WORKING SESSION

I

Aesthetics in Structural Engineering

Esthétique dans les constructions de génie civil

Ästhetik im konstruktiven Ingenieurbau

Co-chairmen:	L.S. Beedle, USA M. Birkenmaier, Switzerland
Introductory Paper:	"Aesthetics in Structural Engineering" F. Leonhardt, FRG
Coordinator:	F. Leonhardt, FRG

(The Introductory Paper is published in the Introductory Report of IABSE 11th Congress in Vienna 1980)

I

Ästhetik im Ingenieurbau

Aesthetics in Structural Engineering

Esthétique dans les ouvrages de génie civil

F. LEONHARDT
Prof. Dr. Ing.
Stuttgart, Bundesrepublik Deutschland

EINFÜHRUNG

Wir leben im Zeitalter des Erkennens der Fehler, die im vergangenen Jahrhundert durch blinden Glauben an den Fortschritt durch Wissenschaft und Technik entstanden sind. Vielseitig sind die Fehler, deren Folgen heute wichtige Lebensgrundlagen bedrohen. Ein Umweltbewußtsein wächst heran. Wir begreifen, daß unsere Gesundheit und unser Wohlbefinden von Qualitäten der Umwelt abhängt. Zu diesen Qualitäten gehören auch Häßlichkeit oder Schönheit der gebauten Umwelt, für die nicht nur Architekten, sondern auch Bauingenieure verantwortlich sind. In häßlicher Umwelt werden die Menschen seelisch krank und verursachen soziale Schwierigkeiten.

Leider ist in den letzten Jahrzehnten viel Häßliches gebaut worden. Der Sinn für Schönheit ist verkümmert. Die Bildung eines Urteilsvermögens für schönheitliche Gestaltung wurde sträflich vernachlässigt. Das Ergebnis ist eine unerträgliche Häßlichkeit mancher Stadtteile, aber auch vieler technischer Anlagen, für die wir Ingenieure verantwortlich sind.

Weil hier ein Wandel nötig und möglich ist, wurde innerhalb unserer IVBH eine Arbeitsgruppe gebildet, die sich um die Grundlagen der Ästhetik, d.h. der schönheitlichen Gestaltung im Ingenieurbau bemüht. Die ersten Arbeitsergebnisse dieser Gruppe wurden in dem Einführungsbericht für die heutige Sitzung dargestellt. Ich hoffe, daß möglichst viele Teilnehmer diesen Arbeitsbericht gelesen haben. Die Frage, ob Bauwerke ästhetische Werte haben, die sich auf das Verhalten von Menschen auswirken, wurde in dem Bericht bejaht. Ästhetische Werte können im Unterbewußtsein wirken oder bewußt wahrgenommen werden. Diese Wahrnehmung ist von Mensch zu Mensch oft recht unterschiedlich und hängt sehr von seinem kulturellen Hintergrund und Bildungsgrad ab.

Wenn man zu einem ästhetischen Urteilsvermögen kommen will, muß man schönheitliche Qualitäten analysieren, d.h. man muß sich immer wieder die Frage stellen, warum empfinde ich dieses Bauwerk als schön, ein anderes als häßlich. Solche Analyse führt zu Erkenntnissen, die frühere Generationen an Hand von Bauwerken klassischer Schönheit wiederholt dargestellt haben. Man findet gewisse Richtlinien für das Ziel schöner Formgebung, die im Einführungsbericht versuchsweise formuliert wurden. Hierzu gehören vor allem gute Proportionen, eine gewisse Ordnung, Einpassung des

Bauwerks in die Umwelt, insbesondere im Hinblick auf den Maßstab im Vergleich zur Umwelt, sei es nun Landschaft oder Stadt. Für Ingenieurbauwerke spielt die überzeugende Darstellung der Funktion eine wichtige Rolle. Die Farbgebung der Bauwerke in Harmonie zur Umgebung ist oft entscheidend für die schönheitliche Wirkung.

Solche Richtlinien schönheitlicher Gestaltung wurden zur Diskussion gestellt.

Das Interesse an dieser Ästhetik-Sitzung war überraschend groß. Es sind 26 Beiträge eingegangen; die verfügbare Zeit erlaubt nur, daß 14 Beiträge vorgetragen werden. Wie zu erwarten war, wurden recht unterschiedliche Meinungen vertreten, die Beachtung verdienen.

Einige Beiträge erhalten wir von Architekten, die bei der Gestaltung großer Brücken mitgewirkt und dort ihre Erfahrung gesammelt haben. Die meisten Beiträge sind jedoch von Bauingenieuren, die schon viel über Ästhetik nachgedacht haben.
Ich bitte nun um Ihre Aufmerksamkeit für die Beiträge.

INTRODUCTION

We live in the age of awareness, awareness of mistakes which arose during the past century from the blind faith in the progress of science and technology. Manyfold are the mistakes which threaten important resources of life. A consciousness for environmental conditions is growing. We conceive that our health and our well-feeling depends on qualities of the environment. To these qualities belong also ugliness or beauty of the built environment for which not only architects but also civil engineers are responsible. In an ugly environment humans get psychicly sick and cause social problems.

Unfortunately, many ugly structures have been built. The sense for beauty became stunted. The formation of the capability to judge aesthetic values has been broadly neglected. The result is an almost unbearable ugliness of many city districts, but also of many technical structures, for which we engineers are responsible.

A change of this situation is necessary and possible and, therefore, a Task Group within our IABSE has been founded which shall deal with the basics of aesthetics, i.e. with the aesthetic design of engineering structures. The first results of this Group were presented in the Introductory Report for this Working Session. I hope that many participants have read this Report. The question if buildings or structures have aesthetic qualities which influence the behaviour of humans was answered in the affirmative. Aesthetic values can affect our senses subconsciously or can be perceived consciously. This perception can be rather different from man to man and depends on his cultural background and the degree of education.

