detail. Here again Ontario has abandoned the AASHTO vehicle. I have just finished presenting a paper on the California procedure where we felt it necessary to include a different load configuration for design. I think the reasons for this are fairly obvious. There is definitely a trend towards increased loads, and the load factor design method influences the structural capacity you get. Also, I think that this whole movement has been given some impetus by energy concerns. The truckers say that it is more efficient to haul with heavier vehicles, and they are probably right. In Wyoming they are going to be hauling coal and the shippers are going to want to use heavy trucks to make that economical.

The difficulty of choosing an appropriate design load also becomes obvious when you look at the variation in the possibilities we have talked about this morning. The new Ontario loadings that were chosen represent something considered to be typical there. Professor Kostem showed some pictures of very heavy dollies. All those wheels with close axle spacings do a lot to help pavements, but they don't do much to reduce stresses in a bridge because you still end up with a very heavy concentrated load. We saw the California vehicle, and it doesn't look like some of the other proposed loadings. We will have a hard time agreeing on what kind of vehicle to use in design. I suspect it will have to be a family of vehicles or a series of vehicles rather than an individual one. It could perhaps be a combination of uniform loads and concentrated loads.

The problem of nonuniformity creates problems for people other than bridge engineers; people that design trucks, for instance. They look at the weight law and decide how to get the most load on a truck, i.e., they design for optimum axle spacing. Interstate transporters have to be horribly confused when they come to state boundaries and find that all of a sudden the rules are changed. If they have not been alert and checked state laws ahead of time they may sit on the border for quite awhile before they get into some states. Those charged with enforcement, we should bear in mind, have to have something relatively simple to enforce. They don't want to have a computer on their scales to decide whether or not the truck being weighed is legal.

Our goal though, despite all of these difficulties, must be to develop, first of all, some kind of uniform policy on extra legal loads as well as legal loads. We need some kind of formula or criteria that will control weights of axle spacing and weights of axle groups. We need some uniformity from state to state on physical dimensions. Some states allow triple trailers, some don't. California happens to be one that doesn't, but Oregon does. That causes us some problems. There are a lot of other details about trucks that vary form state to state. For instance, the kinds of suspension systems that are used. There are some that we don't think are reliable. You may have multiple axles, but if the suspension system doesn't do a good job of distributing the load, you can end up with severe concentrations which are very detrimental to bridges.

I have explained how tough the problem is. Despite difficulties, I hope we will end up developing an idealized vehicle or family of vehicles, or a loading system that can be used uniformly from state to state. I think that we are beyond the point where one single HS anything is going to be the solution. I am not in favor of moving into or continuing with the HS series. We must move into something a little more realistic and a little more sophisticated.

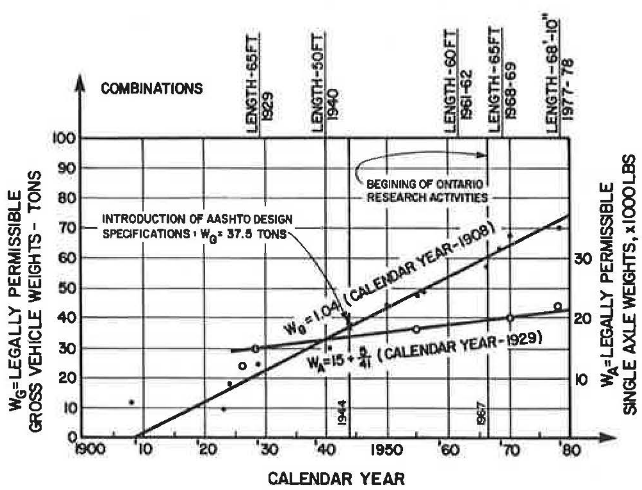
Mr. Csagoly: Being from outside this country, I hope you have started to appreciate what is happening in Ontario, but I am not trying to imply that you should initiate the same thing. During this conference you heard six papers in various sessions where we discussed our new code and new design load. These are based entirely on a limit state approach; any other as being exclusive to our thinking. I would like to give you a short story as to how we got there.

One thing which is very specific to Ontario is that we are trying to cooperate with the politicians and the truckers as much as possible. It is a very familiar thing for us to hear that the loads are going to be set in the United States by the politicians. I recall from our experience that the best way to prevent this from happening is to meet them half-way.

A few figures out of what you have already heard in the last couple of days: we are permitting 140,000 lbs. or 70 tons on our highways in comparison with your 72,000 lbs. There is a 117 percent difference. The calculations would indicate that our loads cause force effects 55 percent above yours. At the same time, you also heard that we are expecting a savings in structural material on the average of 5 to 10 percent which could place our design considerations at a level of HS18. I say on the average, because some members, some components, will come out stronger by using the Ontario code, some will come out weaker.

How did we get here? Canada, being so close to the United States and so connected to it by geometry, geography, trade and technology, has used the AASHTO code ever since it was first published. As shown in Figure 1, we made some historical research as to the permissible weights in Ontario, and it appears that starting from 1908 there was a little over one ton per annum increase in permissible gross weights. In 1944, when the AASHTO code came out and the 72,000 lb. load was established, this curve or straight line, which is of course an average, gave something like 75,000 lbs. At that time there was a reasonably close relationship between design and permissible weights.

Figure 1. Trends in legal axle and gross vehicle weights in Ontario.



In 1967 we had a 58 ton permissible weight. At that time I was a designer and very frankly, had not been aware of actual traffic load. I can safely say that most designers were in the same boat. We simply did not know that the loads on the highway were higher than bridges were designed for. I guess that those who knew, tried not to care. At the same time, there were further applications for additional loads and that was the time my ministry established a group for structural research work. Certain efforts were made, load surveys were carried out, and bridge testing was initiated. I can say that the major reason we feel confident in permitting these high loads is that through our bridge testing program we have been able to establish the actual, or close to the actual, load carrying capacity of HS20 designs. We have also established that most bridges of HS15 design can carry our loads.

Mr. Karasopoulos: Not having the resources in Maine to do as extensive a job as California or Ontario in researching bridge loadings we took a more or less crude approach. Since we are dealing with judgmental and qualitative issues maybe this approach will suffice until we can take advantage of the additional information on this subject that is sure to develop.

Starting in January of this year the Maine Department of Transportation is designing all new bridges for an HS25 loading. We don't, however, see this as a long term objective. We agree with others who have expressed opinions that some kind of new configuration of loads be developed. We took this step in order to react to what was happening in our state and increase our design loads for new bridges.

In 1974 the State Legislature enacted a law that placed legal loads as high as HS30. This law was later repealed by a public referendum, but a new law that followed in 1975 placed legal loads well above the HS20 level.

During all of these legislative activities we conducted studies that indicated that we can design new bridges for an average increase in cost of 4% for an HS25 loading and 7% for HS30, versus the HS20 loading.

