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## **Major Bridge Projects from the Point of View of Owners**

Projets de ponts importants du point de vue du maître de l'ouvrage

Wichtige Brückenbauprojekte vom Standpunkt des Bauherren gesehen

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### **SUMMARY**

This theme paper departs from the strictly technical aspects of structural engineering to examine societal and political influences which control vital phases of the creation of a major bridge project. Emphasis is placed on the need to improve communications, and thereby confidence and understanding, between the three principal groups involved: government, the public and technology. Return to realistic attitudes with respect to cause and effect, and cost vs benefit, is considered long overdue.

### **RESUME**

Ce rapport s'éloigne des aspects strictement techniques du génie civil pour étudier les influences sociales et politiques qui gouvernent les phases critiques dans les projets de ponts importants. Le besoin d'une amélioration dans la communication est souligné, une telle amélioration menant à un climat de confiance entre les trois groupes intéressés: autorités, public et techniciens.

### **ZUSAMMENFASSUNG**

Dieses Referat verlässt die rein technischen Aspekte des Ingenieurwesens, um soziale und politische Einflüsse zu studieren, welche bei grösseren Brückenbauprojekten auftreten. Die Notwendigkeit, Kontakte zu verbessern, wird betont, da dadurch mehr Vertrauen und Verständnis zwischen den drei betroffenen Gruppen: Behörde, Öffentlichkeit und den Technikern entsteht.



The reader is referred to the published SUMMARY which supplements and is an introduction to this theme paper. Further, and to crystallize the discussion of principles within the allotted space, this theme paper will be limited to consideration of how to improve creation of large vehicular bridges built over waterways by owners who are governmental agencies in the USA. Expanding the principles discussed herein to other structures for other owners as the reader may desire should not be difficult.

To further define the basis of discussion, the reader is referred to the August 1969 Report of the Institution of Structural Engineers, entitled "Aims of Structural Design," for an excellent presentation of factors, processes, philosophy and relationships relevant to the subject. The following brief quotations therefrom are significant here:

"Design is an art concerned with the adequate. Its history shows a perpetual extension and refinement of the knowledge of what is needed of a structure and how these needs may be satisfied at least expense of human effort and wealth.".....

"The structure must fulfill its intended functions .... must be safe .... (and) must be of least cost.".....

"Design starts with the appreciation of the client's (owner's) requirements; this is the critical stage in the process and calls for the closest collaboration between the client and the designer. Not every client knows exactly what he needs; many are unaware of what structural engineering can provide." .....

"The works of the structural engineer are of major consequence to society, which can and should define the functional standards of building.".....

It is observed that "safety" and "least cost" are often at odds with each other, requiring the designer to make a calculated judgment as to cost vs. benefits based on his accumulated knowledge and experience. In the words of a multinational company in the construction field: "There are no simple solutions; only intelligent choices." Of course, choices are not limited to technological matters. Many of them relate to definition of functions to be served, to location of structure as a compromise between function, environment and cost, and to a variety of ancillary considerations -- such as aesthetics, cultural impact, and economic consequences. Numerous instances can be cited to demonstrate that a major bridge has critically influenced the culture and economy of an entire political entity.

The "cost" of a major bridge is defined as including operation, maintenance, amortization and demolition charges throughout the life of the structure as well as the initial cost of planning, design, right-of-way and construction; plus the added totally unproductive costs of delays and extra work caused by lack of prompt and firm decisions by the owner, and by interference by possibly well-intentioned but uninformed and/or misinformed segments of society and government. Such delays in providing a needed structure deprive society of needed services and also represent additional tangible costs, and not infrequently double or triple the initial cost at the same time. By the same token, service functions provided have value to the public and to a degree offset cost as broadly defined above.

Contrary to certain political, environmental, ecological, egalitarian, and news media pronouncements, the creation of a needed major bridge is a serious matter, can be analyzed rationally, and is an achievement of great importance.

It meets not only a service function for society but also, perhaps as importantly, will inspire those in other cultures to dream great dreams and to challenge the impossible. Such a design should never be entrusted to those whose credentials are limited to the production of impressive renderings or to the offering of the lowest fee.

Experience in the USA has not included significant use, with respect to bridges, of competitive designs nor of tenders for design plus construction. In each case, only one competitor wins. The costs for all other participants must be recovered by them from the owner conducting the competition or from owners of future projects. For a major bridge project, such costs can be very substantial.