If one wishes to get the capability of judging aesthetic values, then one must analyse aesthetic qualities, this means one must question oneself again and again, why do I feel that this or that object ist beautiful or ugly. Such analysis leads to findings which former generations have described along buildings or monuments of classical art. One finds a kind of guide-lines for reaching the aim of beauty which tentatively have been formulated in the Introductory Report. Such guide-lines mainly deal with good proportions, good order, compatible integration of structures in their environment, especially with regard to the scale compared to the surroundings, be it landscape or city. For engineering structures a convincing representation of the function may be important. The colouring of buildings in harmony to the environment is often decisive for the aesthetic effects.

Such guide-lines for aesthetic design were offered for discussion. The interest in these aesthetic problems was surprisingly large. We received 26 papers, however, the available time allows only to present 14 contributions. As could be expected, rather different opinions are expressed which all deserve consideration.

Some of the contributions come from architects who had helped to design big bridges and got hereby their experience. Most of the contributions, however, are from civil engineering who obviously have given thorough thoughts to aesthetics.
I beg your attention for these contributions.

INTRODUCTION

Nous vivons dans une époque où l'on reconnaît les erreurs qu'on a commises au siècle dernier en croyant aveuglement au progrès dû aux sciences et à la technique. Aujourd'hui, les conséquences de multiples erreurs menacent des bases importantes de notre vie. Une conscience pour l'environnement commence à se former. Nous comprenons que notre santé et notre bien-être dépendent des qualités de l'environnement. Parmi ces qualités figure la laideur ou la beauté de l'environnement construit, pour lequel sont responsables non seulement les architectes, mais également les ingénieurs civils. Dans un environnement laid, les hommes deviennent mentalement malades et sont la cause de difficultés sociales.

Il es fort regrettable que pendant les dernières décennies bien des choses laides aient été construites. Le sens de la beauté s'est appauvri. La formation propre à développer les aptitudes à porter un jugement esthétique sur la beauté des réalisations fut négligée de manière blâmable. Le résultat est une laideur insupportable de certains quartiers, mais également de beaucoup d'installations techniques, dont nous sommes responsables en tant qu' ingénieurs.

Parce qu'un changement est nécessaire et possible, on a créé au sein de notre AIPC un groupe de travail traitant les bases de l'esthétique dans le domaine du génie civil. Les premiers résultats des activités de ce groupe sont présentés dans le rapport introductif préparé pour la session d'aujourd'hui. J'espère que de nombreux participants ont eu l'occasion de lire ce rapport.

On y répond affirmativement à la question, si les bâtiments possèdent des valeurs esthétiques ayant des répercussions sur le comportement de l'homme. Les valeurs esthétiques peuvent être perçues de façon subconsciente ou consciente. Cette perception est souvent très variable d'une personne à l'autre et dépend fortement de ses connaissances culturelles et de son niveau de formation.

Si l'on veut parvenir à pouvoir porter un jugement esthétique, on doit procéder à une analyse des qualités de la beauté, en d'autres termes il faut se poser sans cesse la question: pourquoi est-ce que je trouve ce bâtiment beau, ou un autre laid. De telles analyses nous mènent à des connaissances ayant été à la base des bâtiments d'une beauté classique réalisés par des générations antérieures. On retrouve certaines règles qu'il est nécessaire de respecter pour la création de belles formes, dont une première tentative de rédaction est contenue dans le rapport introductif. Y figurent le rapport des dimensions, une certaine régularité, l'adaptation de l'ouvrage à son environnement, en particulier le choix d'une échelle appropriée par rapport au paysage ou à l'agglomération. Dans les structures des ingénieurs, le fait que la fonction apparaisse de manière visible et convaincante joue un rôle important. La coloration des ouvrages en harmonie avec l'environnement est souvent déterminante pour leur effet esthétique.

De telles règles on été établies en vue de leur discussion.

L'intérêt pour cette session sur l'esthétique nous a surpris. Nous avons reçus 26 contributions dont, à cause du temps limité, 14 seulement seront présentées. Comme on pouvait s'y attendre, les opinions soutenues divergent assez fortement, et elles méritent notre attention.

Quelques exposés sont donnés par des architectes ayant acquis leurs expériences en participant à la conception architecturale de grands ponts. Mais la plupart des exposés proviennent d'ingénieurs civils qui ont beaucoup réfléchi sur les problèmes de l'esthétique.
Je vous prie maintenant de reporter votre attention sur les exposés qui vont suivre.

I

Bridge Aesthetics: 1925 – 1933

L'esthétique des ponts: 1925 – 1933

Brücken-Aesthetik: 1925 – 1933

DAVID P. BILLINGTON
Professor in Civil Engineering
Princeton University
Princeton, NJ, USA

SUMMARY
A review of ideas on bridge aesthetics during the founding period of the International Association for Bridge and Structural Engineering brings out a central question: the role of the architect in bridge design. Many thought that bridge design should be a collaborative effort between engineers and architects, with the architects primarily responsible for aesthetics. Some, however, believed that engineers should make the designs alone and that they should themselves seek forms that were both technically correct and aesthetically satisfying. The article refers also to Robert Maillart, an engineer whose best known designs of that period were made without collaboration.

RESUME
Un coup d'oeil rétrospectif sur les conceptions de l'esthétique des ponts à l'époque de la fondation de l'Association Internationale des Ponts et Charpentes pose la question centrale suivante: quel est le rôle de l'architecte dans le projet d'un pont? Beaucoup de personnes pensaient que le projet d'un pont devait être l'objet d'une collaboration entre architectes et ingénieurs, les architectes étant responsables de l'esthétique; d'autres étaient d'avis que les ingénieurs devaient projeter les ponts seuls, et trouver des formes qui satisfassent simultanément aux critères de la technique et de l'esthétique. L'article mentionne Robert Maillart, ingénieur dont les ouvrages les mieux connus de cette époque ont été projetés sans collaboration d'un architecte.