Did we make the decision to design new bridges for higher loads because we were afraid the HS20 bridges would not handle the new legal loads? Not really. We tried to take a long range look at the future, and our final decision was primarily based on cost-benefit considerations. The following factors were taken into account:

1. Obviously bridges are a long term investment, and present truck weight histograms do very little in predicting what the loads will be twenty or more years from now.

2. The history of legal loads indicates at least a trend for increases. In the case of the State of Maine it has been more than a trend since our legal loads increased by about 64% in the last 30 years.

3. It is relatively far less costly to provide additional capacity to a structure in the original design stage than to try and do so after the bridge is constructed.

These are the facts that were considered and, as stated previously, the decision to design for HS25 was based on cost-benefit considerations plus also the fact that under present AASHTO criteria our legal loads exceed HS20.

That brings me to some comments about present AASHTO Specifications. There are two basic changes that should be addressed in the near future. The first one is the configuration of the loads to be used for designing the bridges that will be in service 20 to 40 or more years from now. I suggest that the loads should be higher than HS20. Secondly, we beleive that present Distribution Factors for multi-beam bridges are conservative and do not accurately reflect the inherent strength of such structures. Therefore, we ask the question, "How long will we be designing multi-beam bridges one beam at a time without giving credit to the superstructure acting more as a unit?"

Even if everyone agreed with me on these two general points, which is unlikely, it would take a long time to address these issues in the specifications. Needless to say, we are dealing with complex and controversial considerations. But in the end changes in the specifications alone are not the total answer. No matter how well you try to predict the loads of the future, you can still be wrong by a great margin.

The surest way to produce bridges that will serve for many years is to use cost effective design procedures. We consider the adoption of the HS25 loading to be such a procedure. We also feel that certain major design parameters are set too quickly in the initial stages and are not reconsidered after development of a final design. We believe that after you have selected your loads, fatigue cycles and all of the other parameters, and have cranked out a design you should sit back and take a long qualitative look and re-examine some of those parameters. Try to figure out what will be the most likely part or parts of the structure to fail first if the bridge gets overloaded.

Often the load carrying capacity of a bridge is limited by small details, such as partial length coverplates or the non-judicious use of stiffeners, that can be avoided or improved for a relatively small increase in cost.

In conclusion, I believe that we need certain changes in the specifications to provide for realistic loads and distribution factors. But more importantly, the bridge designers and administrators must sharpen their skills in order to produce cost-effective bridges that will respond to the demands of the future.

Mr. Wilkes: One approach to the problem of increased vehicle design loads is to compare our present design criteria with current legal maximum loads and with design criteria used in other countries.

Most of you are familiar with our conventional AASHTO HS20-44 design vehicle and the equivalent land loading shown in Figure 1. These criteria are simple to use and, except for the 32^k single axle loads, the design vehicle is typical of the usual truck configuration found on the highways today. The alternate loading was introduced for the Interstate System in 1959 to strengthen the short-span stringers and floor beams.

Figure 2 shows the bridge formula and the graphic presentation of the provisions of the 1974 Amendments to the Federal-Aid Highway Act. This bridge formula which was supported by both AASHTO and FHWA was derived from the AASHTO Road Test results. The formula was also theoretically tested by applying loads which would conform to the formula to typical steel girder bridges. It was determined that these loads would not overstress a typical H-15 bridge by more than 30 percent. It was also determined that these loads produced less moment than the HS20 design vehicle so long as the gross vehicle load limit was less than about 90,000 pounds.

The fact that the act increased the gross vehicle load allowed on the Interstate System to 80,000 pounds received the greatest attention. However, there were some beneficial aspects of the act.

1. Better distribution of the wheel loads was required. The old law simply gave a single axle, the tandum axle, and the gross vehicle. This has a distributing effect.

2. The permitted axle loads included all toler-

ances. For example, those states with 18,000 lbs. single axle with 10% allowance really didn't get an increase in the single axle.

3. One-half of all states already had weight limits as great or greater than these provisions under the grandfather clause. And not all of the remaining states have taken advantage of this permissive increase.

Figure 3 includes six of the twelve axle configurations of the Ontario Bridge Formula discussed here. These are typical vehicles taken from the literature. Their heavier vehicles gross up to 70 tons.

The British HA loading shown in Figure 4 is similar to U.S. lane loading but is substantially heavier. The HB unit loading apparently governs short-span design just as the truck loading governs in our practice.

The loading for France shown in Figure 5 uses a formula and an alternate of heavy vehicles which produces live load moments greater than even the British loading.

As shown in Figure 6, the German (Federal Republic) Class 60 loading is similar to the AASHTO alternate vehicle load for the principle lane. The adjacent lane loading is significantly reduced from the main design load.

If we plot the moments which are produced by these specified loadings for different span lengths, we can see in Figure 7 the substantial difference for each of the several countries. This shows that the Germany Class 60 load is only slightly above AASHTO, but that the France and Great Britain loadings are very nearly double AASHTO in span ranges above 100 feet.

Figure 8 shows how the loads are concentrated for the several design vehicles. This shows that the AASHTO design criteria is comparable to other countries for the short vehicles, but for the longer span conditions, all design criteria greatly exceed our present practice.

We must conclude that:

(1) The allowable vehicle loads in European countries are much greater than permitted in the United States and comparable with those permitted in Canada (Ontario).

(2) The Eurpoean Common Market countries must have a very difficult enforcement problem; much like the problem here in the United States between the various States.

(3) Since each State has different weight limits, there could never be a single design vehicle that would fit each State's requirements. For example, the 1974 act that increased the vehicle weight limits on the Interstate Highway System affected only 26 States. The other States already permitted equal or greater weights under the grandfather provisions of the original act.

From other evidence submitted it can also be assumed that the vehicle manufacturers have the ability to produce vehicles that can be loaded to the maximum permissible limit. I am convinced that an increase in design vehicle size would be an open invitation for an equal increase in truck weights.

The Federal Inter-Agency Committee for "Vehicle Size and Weights After 1980" is preparing a study on the economic effect of increasing both size and weight. The optimum weight of the vehicle in the study is determined to be 120,000 pounds. The study largely ignores the devastating effect that the larger vehicle would have on our existing highway system.

It is also foolish for the bridge designer to think that he can design bridges, or highways for that matter, that will have excess load capacities for future increases. As former Redskin Coach George Allen used to say, "The future is now."

Figure 1. AASHTO HS20-44 loading.

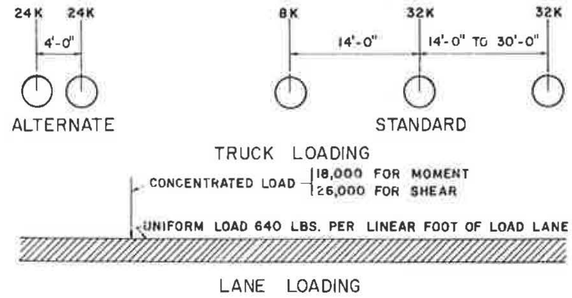


Figure 2. U.S. Bridge Formula with Graphic Presentations of 1974 Amendments to Federal-Aid Highway Act.