On the other hand, there have been recent attempts by government to force competitive bids for design, suggesting various euphoric procedures whereby experience and capability would be given priority. The real purpose of such suggestions is, of course, not to provide better structures from the owner's point of view but rather to relieve the owner (government in this case) from having to make difficult qualitative judgments. Such attempts overlook the fact that in the case of a major bridge there is no basis for bidding to accomplish the design because there is no existing specific definition of the work to be done. Such a procedure is a farce unless the owner has already completed extensive planning, preliminary investigations and feasibility studies. Even then, it fails to serve the owner adequately. Further, if a designer has already worked closely with the owner throughout such first steps, and has performed that work satisfactorily at reasonable cost, then he is quite likely better qualified to continue with the design than another designer of equal or even better ability but unfamiliar with the owner and his project.

The cheapest bid for design, whether by novice or qualified professional, logically will contemplate over-design to assure safety, and will leave many design details to be completed by the construction contractor. The resultant direct increase in construction cost of structure, vague drawings and specifications, and inevitable requests for extra payments by contractors will most likely be in excess of any savings in design costs. In addition, there is no room to be innovative and no incentive to serve the owner properly.

Some persons prefer to think in terms of numbers rather than in philosophical manner. For them, an experienced owner of major projects, who has supervised millions of dollars (US) worth of design and construction, has commented on this subject. In his opinion:

- a) the construction cost is usually 10 to 20 times the cost of adequate design engineering;
- b) the variation in cost from the cheapest to the best design engineering is usually no more than 10%; and
- c) the ratio of potential construction cost increases vs. engineering savings is probably at least 100 to 1.

Then too, it should be appreciated that, from the point of view of the owner who must operate and maintain a major bridge, no bridge is better than its details. The owner may learn too late that it is very important: to have appropriate details for clearances and moving elements; to have adequate cover over reinforcing steel; to have quick and adequate drainage, in particular if salt is used; to be able to readily accomplish cleaning and painting or, better yet, to need none if the bridge crosses heavily traveled roadways;



to have adequate safety features and traffic controls; to be able to easily redirect traffic and clear lanes in case of accident or needed repairs. Such items are the result of careful and complete design, drawings and specifications. They are not a part of short-cut procedures. They are not highly technical; and are given greater emphasis by designers who also have experience in construction and operation.

It is appropriate to ask the question:

What can be learned from experience in the USA that will assist owners in obtaining better major bridge projects for their publics? There are two major aspects to be considered: improvement of knowledge with respect to theoretical planning, design, available materials and methods of construction; improvements in the ways and means of identifying and evaluating needed structures and then utilizing the foregoing knowledge correctly and expeditiously. First, the record will be examined in certain important aspects.

In the USA the improvement of knowledge and its wide publication have been progressing nicely and promise to continue to do so. The ways and means of utilizing that knowledge to identify and construct needed projects has been deteriorating seriously and will be the aspect discussed herein. A few reasons for that choice will be given.

About 25 years ago a state in the USA enacted legislation authorizing a very large highway project, passing through some rural and many highly developed urban governmental jurisdictions. Serious planning and preliminaries were started immediately. Twenty-two months later the project had been designed, financed, constructed within the budget, and fully opened to traffic. It has been one of the most useful and successful projects ever created. It is now greatly expanded, as the original design had anticipated, and is providing tremendously important service to the public. It illustrates beautifully what can be done when government, the public and technology act cooperatively and responsibly in productive and straightforward manner under adequate authority. Today things are different. Why? Several reasons will be cited.

Several years ago Rachel Carson published "Silent Spring."..... The book immediately became a best seller. Clubs were formed all over the USA to prevent engineers from covering the nation with concrete, to prevent industry from making air unfit to breathe and water unfit for use, and to prevent natural resources from being used. It was reported that during the following year members of the U. S. Congress introduced over 3,000 pieces of legislation intended to support the stated aims of those constituents. Nothing happened to most of the bills but the uproar continued and some of them became significant legislation for which new large bureaucratic agencies had, of course, to be created. Today it should be carefully noted that:

- a) There had certainly been some improper actions and policies which warranted intelligent correction;
- b) The surge of public opinion, resulting legislation, plus ensuing administration and regulation largely ignored established relations between cause and effect, ignored essential aspects of costs in comparison with benefits, multiplied the elapsed time between conception and completion of projects; and
- c) The current result is typified by many needed public works projects being delayed for years or being killed, by a major contribution to inflation through multiplied costs, and by substantial roadblocks to our fundamental energy problem.