ZUSAMMENFASSUNG
Ein Rückblick auf die Vorstellungen über die Aesthetik im Brückenbau während der Gründungszeit der Internationalen Vereinigung für Brückenbau und Hochbau wirft folgende wichtige Frage auf: Welche Funktion übernimmt der Architekt beim Entwurf einer Brücke? Viele sind der Meinung, dass der Entwurf einer Brücke ein gemeinsames Werk von Architekt und Ingenieur sein sollte, wobei der Architekt hauptsächlich für die ästhetische Wirkung des Bauwerks verantwortlich ist. Einige waren jedoch überzeugt, dass die Ingenieure den Entwurf allein ausführen und nach Formgebungen suchen sollten, welche sowohl technisch einwandfrei als auch ästhetisch zufriedenstellend sind. Der Artikel erwähnt Robert Maillart, ein Ingenieur, dessen bekannteste Werke jener Zeit selbständig und ohne Mithilfe eines Architekten entstanden sind.

During the eight-year period from 1925 to 1933, there appeared substantial discussion of bridge aesthetics both in Europe and in the United States. The primary aesthetic question in this period, and to a large extent the primary question today, is the role of architecture in bridge design. Although some writers of the earlier period took the position that architecture and engineering, having regrettably gone separate ways in the nineteenth century, should re-unite, with the architect setting form, nearly all writers took one of two other positions. The first group agreed that for technical reasons the engineer should be the principal designer but that an architect was needed for aesthetic advice; while other writers held that the engineer should set the form alone and should learn to combine technique and aesthetics in design.

Bridge Design by Collaboration

Many writers and most designers believed in some sort of collaboration between the architect and the engineer. Perhaps the most detailed survey of bridge aesthetics from this point of view appeared in a four-part 1930 treatise by a young Austrian engineer Paul Abeles [1].

Abeles surveyed the writings of various architects and he then discussed critically the writings of a series of engineers. Abeles singled out two papers presented at the second International Meeting for Bridge and Structural Engineering in Vienna in 1928. One of these was by F. Hartmann who had just published a book on Bridge Aesthetics in Vienna [2]. From analyzing these works Abeles concluded that bridge form must come primarily from engineers. Since in his view the engineer was preoccupied with technical study, however, Abeles recommended the use of an architect as an "astistic consultant". This type of collaboration became common practice on many important bridges and is still widespread.

One of the most significant American writers of this period, Wilbur Watson, recognized the same problem of the busy engineer by comparing pre-nineteenth century designers such as Jean Perronet to twentieth century ones for whom "modern conditions demand far more training and experience than can be expected from an individual" [3]. He concluded that "Collaboration between architects and engineers is, therefore, necessary, and should begin with the inception of the work". Abeles discussed but did not recommend this position because, in his view, the resulting work would lack unity, being a compromise between the ideas of two designers.

The Engineer as Bridge Designer

Hartmann's Vienna presentation stressed the negative role architects had played in bridge design by adding useless decoration. Hartmann emphasized that modern design required a break with established rules and that proper design required a new theoretical knowledge that was foreign to architects. Hartmann concluded that engineering students should be taught aesthetics from several professors so that later judgments would be free from the dogma of a single teacher and would represent the designer's own ideas.

This Vienna paper by Hartmann has substantial historical interest because of the prominence both of the author and of the paper within the 1928 Congress itself [4]. Friedrich Hartmann (1876-1945) was the president of the entire 1928 Congress and he opened the proceedings by outlining its scope and goals in a speech "which had left an exalting impression on all delegates". Hartmann, a professor at the Technical Institute in Vienna, was a distinguished engineer of international stature. The fact that he chose to speak in the technical sessions on the subject of aesthetics marked a significant departure from similar technical meetings.

But the paper's importance also comes from its location as the opening report at the Congress and its stimulus to an extensive discussion. Only two other report topics out of the twenty given received as much discussion. Even more significant to this present paper is the fact that Hartmann began his essay by discussing the role of the architect in bridge design. His argument is characterized by the following quote:

"Today the dogma is held that a masterpiece of bridge design can be gotten only by the close collaboration between engineers and architects even at the outset of the design. However, experience shows that a masterpiece of art hardly ever comes through collaboration but rather only through the direction of one master. That the architect is not that one who today can create alone a masterpiece of bridge design hardly anyone would doubt. The design of bridges depends upon so many different conditions, which only the engineer understands, that the engineer themselves, therefore, must also deal with the artistic side of bridge structure."

This emphasis upon the engineer taking on the complete design including aesthetics had, for Hartmann, consequences for education as well as for practice. Just as engineering designers should consider all aspects of design so should teachers of bridge structures, thus aesthetics should not be just a separate course but more important it should be integrated into each course on structures. "So it will be best if each professor will concern himself basically with the aesthetics of his specialty and discuss that with his students." His implication was that there should be a unity in teaching as much as in design and that the professor should strive for the same completeness in teaching as does the practitioner in designing.

Hartmann's paper and his book are of especial value today because of their numerous illustrations and of his critical comments on them. Particularly instructive is his discussion of reinforced concrete bridges largely because he is critical of their heavy appearance, just the feature, stone-like heaviness, that appealed to so many writers of this period. Hartmann clearly preferred steel bridges largely because they appeared lighter. His criticisms of the largest reinforced concrete bridges in Switzerland are perceptive and useful even today. Because his book appeared in 1928, it predated the mature works of Robert Maillart; some of Hartmann's criticism reflects aesthetic ideas that Maillart would put into constructed form during the twelve years between the Vienna meeting and his death in 1940.