Section 127 Title 23

$$W = 500\left(\frac{LN}{N-1} + 12N + 36\right)$$

Where

W = *overall gross weight of any group of two or more consecutive axles to the nearest 500 pounds*

L *distance in feet between the extreme of any group of two or more consecutive axles*

N = *number of axles in group under consideration*

Maximum weight not in excess of 80,000 pounds

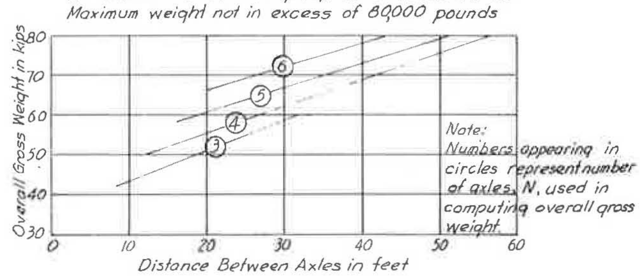


Figure 3. Ontario, Canada, Bridge Formula and some axle combinations.

$$W = 20 + 2.07B_M - 0.0071\overline{B_M}^2$$

W *: Gross Weight of Axle Group (kips)*

B_M *: Equivalent Base Length (ft.)*

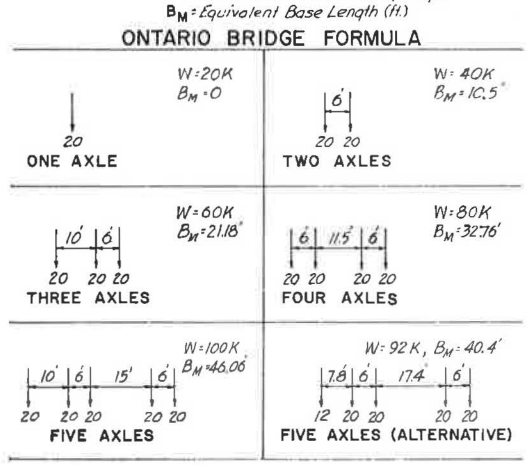


Figure 4. British HA and HB loadings.

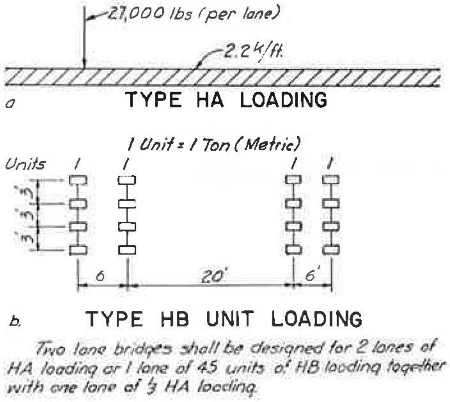


Figure 5. French Bridge Formula with A and B_c loadings.

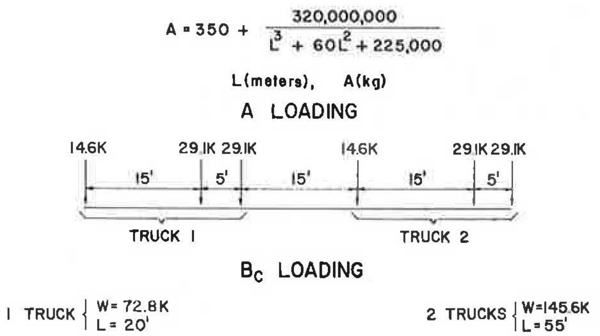


Figure 6. German Class 60 loading.

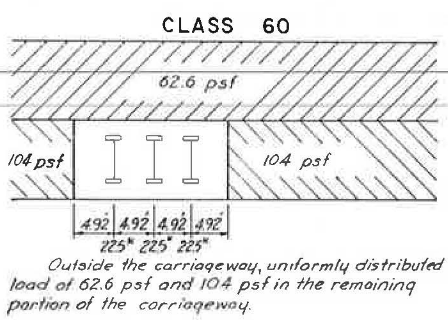


Figure 7. Comparison of liveload moments on simple spans.

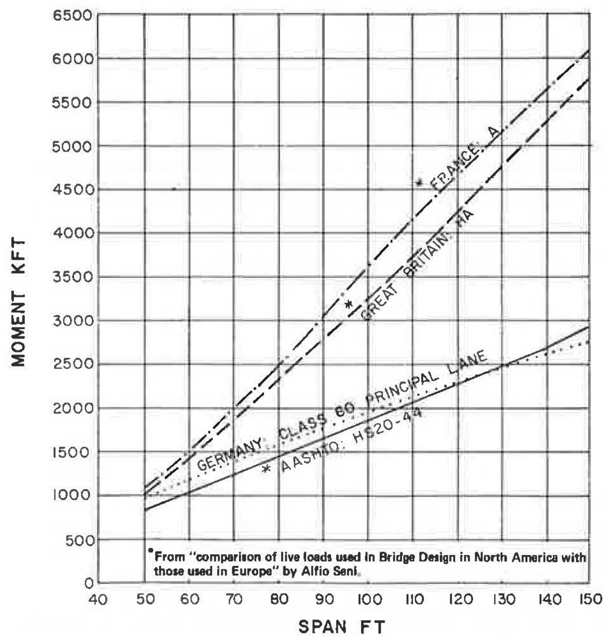
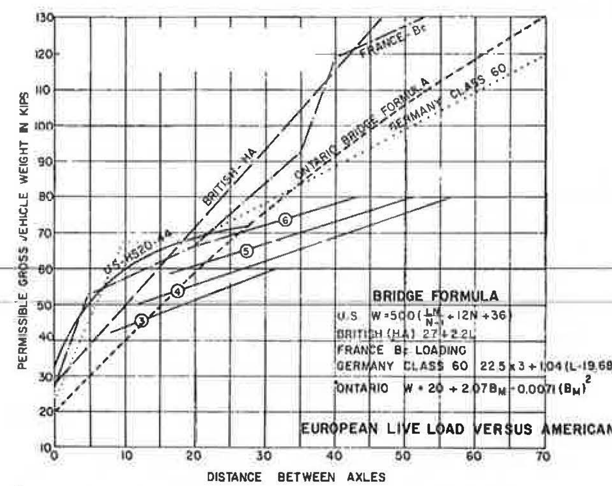


Figure 8. Comparison of load concentrations for design vehicles.



*Distance B_M is the equivalent base length over which the gross weight is distributed. In reality, the distance between axles is less.

Mr. Koretzky: Now we are going to our three minute period each. I now call on Dr. Baldwin.