For example, in one such case, one new piece of legislation was designed to control purity of streams and waterways. The new agency promulgated numerous rules and regulations (interpretation of legislation follows legislation as surely as day follows night). Then the new agency turned to an old agency, which has for decades had other responsibilities for many of those same waterways, for review of the requests and newly required environmental impact statements (EIS) plus recommendation for action thereon by the new agency. It is understood that during the first year of such divided responsibility: the old agency received approximately 11,000 requests and EIS's (some being up to 5 feet thick); reviewed and forwarded recommendations on about one-half of them to the new agency; and that the new agency took action on twenty-two. A bridge over a waterway must pass through these procedures.

It is to be emphasized that the creation of a major bridge is not limited to technological capabilities. As a matter of fact, the real decision makers in such a project are NOT the engineers. Such critical decisions as whether or not the project will go forward, what functions it will serve, where and when it will be built, how it will be financed, what zoning regulations and building codes will govern, and who will administer and design the project are made, and rightly so, by elected or appointed governmental officials often having little, if any, technical knowledge or experience.

It is, therefore, self-evident that the successful and timely creation of a major bridge project requires complete cooperation, trust and respect between those decision makers on the one hand and the engineers on the other hand. The public, those persons who both pay the cost and receive benefit from the services to be provided by the completed project, is a very interested third party and should be represented in the planning and preliminary studies. Each of these three groups has its own background, its own experience and desires, its own priorities, and its own brand of logic.

Without in any way making a judgment that any of the following should be done, it can be noted that in the fifty-year history of IABSE, being celebrated this year, the design profession and the materials, equipment and construction industries have made advances which now make it technologically possible to span the English Channel, the Strait of Gibraltar, the Store Baelte and the Stretto Messina. Each project has been under discussion time and again. None have gone ahead because the decision makers have not acted favorably; and it may be a l.o.n.g t.i.m.e before they do if the ideas and attitudes now prevailing in the USA spread over the rest of the world.

More specifically and in more common dimensions, there are today in the highway systems of the USA and in urban areas near great rivers (most big cities grew up along rivers) tens of thousands of bridges designed 50 to 75 years ago for far lesser loads and traffic densities than they now are forced to carry. Upgrading and replacements are proceeding at a snail's pace. Probably little will be done to update essential links in transportation vital to commerce and industry until after several failures occur. The designers will be blamed, the politicians will rush to the rescue (particularly if an election is near), and the public will be hurt. WHY? Certainly not because of lack of technical design ability, construction skill, nor concern for least cost!

The basic reason for this essential non-existence of progress is a fundamental lack of meaningful communications -- and therefore understanding, respect and trust -- between those same three groups -- government, public and technology. Organizations such as IABSE are as responsible for that lack as anyone else, perhaps even more so, because they alone know how to do the job as well as the consequences of not doing it. Correction of the situation is vital.



Misguided policies and isms are strangling needed public works in the USA; minor as well as major bridges, flood control projects, water purification and sewage treatment plants, transportation projects, power generating plants and all other facilities which distinguish a developed nation from an undeveloped one. It is vital to correct the misunderstandings of related causes and effects; and of the current unrealistic limitations being imposed by a few on the qualities of living for the many. It is vital to broaden the understandings of the responsibilities and limitations of governmental agencies. It is vital to broaden the understandings of capabilities and limitations of technology as regards costs, benefits and economic health which flow from appropriate utilization of technology.

It is vital to develop mutual trust and respect for each group's problems, needs and capabilities so that all can work together constructively as a team. What has been done in the past is truly considerable. What can be accomplished in the future with meaningful cooperation would be unbelievable. The answer to how owners could obtain better major bridge projects would become self-evident to all concerned.

During this present exercise of examining where we have been as an aid to better performance where we are going, it is to be noted that the design profession has not been above reproach in the USA. It has espoused the sound virtues of selection on the basis of demonstrated ability and experience, as demonstrated by prior performance and satisfied clients, followed by negotiation of a fair and reasonable compensation BUT it has done precious little to provide an adequate environment and public support for the public officials required to make such really difficult decisions. Recognition of that important shortcoming is long overdue.