Hartmann's book was not a systematic treatment and we would not today agree with all his judgements; but he did make judgements and he tended to avoid general arguments based on rules. But most significant was his emphasis on the importance of the engineers thinking out the problems of bridge aesthetics freed from the proscriptions of the past so often based upon architectural ideas no longer appropriate to the building materials of the twentieth century.

Many of the ideas of the period 1925-1933 were also summarized in a 1933 book on bridge aesthetics "Brückenästhetik" by Herman Rukwied, an engineer for the German highway authority. Rukwied saw bridge aesthetics as a part of architecture the analysis of which followed from such "concepts as unity, variety, symmetry, line, contrast ... proportion" [5]. Although Rukwied stressed what he believed to be the architectural character of bridge aesthetics, his book stimulated perhaps the first clear expression of bridge aesthetics as a characteristic of modern engineering.

On March 11, 1933, Werner Jegher wrote a review of Rukwied's book for the 'Schweizerische Bauzeitung' in which Jegher strongly criticised Rukwied's attempt to apply "eternal standards" to modern works of engineering [6]. According to Jegher, modern engineering has little relationship to the architecture of past times and "it does not do to stand in an isolated place and to wish to comprehend today's bridge by contemplation as if it were a Greek temple".

This critique continued in the October 28, 1933, issue of the 'Schweizerische Bauzeitung', in an article by the editor on several deck-stiffened arch bridges of Robert Maillart [7]. Rukwied had criticized Maillart's Valtschielbach bridge for having too thin and too flat an arch. For Rukwied, the heavy, solid-walled Via Mala bridge nearby was "magnificant and well-proportioned". The editor of the 'Schweizerische Bauzeitung' (probably Jegher) criticized this judgement with relish, noting that the poor mountain people of the region Graubünden and Berner Oberland happily were not "infected with aesthetic scruples when they requested from their engineer the least costly solution" for their bridges. The editor noted further that "the results must be pleasing in an everyday sense; it is not for Sunday dress that they reach".

The editor stated the goal that "a structure in the first place must be true to its inherent features, a pure expression of its being, of its purpose. Thus, an expensive beautiful heavy masonry arch for this bridge (Valtschielbach) would be a lie even if the proportions of deck and arch were handled with subtlety". The Maillart bridge was "simple and true and the aesthete will have to learn to see and to appreciate the beauty of these newly created forms and proportions. Then he will no longer condemn those works automatically on the basis of a comparison with works formed under totally different conditions and appropriate only to their time".

The 'Schweizerische Bauzeitung' editor put forward a radically new idea for bridge aesthetics in which beauty arose from the solution of new problems. In his view, to understand the aesthetics required an understanding of the technical and economic conditions under which the work was designed. In the case of the Valtschielbach bridge, Rukwied did not understand that the arch could be thin and flat because it was stiffened by a deck girder. This new technical idea made possible a new form of aesthetic expression which altered the conventional proportions of deck and arch.

Two major reasons for the special insight of the 'Schweizerische Bauzeitung' into bridge design were, first, the emphasis of the magazine on individual works and individual designers, and second, a policy of giving aesthetic judgements mainly on works about which it also gave considerable detail on the structural behavior and costs. For the 'Schweizerische Bauzeitung', Robert Maillart was the most important contemporary Swiss Bridge designer of the 1925-1933 period and it was therefore no accident that the editor used one of Maillart's bridges as the example with which to refute Rukwied's thesis.

From Valtschielbach to Schwandbach

The 'Schweizerische Bauzeitung' criticism came in the context of a discussion of Maillart's 1933 Schwandbach bridge. The progression from the Valtschielbach to Schwandbach bridges gave new evidence of the aesthetic possibilities of engineering by engineers [8].

Contrary to the views of writers who thought the technical problems too time-consuming to permit aesthetic study, Maillart's thirty year experience with arch behavior gave him the insight essential to simplify radically the technical analysis for the Valtschielbach bridge. As a result, he did not need long hours of study to analyze the form but could draw upon long years of technical experience.

Valtschielbach represented not merely a culmination of technical experience, but also a new beginning in the aesthetic possibilities of deck-stiffened arches. While Valtschielbach is a technical masterpiece, still in fine condition after fifty-five years of service in the harsh, high-altitude environment of Graubünden,

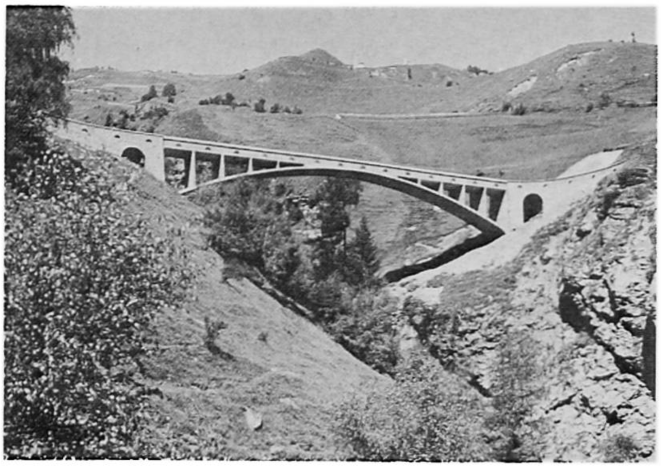


Fig. 1: Valtschielbach Bridge

it is not an aesthetic masterpiece (Fig. 1).

At Valtschielbach, a U-curve across a ravine is accomplished by a straight roadway deck and arch combined with sharp transition approach curves (Fig. 2). At Schwandbach, however, the same U-curve is achieved by one smooth elliptical curved deck supported by an arch whose concave side is curved in plan and whose convex side is straight in plan (Fig. 3). At Valtschielbach, the approaches are of heavy stone Romanesque arches. The arch is curved and merges with the parapet at the crown. At Schwandbach, the approach structure is light and open and has a girder of the same depth as the deck stiffener. The arch is polygonal and is separated from the lighter deck girder up to the crown.