Dr. Baldwin: I previously commented on the difficulty we are going to have in estimating the costs likely to accrue from increased vehicle weights before our political bodies make their decisions. I would like to follow that up by projecting what I think will happen after the decisions have been made. I am still presuming that there are going to be increases in allowable loads, and I think that the increases will not be a one time event. It seems to me that there will be continuous pressure for increased loads. After a decision to increase allowable loads has been made I see the engineering community faced with the task of trying to squeeze the longest possible life out of old bridges that are carrying loads much heavier than we would like to see. To do that we are going to have to improve our inspection techniques. Largely at the urging of Stan Gordon of the Federal Highway Administration we have made substantial advances in bridge inspection during the last few years. Even so, the current state of the art is woefully inadequate to ensure adequate safety while squeezing the maximum possible life out of these overloaded old bridges. We must develop a huge increase in our inspection capability. I think that ultimately we will be forced to some sort of routine proof loading in order to provide reliable results under these conditions.

Mr. Cassano: I kind of agree with Dr. Baldwin that engineers are not the ones who are going to decide what happens to future vehicle weights. It is fairly obvious that it will be a political decision and maybe that is proper. It is not likely that engineers will control the economic conditions and the environmental conditions that will result from decisions on heavier loads. What then is the appropriate role for the engineer? I think that our appropriate role is to apprise the decision-makers of the consequences of what they do. One major consequence of increased loads is increased costs for highway facilities. I might mention that there is a task force working in AASHTO headed by Roger LeClerc of Washington State that is charged with coming up with cost figures related to increased legal loads. In the highway area this relates to existing pavement life and to changes in design criteria for new pavements. For bridges we are trying to break the cost considerations into three elements. One would be the maintenance costs attributable to increased loads. That to me is the most difficult element to assess, because when you look at maintenance records a lot of costs are not related to loads at all. Things like painting, replacing expansion joint materials, replacing frozen bearings, etc., don't really relate to loads. The major element of load related cost is the cost of strengthening bridges that are adequate for current loads but would be inadequate for increased loads. Here we are going to rely on Stan Gordon's vast inventory of information that state engineers have been submitting to FHWA for years. We hope to extract some cost information from that file. The third element relates to the cost of new bridges. You can increase the design load on new bridges without affecting the cost very much. I wouldn't argue with Mr. Karasopoulos' figure of 4% at all.

I would say to Jack Wilkes that if our only problem was legal loads, then I think our AASHTO design load would be great. The real problem is not legal loads, but permit loads. Permit loads have been moving in California for 30 years and there is no way to cut them off. They are going to continue to grow both in zize and frequency. I will stick with my original position that we do need an increase in bridge design loads. I take this point of view, even though it may invite additional demands by truckers for load increases. You can't ignore the fact that the loads are increasing whether or not we change our design criteria.

Mr. Csagoly: I am not trying to defend Ontario's position. All I am trying to say is that for all practical purposes, the loads which are at the present time using the Ontario system, have been doing so for at least 10 years. We do not see any sign of distress in our system due to loads. We were losing bridgès at a certain rate, comparable to yours, which is something like 250 bridges out of 550,000 a year in the United States. For some years we used to lose about 12 in our Province. The number increased later to 15 and then to 18. We now have introduced a program by which all bridges are inspected and evaluated, with the hopeless ones being taken out of service. Last year's product reduced to three bridges. I would suggest that at a time when you are building about 6000 bridges a year and losing only 250, you should perhaps concentrate on the 250.

Coming back to the increase in design load: I would like to think that our design load of 156,000 lbs., for all practical purposes and considering all the factors, is only at an HS18 level. I do not really see any reason to go higher. This particular question was discussed at the last central region meeting of the AASHTO bridge committee, of which I am a member, and the motion for increase had been defeated. The main argument was that, in both the U.S. and Canada, the highway systems are more or less completed. Introduction of an HS25 or greater design level at this late stage in the development of the highway system is really defeating the purpose; it is only calling for problems. I am sure that the slides shown by Mr. Wilkes gave full justice to the Ontario condition. We have to distinguish between what is permitted on the road and the design load as the two are not the same. There is a 10 ton difference between them.

Regarding special permit consideration, we are using a set of guidelines and are at this moment in a state of completing them. We are trying to put all the special permits requests into three to five categories and by using a limited number of tables we expect to have this problem resolved soon. The way our policy stands, we would permit the P11 and P13 Califronia loads on our highways without much hesitation.

Mr. Karasopoulos: I would like to expand on the cost-effective design concept a little more and give you a couple of examples because I think it may be one of the most important factors in providing for adequate future bridges.

I said that sometimes we set the parameters for designing a bridge a little too early. After the bridge is designed somebody ought to sit back and take a long qualitative look at the results and try to figure out the most likely parts of the bridge that would fail if the structure is overloaded. Often the load carrying capacity of a bridge is limited by small details that can be avoided or improved for relatively little cost. I would like to cover two examples of cost-effective design that tend to illustrate this point. First, we analyzed a case where the fatigue capacity of a particular $500,000 bridge could be increased from 100,000 to 2,000,000 cycles by merely increasing the length of the negative moment coverplates by four feet on each end. The extra weight of steel involved was only 1,000 pounds. A great increase in capacity for minimal cost. Secondly, since 1965 we have desinged all our medium span welded bridges with heavier webs so that intermediate stiffeners are not required. We did this long before fatigue specifications started to reduce allowable stresses for girders with stiffeners. By substituting extra metal in the web for the labor required to attach and fit stiffeners we saved money and provided a cleaner structure with added fatigue life capacity.

Mr. Koretzky: The floor is now open for questions. Please state your name and affiliation and direct your question to a panel member.

Mr. Sweeney, Canadian National RR: I would like to address my question to Mr. Cassano. Back in the 1930's D. B. Steinman tried to improve railroad loadings with an M loading which at that time represented locomotives better than Cooper's loadings. He didn't succeed, I presume, because of vested interests and inertia in sticking with the loading that they had. At this point in time real locomotives and cars don't look anything like either Cooper's or the M loadings. I feel that if you change your loadings to some other system that you find represents today's loadings, within 10 years it won't represent them anyway. I was wondering if there was really some other reason for going to all the trouble of changing design lengths rather than simply stepping up the absolute load.

Mr. Cassano: I don't think that our main motivation was to basically change the conventional design load. We're still using HS20 loads for checks at the working level. What we were trying to do was to get bridges of nearly equivalent strength using the higher stress level that is commonly allowed in actually operating the highways. The load that we introduced is representative of those loads we've been issuing permits for. There could be an infinite variety of trucks on the road. Our goal should be to use a design load that is representative of the maximum loads for axle spacings that actually exist. By building into our design procedure a check at the operating level we're assuring ourselves that we have uniform capacity at that stress level. Basically, if we're concerned only with legal loads the HS20 loading is fine, and we use it to check fatigue and deflections. For the operating level which deals with permit loads, we thought it desirable to kick the load up to a realistic level and check capacity at a higher stress level. It doesn't really change the cost of a new structure that much.