A considerable number of other elements hindering progress can be distilled from experience in the USA in recent years. Of first importance is the fact the three principal groups involved -- government, the public and technology -- do not speak the same language. The situation is analogous to that of three men -- one speaking only Chinese, one speaking only Greek, one speaking only Arabic -- attempting to discuss a complex problem and reach intelligent decisions. The resultant lack of communication precludes intelligent progress. Whether he is right or wrong, the dominant one will control and the other two have no basis for understanding nor meaningful comment. They will be confused and unhappy.

None of the three groups is perfect; each has its shortcomings and difficulties. Each tends to concentrate on and to present in the mass media (which prefer the negative) the faults of the other two. For example, a group of structural designers will usually discuss the difficulties they see with clients or with their public rather than address themselves to ways and means whereby they might better understand the problems faced by such groups; and thereby improve cooperation with them.

There are certain innate difficulties. For example, elected or appointed officials and legislators come from a wide variety of backgrounds. A large proportion of them hold office for relatively short terms -- say 2 to 4 years -- and during that period their primary concern becomes re-election or re-appointment. Re-election or re-appointment definitely are not determined by how well they handle major bridge or other public works projects; unless they have made a scandalous mess of one. It is evident that, under the circumstances, such individuals cannot become experts; also that the problem of establishing communications, understanding and respect between the three groups is an endless one.



Among the design professionals there are all degrees of training, experience and capability. It must be so. Various individuals will always be beginning their profession, well established in it, or too old to function effectively. There is also, fortunately, keen competition and laudable ambition for achievement. The design profession is still striving to devise better format and methods for fostering this essential growth and, simultaneously, providing owners with better procedures for selecting designers in the best interest of the owners. Only recently did IABSE actively recognize the need for this growth and revise its by-laws to encourage it.

Perhaps the most poignant difficulty is that each of the three groups is composed of humans. Among humans there are always a few conniving power-hungry grasping and dishonest individuals whose actions, when they become known, are widely publicized under the principle that "No news is good news" which has been translated into "Only bad news is news." As a result, neither Government nor the engineering profession fully trust each other; and the public questions the integrity of both.

The basic problem is fundamentally no different than that faced by a continuing private corporation with respect to maintaining effective and efficient management. But it is much more difficult by reason of the lack of coherence between groups exercising various significant aspects of control, and because of their inadequate understandings of factors which determine need, excellence and cost. There is no concise profit and loss statement by which to measure progress definitively.

A technological problem worth mentioning is the difficulty of obtaining financial support for timely specific project research for improvement of design and construction, two closely related factors, for a major bridge. The bridge will most likely be a one-time, large and unique operation requiring very substantial capital investment. It will usually be under discussion for decades. However, final decisions as to type, location and capacity are customarily not reached until money for construction is assured. There is then no inclination on the part of the owners to allocate time to research. One example will be cited.

Nearly 50 years ago the writer participated in a university research project which constructed and then studied a structural model of a suspension bridge of modest size to investigate the accuracy of design theories. The work done demonstrated that additional research on a broader scale would be of appreciable value. Attempts were made to organize and finance an appropriate series of research projects in cooperation with government and related industries. The attempts were unsuccessful. Then a suspension bridge collapsed. Too much extrapolation of design experience had, by necessity, replaced research. Immediately government, the only owner of large suspension bridges, sponsored numerous investigations and finally the needed research.

The public always pays for any and all public works projects regardless of the method of financing. In perspective, it is inevitable that to many if not most individuals, the near-term increase in taxes, tolls or other charges will loom larger than the long-term future availability of any improved or new service function. It is also true that today, even in democracies, questions placed before the public are decided by organized minorities making deals with one or the other of more or less inert larger groups who concede to the minority point of view in exchange for an I.O.U.



Limited space now calls for a summary which should then be followed by suggestion as to how governmental owners can obtain better major bridge projects, when needed, at least cost.