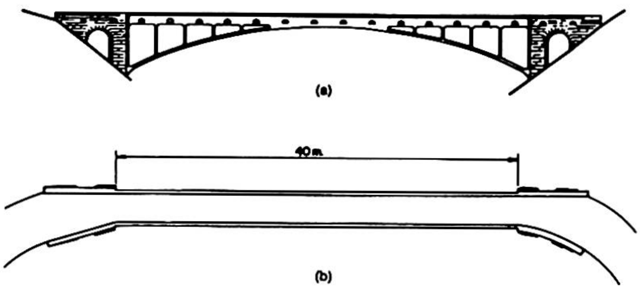


Fig. 2: Valtschielbach Bridge Plan

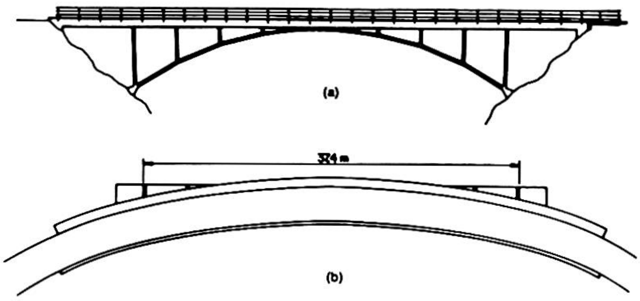


Fig. 3: Schwandbach Bridge Plan

The most dramatic difference between the two bridges, though, lies in how Maillart has connected the arch to the deck. In the 1925 bridge, the arch and the deck were exactly parallel and rectangular cross walls easily connected them. At Schwandbach, however, the arch was wider than the deck. Maillart introduced trapezoidal cross walls that provided not just a technically correct transition of forces but also gave a visually striking transition in form (Fig. 4).

Fig. 4: Schwandbach Bridge

Maillart defended his Schwandbach design in the 'Schweizerische Bauzeitung' in early 1934 by showing how alternative solutions proposed by an engineer F. Bohny from Sterkrade (Rheinland) would have been inferior both technically and aesthetically [9], Figure 5, taken from Ref. [9], illustrates Maillart's defence of his design. The first drawing shows the bridge as built, the second as proposed by Bohny and the third suggested by Bohny's argument. Of the second, Maillart noted that the constant width arch (follwing the plan of the curved roadway) gave the appearance of tipping toward the right whereas his design by having a wider arch at

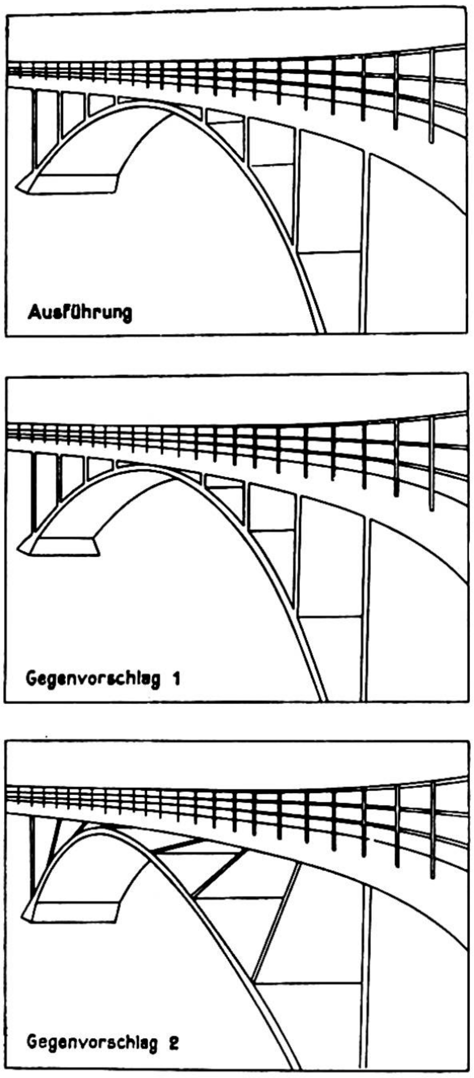


Fig. 5: Schwandbach Bridge and alternate proposals

the support "gave the appearance of stability and rest". As for the third design, where the arch would be straight in plan, Maillart commented that in addition to its greater cost und use of more materials, "also its aesthetic result is barely worth even discussing". His reply also including a careful technical discussion of how the loads were carried.

In this and in later writings, Maillart showed an inseparable concern for both technical and aesthetic excellence. In his eight-year experience between 1925-1933, he consulted no other designer. His three principles, articulated in the 'Schweizerische Bauzeitung', were to work within the constraints of the relatively new material of reinforced concrete, to apply his original insight into deck-stiffened behavior, and to achieve minimum cost. There was no imposition of aesthetic rules in his designs but there was a strong desire for aesthetic results.

At the close of this eight-year period, discussion of bridge aesthetics waned but the record of those years still provides a sound basis on which to analyze works of the 1980s: to achieve a more perfect integration of high technical quality, low cost, and aesthetic excellence in bridges.

Acknowledgement

The research for this paper was supported by grants from the National Endowment for the Humanities and the National Science Foundation for the writing of a biography of Robert Maillart. Support has also been provided by the National Endowment for the Arts, a Federal agency in Washington, D.C. Finally, I would like to acknowledge posthumously Dr. Paul Abeles who not long before his death kindly sent me his 1930 paper on aesthetics which stimulated this present paper.