Bernard Haber, Hardesty and Hanover: With the exception of Mr. Wilkes most of the panel was in favor, I believe, of increased highway loadings. I also noted that you gentlemen mostly talked about highway loadings with regard to highways on the interstate highway system. Somewhere along the line the trucks will get off the interstate highway system. They will travel in our urban and our rural areas, which probably contain more than fifty percent of the road mileage in the United States. The imposition of particular heavy truck loads on these local areas, N.Y. City, Chicago, any city, is a major problem. How would you deal with increased loads on these local areas, and what do you expect the effect of those increased loads will be? Dr. Baldwin, please.

Dr. Baldwin: First of all, I am not particularly in favor of or against increased loads. I am trying to look at what I think is going to be reality and how we will handle it. I think that this problem is one that we face for all bridges and not just for the interstate system. In fact, we have this problem already with our rural bridges. It is a rather extreme case in that we have bridges that were built for horses and wagons. These bridges are carrying heavy agricultural equipment that is equal in weight to some of the interstate loadings. I don't see that we really have a difference in problem between the interstate system and the off-interstate system. Funding of the solution is again a political problem and must be addressed by our political bodies.

R. G. Moore, County of Elgin (St. Thomas) Ontario: We are very familiar with the problems caused by triple axle trailers. You begin to wonder when you see a triple axle trailer grossing 70 or 75 ton headed over a County Road System Bridge which probably shouldn't even carry a car.

I would like any panel member to comment on the overload situation which often occurs on triple axle trailers when the front air lift axle is about 10-12 feet ahead of the back tandem. This air lift axle is supposed to be down when the trailer is loaded. The other day I saw a loaded trailer, the driver of which hadn't bothered to put the air lift axle down. Now, I am sure that this creates problems with your axle calculations for bridge loadings, for suddenly you are in an extreme overload situation. Has anyone considered these monstrous problems?

We know that truck weights all over are going up, even in our own municipality every trucker looks at the load he can legally carry. Every 15 yard tandem truck box is filled to overflowing because the trucker doesn't want to make that extra trip.

Mr. Karasopoulos: Our largest equivalent HS loads are as a result of this triaxle configuration. We have a four axle vehicle which is allowed in Maine, mainly in the forest products industry, which has a triaxle in the rear. Those axles could be four to four and a half feet apart, thus in a nine foot space a load as high as 69,000 pounds is allowed for those trucks. This 69,000 pounds is more than is allowed by the same law for a three axle truck. There is a provision in the law that this kind of a truck would be phased out by November 1979. I guess we will find out how that is going to work, because they are still prevalent on the highways. This temporary provision to allow such a high limit on a triaxle is the most critical axle configuration that we have. It adversely affects short span bridges, but every bridge has components in it that are susceptible to damage by very high concentrated loads.

Mr. Csagoly: I made some reference to the fact that a certain number of bridges each year were lost. The record is that on the primary system in Ontario we did not lose a single bridge in the last 12 years. All the bridges lost on the municipal system, were analyzed: the particular truck configurations which are almost exclusively responsible for the demise, are the two and three axle gravel trucks, which are not trains.

Mr. Wilkes: I think that is a very real problem, and we see this in the attempt to enforce load limits at weigh stations. The truckers have extensive citizen's band radio networks going so that news of a new weighing station or enforcement gets to the truckers pretty quick. They can find alternate routings. Quite frequently the trucker who knowingly has an illegal load will deliberately take his vehicle around weigh stations and put this vehicle on the secondary system that is certainly not designed for it. I mentioned that the bridge formula that was included in the 1974 act was theoretically tested on an H15 bridge because the best information that we had was that most of the 270,000 off-system bridges that were in service were more than 40 years old and were designed for H15 load or less. We tested this bridge formula load distribution and determined that it would not overstress steel stringer bridges by more than 30 percent. This accepts the fact that an infrequent load would not collapse the bridge or reduce its serviceability, and hopefully that you would not have the frequency of loading that would develop fatigue cracks or fail in that respect.

James Porter, Louisiana Department of Transportation and Development: I would like to direct my question to Ted Karasopoulos. You mentioned that you tried to project into the future a study of the past legal weight limits to estimate future weight increases. Typically, I think we attempt to project 20 years into the future for traffic volumes to decide how elaborate to build our bridges to begin with. It occurs to me that we should be projecting 20 years into the future for design truck weights. I see that the panel is devoid of a member from the truck manufacturing industry that builds the vehicles that carry the increased weight. Did you give any consideration to communication with vehicle manufactures to obtain their input? I read ten years ago where a Massachusetts Institute of Technology study was investigating methods to make a 24,000 lb. steering axle more maneuverable for a truck driver. When manufacturers provide a vehicle with this capability, surely you can expect trucking interests to buy them. When the trucking interests purchase this equipment they put it into operation and they are not concerned with how we highway engineers are going to accept it or what it may lead to. Our only communication seems to be in the presence of our legislators in confrontation with the trucking interests rather than trying to settle many of our problems in advance. I don't think legislators and governments act, they react to the strongest argument. I think highway engineering should be a two-fold process; not only the building of a facility but the utilization of it. It seems we have attempted to avoid here today the utilization or operations side of the picture. Would you address this with some thoughts that you may have had in your attempt to project into the future for vehicle weights.

Mr. Karasopoulos: I would like to reverse your statement about action and reaction. So far we are really reacting and not acting. We are reacting to increases in legal loads with the steps we took to design for higher loads. Maybe we should be looking more into what is planned for the future, but we don't know of any clear cut means of accomplishing this. This is the reason that we emphasize the concept of cost-effective design. Provide additional capacity to a bridge in the original design stages if this can be accomplished for a reasonable cost. This is probably the best hedge against what may happen in the future. I doubt that you will get where you want to go by talking to manufacturers, they probably react to legislation in the design of trucks. So far we haven't coordinated with truck manufacturers to the depth that you suggested. We probably should.

Mr. Jackson Durkee, Consulting Structural Engineer: In the AREA bridge specifications committee we are presently, and have been for some years, struggling with the problem of revising the bridge rating provisions. The rating rules as they presently stand suggest that loads beyond the given design maximum should not cross the structure regularly; however, loads are not actually restricted until they exceed the rated maximum. As far as I know, railroads are free to run a very heavy train across a bridge that has not been designed for it, any number of times, provided that member stresses do not exceed their ratings. Now, I am interested to know whether in the highway loading situation we have a similar problem. I would like to ask Mr. Cassano whether a trucking company that wanted to run its trucks at the absolute legal-maximum weight, could run them indefinitely across a bridge designed for lesser loads, as long as the load capacity rating of the bridge is not exceeded.

Mr. Cassano: There is some attempt made to limit frequency of permit loads. For one thing, our policy is that we do not issue permits for reducible loads. That is, if you are hauling dirt, potatoes, oranges, anything that can be easily broken down, you are limited to legal loads. The definition of "reducible" does get fuzzy because a large piece of equipment can be dismantled. We apply some judgment in deciding whether or not a particular load should be reduced. We have had some occasions where we have allowed a number of trips under one permit. A recent example was in the delivery of large pieces of pipe where there was a limited number, maybe 50 trips involved. There is no limit on the number of trips that can be made with legal loads.