It should by now be understood by the reader that, in the opinion of the writer, the environment for accomplishing that objective has deteriorated in substantial manner in recent years. The public is being deprived of needed projects. Those being built must run vicious gauntlets, again and again, of uninformed questioning, unfounded criticism, and of cost multiplying delays. The public is paying and paying. Firstly, far too much for the study and planning costs of the projects which are killed by the devastating powers of obstruction and negation. Secondly, far too much for those which do survive. Thirdly, by reason of the delays in creating needed service functions. And, fourthly, because of the real contribution made to inflation by the items just now mentioned. Public works financing forms a substantial portion of governmental budgets; and taxes to support governmental budgets are a major portion of the cost of living. In practically every developed nation today more than one-half of average income is devoted to payment of taxes.

Our engineering friends in other national groups may feel they do not have the problems mentioned here. It is reasonably certain that at least some do, that in time more will, and that even now it is probably only a question of form and size of the problem and not whether one exists. It is urgently recommended that IABSE avoid complaining about anti-technological sentiment and energetically attempt to establish better ways and means for mutual communications and understandings between the public, government and technology. No other solution appears feasible within the existing environment.

For those who may doubt feasibility of such an attempt, it can be recalled that the Offshore Technology Conference has a ten-year history of attracting annually from widely diverse disciplines and cultures as many as 65,000 persons. Also, at the 1977 International Conference in Paris, sponsored by UNESCO and organized by the IABSE supported Council on Tall Buildings and Urban Habitat, about half of the attendees were public officials. Another form of successful communication is represented by The Road Information Program (TRIP), the very effective public relations effort of the roadbuilding industry in the USA that consistently generates excellent and informative front-page newspaper coverage and editorial comment of road needs and how to satisfy them, as well as the costs of not doing so.

Any effective program to improve communications in the area of public works must convey its messages in language clearly understandable by all concerned. It must be persistent, tolerant, and dedicated to the public good. It must be broadly organized and widely supported.

The most effective messages will be those so presented that the reader will come to think they were his ideas in the first place. The information must be delineated in a manner designed to constructively instruct, rather than set out in a manner designed to emphasize the cleverness of the author. It must reach all interested parties; not just those who are already informed believers.

These design criteria may make the assignment seem difficult; but not impossible. What major bridge has not been characterized by similar terms? IABSE is a can-do organization. The public good which can result from increased intelligent USE of technology quite possibly exceeds that which can result from improving

technology. Creating technology is only an exercise. It must be used to become valuable. A philosopher once opined that a bridge is as important as a printing press because it also provides communications for people and their needs.

A structural engineer needs to be more conscious that he is also a member of the public and a citizen of government with accompanying non-technical responsibilities in both categories. One of the better definitions of an engineer is "A person who, by reason of training and experience, can utilize the materials and forces of Nature for the benefit of mankind at a cost mankind can afford to pay."

It will be observed that this paper has been limited to discussion of principles. It should be until those principles have been agreed to and formalized by all parties concerned, i.e. representatives of government, the public and technology. Before a major bridge project reaches the design-and-construct stage a definitive master plan should be refined from comparison of reasonable alternates in the light of all known factors. Similarly the "subsurface" conditions and the "forces" to be brought to bear by the "superstructure" should be thoroughly investigated before the design of the substructure is undertaken. During such developments it must be remembered that a major bridge is designed one member at a time; and that laboratory testing is a useful procedure.

From the IABSE point of view, a part of any approach must be the strict realization that no international organization can go into any individual nation and be effective in the matters here discussed. The role of the international organization must be to collect all applicable experience from each of its national groups, correlate and digest that experience, and then produce methods, procedures, publications and other supplements to aid a definitive program under the cognizance of the national group in each nation. In such manner, and by continuing to exchange experiences through the international organization, each national group can make two plus two of its efforts add to more than four. It isn't necessary that each national group invent the wheel! Nevertheless, they must put their shoulder to their wheel if they want it to turn and progress in their nation.

Irrevocable laws of Nature are the basis for scientific research, technological applications and human progress. If owners are to create better major bridges to fulfill their potential role in the future, it is essential that engineers as well as society in general regain the urge to improve qualities of living by their own cooperative efforts. IABSE should start with correcting known non-technical deficiencies within its own profession. The next step should be to assist the public and the decision makers in the application of established Natural laws of cause and effect; and in application of experience, judgment and rational analysis in evaluating costs and benefits.

Excellence in technology is necessary but is not sufficient to permit bridge designers and owners to serve their public in adequate manner.

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