References

[1] Abeles, P. "Ueber die künstlerische Gestaltung von Ingenieurbauwerken", Oesterreichische Bauzeitung, No. 2, 3, 4 and 5, 1930.
[2] Hartmann, F. "Aesthetik im Brückenbau", Leipzig and Vienna, 1928.
[3] Watson, W.J. "Bridge Architecture", Wm. Helburn, Inc., New York, 1927.
[4] Report of the 2nd International Congress for Bridge and Structural Engineering, Vienna, Sept. 24-28, 1928, Vienna, 1929. Hartmann's paper appears on pages 12-25. Pages 1-11 describe (in three languages) the organization of the Congress and Hartmann's prominent role in it.
[5] Rukwied, H. "Brückenästhetik", Berlin, 1933, p. 75.
[6] Jegher, W. "Review", Schweizerische Bauzeitung, Vol. 101, 1933, pp. 121-122.
[7] "Gekrümmte Eisenbeton-Bogenbrücken", Schweizerische Bauzeitung, Vol. 102, 1933, pp. 218-219.
[8] D.P. Billington "Robert Maillart's Bridges", The Art of Engineering, Princeton University Press, 1979, pp. 94-98, from which come Figs. 2 and 3.
[9] "Discussion", Schweizerische Bauzeitung, Vol. 103, 1934, pp. 132-133.

I

L'esthétique des ouvrages d'art

Die Aesthetik der Bauwerke

Aesthetics of Constructions

PAUL CONIL
Architecte-Ingénieur EIM
Carpentras, France

RESUME
Un ouvrage d'art doit avant tout remplir sa fonction,

– il doit être solide et stable,
– il doit aussi ne pas être désagréable d'aspect.

La beauté est le résultat d'une action humaine qui exige connaissance, culture et un effort de recherche.

ZUSAMMENFASSUNG
Ein Bauwerk muss vor allem seine Funktion erfüllen:

– es muss solid und standfest sein
– es muss auch einen angenehmen Anblick bieten.

Die Schönheit ist das Resultat einer menschlichen Tätigkeit, die Kenntnis, Kultur und Forschung voraussetzt.

SUMMARY
A construction should first of all fulfill its function:

– it should be resistant and stable
– it should also be not unpleasant to look at.

Beauty is the result of a human activity which requires knowledge, culture and research.

1. BASES

Un ouvrage d'art c'est de l'architecture monumentale.
VITRUVE il y a 2000 ans, en a défini les bases dans son livre premier dédié à CESAR:

- la disposition "Diathesis"
- l'ordonance "taxis"
- l'eurythmie, la proportion et la distribution "oeconomia"qu'on traduit par utilité, c'est-à-dire fonction
  solidité, c'est-à-dire structure
  beauté, c'est-à-dire forme.

2. VISION ET FORME

L'acquisition de la forme se fait par la lumière, puis la vision oculaire, simple relais, et l'enregistrement dans le cerveau.

Seules les radiations de 4000 à 7000 A° sont visibles et l'oeil observe l'Univers comme un astronome qui examinerait le ciel du fond d'un puits.

C'est toutefois une merveilleuse lucarne qui distingue les subtiles variations de fréquence permettant de séparer les couleurs et d'apprécier les jeux d'ombre et de lumière.

Il est des visions réelles ou virtuelles, objectives ou subjectives, affectives, poétiques, imaginaires ou intérieures. C'est par cette dernière que commencera une étude plastique.

La forme étant la partie visible d'un objet, elle se modifie par le déplacement de l'oeil, la vision binoculaire permet d'apprécier les distances et distinguer les reliefs qui peuvent être accentués par le jeu mouvant des ombres suivant l'heure, la nébulosité, la latitude.

"Il faut des yeux pour voir un objet mais il faut de l'Esprit pour apprécier une forme".
Cette citation n'est pas récente car elle est de PLATON dialoguant avec DIOGENE.

3. INVENTION ET CREATION

Il n'est pas nécessaire et c'est même inutile, d'inventer deux fois un mode constructif ou une structure qui donneront des familles de formes. Par contre, la création a un visage multiple et peut être indéfiniment renouvelée, elle complète l'invention sans être enopposition, mais si l'invention peut être collective, la création est habituellement individuelle.

Créer, c'est affirmer et mettre au point une forme respectant toutes les contraintes de fonction et structure, ce sera le fait de la méditation et du travail pour le plaisir de réussir.

On fera de la recherche plastique pour "donner de l'Esprit aux formes".

Si la résistance et la stabilité ont des règles et même des règlements, la beauté n'a pas de définition.

Les éléments de la recherche plastique sont principalement:
- l'ordonnance;
- la proportion et l'harmonie des composants;
- le rythme;
- l'échelle humaine;
- la couleur et le modelé de surface.

Ces éléments ne peuvent être codifiés.

L'ordonnance doit donner une juste mesure, par rapport à la destination de l'ouvrage.

La proportion et l'harmonie des composants s'obtient par un rapport subtil entre leur dimension en volume et entre les longueurs hauteurs des grandes lignes jusqu'au détail.

Le rythme est, comme en musique, un rapport dans la cadence des dimensions linéaires et des valeurs donnant une périodicité.

L'échelle humaine est la base harmonique et rythmique de tout ouvrage, car l'homme construit pour l'Homme.

On a souvent employé les rapports du pouce, du pied, de la coudée et de la toise, qu'on agrandit par analogie.

Des tracés modulaires tenant compte de ces proportions et aussi de rapports algébriques simples, ont été établis depuis l'Antiquité (canons de Polyclète, de Vitruve, de le Corbusier ...).

Pour des ouvrages de très grande dimension, il est certain que l'échelle humaine, n'apparaît que dans les zones restreintes, où passe l'Homme (ex: gardes corps du pont Verazzano, N.Y.).

La couleur et le modelé des parois, sont des éléments plastiques dont l'emploi est souvent aléatoire.

Il faut distinguer les couleurs:
- uniformes;
- en camaieu;
- en harmonique;
- en hiatus;
- naturelles ou appliquées.

Il est nécessaire de les intégrer au site.

Les ouvrages en pierre ou en béton armé, ont la couleur de leurs composants en surface. Certains liants gris-foncé ont un aspect souvent déagréable, c'est une question de choix au départ.