While I have the microphone I would like to make my position clear on the issue of increased loads. What I have been advocating is another performance check on bridges as part of the design process rather than an increase in loads in general. The problem is that under real traffic we are often operating at a high stress level, and we don't have a systematic procedure in the design specifications for a performance check of that condition. To make that performance check you have to introduce an appropriate loading to go with the higher, operating stress level. I wanted to emphasize that point once more.

Mr. Wilkes: I want to strongly endorse Bob's comment. I am not trying to discourage load factor design or more sophisticated methods of analysis, or actual load distribution research and application. I didn't want to put a title on it that this is a heavier vehicle and invite changing the load limits on our bridges. I endorse this idea that California uses as a method of analysis using as a basis the HS20 vehicle.

Mr. Koretzky: We have reached the end of our self imposed time constraint. Speaking on behalf of the Bridge Engineering Conference, I appreciate your coming. To our panel I would like to express our thanks to Dr. Baldwin, Mr. Csagoly, Mr. Karasopoulos, Mr. Cassano and Mr. Wilkes. The session is adjourned.

PART 3

INTERVIEWS WITH PARTICIPANTS

By ANN HAMLIN, Missouri State Highway Department

LESTER A. HERR, Federal Highway Administration

Interview with Lester A. Herr, Chief, Bridge Division for the Federal Highway Administration. (This interview took place September 25, while Congress was still considering the Surface Transportation Act of 1978 to include bridge legislation. The additional money and legislation Herr briefly mentions here referred to that bill. Herr's statements regarding those funds are pertinent to whenever the money comes available.)

Q. What is your biggest concern right now?

My biggest concern is hearing we have so many bridges to replace and not really the organization or the funding. We spent about $2 billion yearly for the last several years on bridges alone on just the Federal Aid System. These $2 billion build anywhere from 2000 to 3000 bridges of various types and so forth. We are supposed to get some additional money because we are not building enough. A lot of those two or three thousand bridges can be accounted for by the Interstate System, because the Interstate System is sort of a new system.

So, what we're starting now is bridge replacement program to replace old bridges. The farther East you get, the older the bridges are. Bridges were worn out in Pennsylvania, let's say, before California became a state. Missouri is somewhere in between. In 1925, Pennsylvania had some bridges 50 years old and some of these are still in use. The Eads Bridge in St. Louis is one of these older bridges.

Now, the trucks are getting bigger and bigger. Every day more and more railraods are being abandoned. And as they abandon railroads, industry products have to be taken to market on highways. Often, the bridge or a part of the highway is not constructed for heavy truck traffic.

So, our biggest problem right now is to know how many bridges we have and their condition. Many of the counties don't know if they have 300 bridges or 500 bridges. And it is interesting to note -- we have run into the problem of "who owns a bridge?"... this happens in some of the western states. Over the years, nobody was concerned as long as they could maintain traffic over the bridge, but now comes the time when you have to replace it or repair it, and somebody has to come up with some money. Then comes the question "Who owns it?", and the answer is unclear in some instances.

Q. What do you see in the next 10-15 years ahead?

Right now, we estimate that to do the job with today's dollar, it would cost us $25 billion to put the bridges in the shape we'd like to see them. Now if you divide that by the number of years, if we spent a billion dollars a year it would still take 25 years. And we're not spending a billion dollars a year extra on these bridges now. That's why Congress is trying to get a bill through to get an extra $2 billion annually, because they want to clean up the situation in say 10 or 15 years.

So, what I see in the future is that we are going to have a bridge program for at least the next 20 years.

Q. If Congress should vote the money and the President signs the bill, how would the money be apportioned?

If we get the money, we have to allocate the funds to the states on the basis of need, the way the law says. We don't allot funds according to the number of people a state has, or the length of highway, or the number of bridges. The program would be set up to give the money according to how bad the bridges are. So really, if a state had all good bridges built just yesterday (theoretically), it would not get any of this money at all.

Q. How difficult is it to determine that amount of need?

We first have to know how many bridges a state has, their size, width, so forth, and then evaluate them. That takes some technical expertise to say that the deck is bad, that a pier is bad, or determine what else the bridge really needs. So, we have to get some kind of evaluation so we can compare the needs of that particular state with other states.

So, if a state had few bad bridges, they wouldn't get much money. And really, we would look upon that as being excellent. The state, however, might not look at it that way, since they would not be getting any money. But the whole principle is to get all deficient bridges in good shape.

This is why we need to know how many bridges we have, and what condition they are in, and that information we don't have at the present time, particularly on bridges located on highways that are not on the Federal aid system.

The bill, as introduced into the House and passed out of committee, would provide $2 billion a year for a special bridge replacement program. The funds would be not only for replacement but, additionally for rehabilitation. Up to this time, states or local jurisdictions were expected to take responsibility for rehabilitation.

Q. Does the fact that bridge failures bring more dramatic consequences perhaps draw excessive attention to the bridge problem?

Although this last year we got a lot of attention to potholes, a failure in the roadway is not as catastrophic as some people getting dumped into a river. Plus the fact, that a bridge, per foot of roadway, is pretty expensive. If a county would get $50,000 a year, this would build maybe one bridge. But it would also build perhaps 10 miles of roadway. So planners most often build the 10 miles. That is why bridges, because of lack of money, have been allowed to deteriorate to the point of no return... it has to be pretty serious before people will collect money to deal with it.

Looking back a bit...when the Interstate System was started back in the early 60's...there was a big push. There were traffic jams much worse than there are today. We even had traffic jams in the 1930's. When I was in high school coming back from Atlantic City, it took us four hours to get across the bridge at Philadelphia. They had two-lane traffic and it was a mess. When I went to Washington in 1935, from Baltimore to Washington, a two-lane road again, you couldn't move. So we had traffic jams a long time ago. Then they came up with the idea of the Trust Fund. People were just tired of fooling around with the traffic problem. So again, it's just a matter of how serious it's going to be before we get some money.

I think the bridge community of the highway departments and the consultants are an excellent bunch of people, and everyone of them is conscientious about getting our bridge situation improved.

JOHN W. FISHER, Lehigh University

Dr. John W. Fisher is Associate Director of the Fritz Engineering Laboratory at Lehigh University, Bethlehem, Pennsylvania. He is widely regarded as a top consultant in the area of bridge fractures and failures and is called to all parts of the nation as failures occur. He was involved in the AASHO Test Road in Ottawa in the late 50's. At the St. Louis Bridge Engineering Conference he chaired the session on Long-Span Bridges. Here, Fisher expresses his concern for anticipated problems of earlier bridge structures, and also voices concern over the use of the transportation and research dollar.