La couleur des ouvrages métalliques est généralement celle des peintures de protection, on les maitrise aisément.

On a intérèt à garder la couleur naturelle des édifices en bois.

Le fini de surface, particulièrement pour le béton armé, peut être conçu avec une infinie variété d'aspects, c'est une question de coffrage, on peut obtenir tous les jeux d'ombre et de lumière imaginables. Il faut tenir compte des distances de vision, de l'intégration sur le fond, et la règle générale sera la sobriété.

Symétrie

La symétrie est un moyen d'expression, mais il ne faudrait pas croire que c'est une panacée. Si l'on veut sortir du banal, son maniement n'est pas simple. Un musicien que les Viennois connaissent bien, savait, jouant avec des symétries cassées presque imperceptiblement, faire passer une phrase musicale du banal au sublime; il s'appelait MOZART.

Le Parthénon est un exemple de symétrie, mais il n'est pas un tracé simple, oeuvre d'architecture et de génie civil c'est bien un ouvrage d'art.

On n'y trouve aucune parallèle, aucune droite, pas de verticale, si ce n'est l'axe de symétrie qui est une ligne imaginaire.

La symétrie est un moyen extraordinaire d'expression pour l'homme de talent capable aussi de créer des chefs-d'oeuvre en dissymétrie (ponts de Cologne et de l'Alma).

Les contraintes

- le Site et l'Environnement immédiat, peuvent restreindre le choix des formes de des couleurs. Une bonne connaissance du site est nécessaire. Il est des sites neutres, passifs ou actifs, stables ou évolutifs.

  Souvent l'ouvrage modifie le site, il faut harmoniser, mais il y a des cas où il le crée, il y a de multiples exemples tels:

- les pyramides de la plaine de Giseh. Il faut respecter les vues et les perspectives existantes, et vérifier si l'oeuvre projetée imposera son échelle au site et réciproquement, et imagnier quels seronts les points de vue principaux et leur niveau, et parfois même les créer.

- citons les contraintes de sol, de fondation, d'ancrage;

- les divers types de structures posent un problème de choix, de comparaison puis de décision, qui s'intègre à toutes les autres contraintes.

- L'aspect plastique est primordial pour l'intégration au site. Il faut trouver une moyenne mesure entre le neutre et l'agressif.

- On ne réalise pas un grand ouvrage pour une seule génération;

- L'Homme construit pour l'Homme et le politique et l'administratif jouent souvent un rôle décisif dans la génèse et l'implatation.

- L'économique et le social interviennent dans les coûts et les délais.

- La presse, les critiques, l'opinion publique, les compétents et les incompétents, jouent quelquefois un rôle inopportun ou négatif, car "la démarche de l'Esprit est aisée tant qu'elle n'est pas soumise au réel." (Lecarme).

  Le projeteur, porteur des responsabilités, le sait bien.

Les structures

Les divers types de structures posent un problème de choix, de comparaison puis de décision; qui s'intègre à toutes les précédentes contraintes.

Le choix d'une structure est souvent conditionné par des problèmes de sol, d'accès, d'approvionnement, de coûts, de délais, de qualification de la main d'oeuvre disponible, outillage, levage force motrice.

La prise de décision est souvent ardue. Elle influence largement le choix des formes et l'aspect plastique de l'ouvrage.

L'Ingénieur et l'Architecte

Chaque type de structure impose une famille de formes, et les structures nouvelles en augmentent le registre sans modifier les bases de l'esthétique: harmonie, rythme, échelle.

Il est facile d'analyser une oeuvre existante, ancienne ou récente pour en tirer un enseignement car nous bâtissons pour le futur avec l'apport du passé. Par contre, la création est une action de synthèse, caratérisée par la simultanéité des options et des contraintes.

Les excès doivent être évités et l'utopique n'a de place que dans les revues.

Dans l'étude d'un grand ouvrage d'Art, l'architecte a un rôle mineur mais toujours indispensable.

L'ingénieur a le choix des structures et donc de la famille de formes.

L'architecte étudie l'environnement, l'intégration de l'ouvrage au site, et les rapports d'échelle. Il est le plasticien et il apporte sa contribution à la mise au point esthétique, dès le début de l'étude.

Il suffira souvent de modifications mineures pour changer complètement l'aspect d'un ouvrage.

Le rôle de l'un et de l'autre, doivent être non antagonistes mais complémentaires et conjuguer l'Esprit d'analyse de l'ingénieur avec l'Esprit de synthèse de l'architecte.

Leur collaboration peut faire d'un ouvrage d'art, une oeuvre d'art.

Leere Seite
Blank page
Page vide

I

Relativity and Optimization of Aesthetic Rules for Structures

Relativité et optimisation des règles concernant l'esthétique des constructions

Relativität und Optimierung der Aesthetik-Regeln für Ingenieurbauten

T.P. TASSIOS
Prof. Dr.
Nat. Techn. University
Athens, Greece

SUMMARY
An attempt is made to "translate" basic theorems of aesthetics into guidelines and rules for the appearence of engineering structures. Some incompatibilities between these rules are stressed and the need for an optimization is made evident. Some levels where such optimization should take place are commented. The paper presents a few examples of bridges.

RESUME
On s'efforce de "traduire" les théorèmes fondamentaux de l'esthétique en directives et règles concernant l'aspect des ouvrages de l'ingénieur. Quelques incompatibilités entre ces règles sont soulignées. La nécessité d'une optimisation est montrée. Quelques niveaux sont indiqués, auxquels cette optimisation doit avoir lieu. La communication présente quelques exemples des ponts.