Q. What areas of concern does your research involve?

Generally, I've been involved in the investigation of many failures and developing design criteria to prevent fatigue cracking. When a cracking problem develops I often become involved in it in some way or another as a consultant. In my own state, Pennsylvania, we have one of the higher populations of old bridges in the country, because it's a relatively old state, going back to the first colonies, although the bridges aren't all that old.

Nonetheless, in the East there is a much higher volume of traffic. So many of these problems associated with serviceability manifest themselves there, before they do elsewhere in the country. As a result we have had a lot of problems in the state. We've studied some of the state's bridges and future related problems. The Transportation Department has supported us in this ongoing research. We have also carried out a number of NCHRP projects in the area of fatigue.

With so many rivers -- the Monongahela, the Allegheny, Ohio, and Delaware -- Pensylvania has a lot of long bridges similar to those over the Mississippi in Missouri.

Most long span bridges are steel bridges, and my work is in steel structures.

Q. What are you anticipating in the next 10 years in your field?

I think there will be more problems, and that's because we have only realized in the past 10 years that there was a potential for a really serious problem. I think this is because, in general, when welding was introduced into bridges in the late 40's and early 50's and the severity of certain details that were used was not recognized. Therefore, we have a lot of older bridges with fatigue sensitive details. Unacceptable details exist on these older structures, and therefore, we are going to have problems associated with them as they age and see more service. But there are an awful lot of older bridges -- we did a lot of construction of bridges during this earlier period of time. That's our problem now.

I think some of the thrust of the work in the future will have to deal with how to retrofit these types of bridges. How you repair without replacing the structures -- because economics dictate this kind of solution. I'm less concerned about new bridges because I think we have enough knowledge now that we can design new bridges to avoid these problems.

The other problem is with designer's using details without recognizing their severity. Often this is because there is insufficient experimental work.

Q. With the failures you anticipate from these earlier constructions, will research people be able to keep up with the increased needs for both better design on new structures, as well as ways of solving arising bridge failure problems?

I think there are a lot of potential failure problems and whether or not we are able to keep up depends on whether or not funding will be available.

It's the economics that matter here. I believe there is too small a percentage of research money going to other work. I feel that possibly too much of the transportation and research dollar may be going for administration or soft type research vs. hard type research. Whether that is a reality in fact, I'm not so sure I could prove, but it's just a feeling I have.

GERALD D. LOVE, Federal Highway Administration

Dr. Gerald Love is Associate Administrator for Research and Development, Federal Highway Administration. Dr. Love discusses his concern for bridge rehabilitation, new developments in research, his concerns and anticipations for the future.

Q. Right now there is a growing emphasis on bridge rehabilitation, rather than bridge replacement alone. How does this new emphasis affect you people in the field of research?

I wouldn't consider it a new emphasis. We've always been concerned with this problem. In fact, the thing that has brought it into the fore at the present time is the fact that we do have a very serious problem as far as the condition of our bridges throughout the country. We must recognize that additional funds have to be made available not only to replace some of the structures, but also to rehabilitate those that can be saved.

Q. Do you see a lot of new types of replacements, new methods of rehabilitation coming? Are we going to go about this work at a different pace?

Well, I certainly think there will be new developments. We will go about it in a different pace in the sense that one of the most serious problems we must recognize is that we have a highway system in need of maintenance. The majority of the miles of the highway system are already constructed. So, the problem in the next decade basically, will be one of upgrading and really rehabilitating the existing system. So the emphasis of the immediate future certainly will be more toward rehabilitation and upgrading, rather than construction of new facilities, which has been the thrust for the past 20 years with the Interstate System.

Q. What is your greatest concern right now?

The greatest concern to the highway industry is the very serious condition of many of the bridges throughout the country. And it's not only the older bridges where you find structural deficiencies in the superstructures. We also have a very serious bridge deck deterioration problem in some of the structures constructed as part of the Interstate System. So, the bridge deck problem is perhaps one of the most serious problems facing us.

Q. What new developments in scientific work do you see coming up?

I think our research efforts have come up with some new innovations for providing additional construction techniques for bridge structures. Perhaps you've heard of the term "epoxy coating" coated reinforcing steel. That is one of the outputs of our research program which protects the reinforcement steel from the action of deicing agents. We have worked with the states on a project using "wax beads" in the bridge decks.

Q. How exactly does this system work?

The problem associated with bridge deck deterioration is the deicing agents coming in contact with the reinforcing steel, causing corrosion, which in turn tends to cause the concrete to crack and fail. This causes accelerated deterioration in concrete bridge decks. So, we need a means of preventing the deicing agents from penetrating through the concrete to reach the reinforcement steel. So we mix small wax beads with the concrete in the top two inches of the bridge deck, and then melt the wax beads by the application of heat after the concrete has cured. The wax then fills the small pores, thereby creating a seal where the deicing agents can't get in contact with the reinforcement steel.

This technique appears to have a good potential. It is a little more expensive, but it would prolong the life of a bridge. It's difficult to say just how long, but we would anticipate that it would give a bridge deck a comparable life to the rest of the structure.

Q. Dr. Love, you've been Associate Administrator for Research and Development for a little over four years. What is the most exciting aspect you find in this job?

I think the most interesting thing is that we are working with new ideas and new concepts and we intend to come up with better solutions to some of the problems basic to highway industry for many, many years. That, to me, is the most challenging and most interesting part.

Q. Dr. Love, what do you see the the next 10, 15, 20 years ahead?

I think basically the emphasis will definitely be on rehabilitating and maintaining the system, and in some cases some upgrading. But there certainly will not be any significant new construction.

Q. Do you think the biggest problem will be a problem of funding or of time?

We are concerned that we will not be able to maintain an adequate funding level. In terms of the overall priorities in transportation, we have to fund the highway program at an acceptable level. It is generally true, I believe, that most states are capable of funding their highway program. I am sure that this would be true in Missouri. You could use some more money, perhaps, but we could use a little more money in our programs too.

Q. Do you see any problem when we get into upgrading the existing system? Can we "gear up" to this if funding should quickly become available?

I think we have a cadre of capable engineers and a construction force around the country that can effectively manage the program that is now proposed. I don't really see any problem.

In fact, we're much better off today than we were when the Interstate first started because we do have a more experienced cadre of engineers than we did 20 years ago. Really, there should not be any shortage of qualified highway engineers in the foreseeable future.

GEORGE H. ANDREWS, Sverdrup and Parcel Associates, Inc.

George H. Andrews is a man who says the best part of his day is "getting up!" He was top administrator for the Washington State Highway Department, from which he retired with 35 years' service in 1975. He then joined Sverdrup & Parcel Associates, Inc. Andrews is also a past president of AASHTO.

Andrews lends an unusual combination of expertise in both the public and business sector to a conference such as the Bridge Engineering Conference in St. Louis. Here he reflects on the differences he encountered in the trnasition to the business sector after some 35 years in government. In 1974 Andrews was named one of the Top Ten Public Works Officials in the U.S. He presently is Vice President of Transportation and a partner of Sverdrup & Parcel.

Q. How great is the transition you made in moving from the position of top administrator of the Washington Highway Department to your position with Sverdrup & Parcel Associates, consulting firm?

It is a great transition going from almost daily public involvement, meetings, talks, conferences, to the business setup, where you have to worry about how your staff is doing, whether you are able to produce the work, or for that matter where the next job is coming from. It's more a competitive situation. It has been quite a transition.

But to my advantage, I had the experience of having worked with a number of consultants in our Department and knew what they were doing, how they were doing it. And then I moved to the other side of seeing that it got done. My work now is mainly in the internal administration of the business, business contacts with clients, etc., no public meetings, as before. In a way I kind of miss that.

A great satisfaction from working with people in public life happens when you can hear what they are saying and have some ability to respond and do something about their problems. It's a great satisfaction to be able to do that.

Combining experience in public life with the private sector: Having been a professional engineer in the (Washington) Highway Department gave me a background in general engineering problems, particularly highways and bridges. It's helped me in knowing what some of the design problems are that we now have under contract as a consultant. Having had the advantage of several administration positions in the Highway Department gave me a feeling for business and engineering practices that are common to both private business and public life. One big difference is that I now don't feel the pressure of the administration of a Department as big as the Missouri Highway Department or the Washington Highway Department -- they're about the same size. Pressures are there in this job too -- but they are different. I don't miss that part of public life!

Q. What brought your attention to this conference?

This is a great conference. It is a timely meeting, as right now there is a lot of interest in bridges. The condition of our bridges throughout the country has got to be a concern to everyone. By and large, so many of them were built right after the turn of the centruy and so many of them are wearing out.... There is a lot of serious interest in these problems because attendance here is bigger than had been expected...I think every state in the Union must be represented. It is good for the bridge engineering fraternity to get together and share some views. There is constant change in this business, and all of us have to stay on top of it.

ROBERT C. CASSANO, California Department of Transportation

The following interview was with Robert C. Cassano, who with Richard J. LeBeau of the California Department of Transportation, co-authored the "Best Paper" of the Conference on "Correlating Bridge Design Practice with Overload Permit Policy." Their paper identified the need for design and permit people to combine their efforts at the time a structure is being planned, and they specified how this was implemented in the California DOT recently.)

Q. Were you and co-author Richard J. LeBeau expecting the "Best Paper" award at the time you submitted your writing?

Oh. not. I was very amazed. In fact, after listening to the various papers being presented at this Conference, I'm still more amazed. Ours is kind of a "not-very-spectacular" topic, and I was very surprised that it was selected for an award.

Q. Where did you conceive the idea presented in your paper?

The paper related what we in California are doing, i.e., how we switched from the usual AASHTO specifications to the present California practice. We also give the rationale for why we think it's desirable to change national practice. It isn't an idea we thought of just for this conference. It's something we saw a need for a long time ago. I can't claim the concept as my own. It kind of grew out of our staff as a team effort.

Q. How do your specifications change, generally?

Basically, with what we were doing in the past there seemed to be two groups of people: People who designed bridges using a set of specifications, and then a second group of people in the maintenance field who wrote the permits for bridges, deciding what kinds of loads to put on them and inspected them. The second group operated independently of the designers. The permit people were using different criteria for deciding how to load the bridges than the designers had used to design them. In general, there is a communication gap between maintenance and design engineers.

We've got to get the two groups together, so that the designer takes into account the same stress levels and same loadings that maintenance used for the completed bridge. This seems quite fundamental, and it's kind of amazing that it's viewed as a new idea. It seems logical that you would design a bridge for the load you expect it to carry - but still that's not the common practice.

The purpose of our paper is to get the two functional groups together so that they use the same specifications right from the start.

Q. Have you implemented this idea in California?

Yes, we decided the way we were doing business was almost absurd, so about four or five years ago we began talking about what we should do about it. We've been using our new criteria routinely for the last couple of years in California.

Q. What reactions do you anticipate to this idea?

Many AASHTO members in the western United States already think it makes sense. But there is considerable effort involved in switching to new procedures. You have to retrain designers and rewrite computer programs. There is a certain amount of investment in time to make the switch over. That's one of the reasons why our procedure may not be widely adopted. You have to be highly motivated to conclude that the required effort is worthwhile.

Another reason why we will have some trouble getting it adopted is that California's system might not have nationwide appeal. We are cognizant of the fact that permits for overloads and levels of overloads vary drastically from state to state. This lack of uniformity is a serious factor.

BRUNO THUERLIMANN, Swiss Federal Institute of Technology

Dr. Bruno Thuerlimann is presently on a sabbatical from the Swiss Federal Institute of Technology, Zurich, Switzerland, where he is a professor of Structural Engineering. An internationally known consultant, Dr. Thuerlimann is president of the International Association for Bridge and Structural Engineering, and performs consultant work on the North American continent, Europe, and the Middle East. He left the St. Louis Conference to begin a five week series of lectures on elasticity of reinforced concrete at the University of Texas. Dr. Thuerlimann received much of his education at Lehigh University, Bethlehem, Pennsylvania.

Q. Dr. Thuerlimann, your consultancy exposes you to bridge failure problems on three continents. What, right now, is your greatest concern for these structures?

One of the biggest problems is maintenance. Here, and also in Switzerland, there is a tremendous system of highways and bridges, and we see a much faster deterioration of our structures than we had expected. I think maintenance will be one of the very big problems.

Personally, I'm not involved in maintenance, but I do see this as a big problem. I think in design we should become mindful of this problem and attempt to design maintenance-free bridges.

We have to have monies appropriated to keep up a good system. Switzerland, compared to the United States, is a much smaller country. We have similar political systems: a state highway system and a federal highway system. I think our problems are quite similar to one another, just on a smaller scale.

PART 4

ERRATA FOR TRANSPORTATION RESEARCH RECORDS 664 AND 665: BRIDGE ENGINEERING

RECORD 664

Page 155, in Table 1 for Bridge Number 3 the Reinforcement for Panels 10, 11 and 12 shown in column 5 should read 0.6%.

RECORD 665

Page 238, in the second column, the tenth line from the top should read: the scaled stiffness of the required post-tensioned system should be about 42000 kN/m (240,000 lb/in).

Page 238, in the second column, the twentieth line from the top should read: to provide a scaled stiffness of 42000 kN/m (240,000 lb/in) based upon a modulus of elasticity of 200 X 10^6 kPa (29 x 10^6 psi) for steel, and measured value of 0.38 0.38 x 10^6 kPa (0.055 x 10^6 psi) for wood

Page 239, in Figure 6 the following entries should read:

Known Conditions (R,r)
- (1) (0,1.0)
- (2) (5950, 0.91)
- (3) (68100, 0.15)
- (4) Curve Assymptotic to R axis

Approximate Solution $r = \frac{195}{R^{1.66}+195}$

The numbers on the horizontal axis should be 5950 replacing 6300 and 68100 replacing 118600.

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