ZUSAMMENFASSUNG
Der Verfasser versucht, grundlegende Sätze der Aesthetik in Richtlinien und Regeln über das Aussehen von Ingenieurbauten zu übertragen. Gegensätze dieser Regeln werden aufgezeigt, und das Bedürfnis nach einer Optimierung wird angedeutet. Es wird diskutiert, wie diese Optimierung angewendet werden könnte. Die Arbeit zeigt auch Beispiele von Brückenbauten.

Preamble

This paper is largely based on a Monography, of the same author, entitled "Theoretical attempts for the Aesthetics of Engineering Structures", Hellenic Humanistic Society, Athens, 1980.
The basic statements to which that monography has concluded, are here "liquified" (so to say) into general guide-lines and, subsequently, to possible design rules.
However, it is very important to emphasize right now that all we are dealing-with here is but a vague, insinuative and oversimplified sketch of a very complex and intricate mechanism. Consequently, the final results of our endeavours have to be equally seen with great reservedness. After all, to quote HUISMAN, 1961, "the only criterion of Art is ecstasy"...

1.- GUIDE-LINES

To begin-with, under the heading "guide-lines", Table I includes first a translation of the aesthetic theorems (major statements) and principles (minor statements) into some more common expressions.
Here come only few comments related to some of these "translations" connected with the optimisational approach this paper is dealing with:

a) **The functionalistic panacea**

An engineering "product" should express its purpose; otherwise it would violate the first theorem. It should, therefore, have a clarity of its function.
On the other hand, function alone does NOT necessarily suffice to dictate every characteristic of the final form; such a wholistic claim would arbitrarily abolish all other theorems and principles of aesthetics. And with a nice "theory" it would possibly lead to ugly structures, unless functional consequences happen (by coincidence) to fulfill many other aesthetic prerequisits. As this is not always the case, functionalism in Struct. Engineering cannot be retained as an aesthetic panacea.
Nervi's wonderful structures offer possibilities for discussions on statical functionalism. His Wool Factory, Rome 1953, has become famous for its ceiling (Fig. 1): The pattern of its ribs follows the isostatic lines of the principal bending moments, "a design which makes possible strict adherence to the laws of statics, and therefore makes the most efficient use of the materials. The aesthetically satisfying results is a clear reminder of the mysterious affinity to be found between physical laws and our own senses", (NERVI, 1965). A micro-functionalism is set-forth here but with much less success, I am afraid:

- There is an infinity of lines of principal moments; which were the criteria for the selection of exactly three M_t-lines and sixteen M_r-lines?
- The "most efficient use of materials" contradicts in this case the "most economic result": curved ribs are much more expensive than straight line ribs...
- Yet, which was the criterion for the selection of structural height and thickness of the ribs? And why not variable height or thickness, following the variability of moments? Incidently, this was in fact the case (variable thickness) in the rectilinear ribs of the ceiling of the Bologna's Monopoly Warehouse (Fig. 2) of Nervi...

The writer of this paper takes the liberty to suppose that the Engineers have saught, here too, an interesting form based on their indisputable inspiration and the well known rules for modern indus-

Table I: A e s t h e t i c a l features to be O P T I M I Z E D (*) in the specific structures and under the specific circumstances

	BASIC STATEMENTS ON AESTHETICS	Constraints: Physiology	Constraints: Historical environment	Constraints: Education + experience	Constraints: Psychological conditions	Guide lines: Positive statements	Guide lines: Possible negative extremes	Possible design rules (which, nevertheless, should be optimized)
Major	1.- Compatibility of form and substance		+	+	+	• Clarity of function, plus possible message	• Boredom	- Give the appearance of strength and stability (+camber of beams, concave soffit of cantilevers etc) - Display the statical solution - Exhibit function and purpose - Slenderness?
						• Sincerity related to the properties of materials	• Mannerism	- Elimination of the needless elements (i.a. by means of colours) - Display the basic consequences of using specific materials - Avoid unconnected ornaments
	2.- Freedom and variety in the small scale			+		• Diversification-internal antagonism	• Chaotic complexity	- Limitation of the number of direction of lines - Repetitions ("rhythm") - Odd number of bays etc - Use of textures
	Order and unity in the large scale	+			+	• Harmony and whole-seeking organization	• Unpleasant uniformity	- Fittness in environment - Expressive proportions - Transition lines - Unity by means of dynamic lines tending to unify, (not to uniformize) - Optical corrections
Minor	a.- Maximization of "information" or minimization of effort to understand and explain it	+	+	+		• Meaningfulness	• Fatigue feelings	- Point of reference in the environment (without descaling it) - Additional simple symbols
						• Simplicity and clearness	• Monotony	- Underlying contrasts to subline main topic - Simple line boundaries
	b.- Some margins for self-action (for imaginative completion)			+	+	• Elleiptic style	• Feeling of disorder	- Interrupting elements - Local disproportions - Certain blanc spaces

(*) For the space where optimization is to be performed, see § 3.

trial design. The idea of the isostatics has contributed to the creation of order with variety; but when these lines are seen in perspective produce a certain confusion (which does not exist in the solution of Bologna's Warehouse...)
Consequently, "there is not only one true form, as Nervi would seem to claim, nor can the science of statics alone determine an architectural form"[a], (MICHELIS, 1966). In this connection too, it is worth to remind that statics does NOT always lead to a unique form. It suffices to remind the possibilities offered for a heavy simple beam (Fig. 3): You may adopt a concave lower boundary line (adapted to the diagramme of bending moments), or a straight line (if an internal, thus invisible, prestressing is used), or even a convex line in case a shear-sensitive material is used!
Definitely, pure functionalism seems today as another obsolete "scientific imperialism"; the modern complimentarity principle in philosophy of science tends to replace, here too, wholistic oversimplifications by a more modest vision of a multiface-reality.

b) **Sincerity related to the properties of materials**

This is another understandable translation of the theorem of compatibility; it has been said that the sensitive aesthetic mechanism is destroyed as soon as any fraud or make-up is unveiled. Therefore, it is reasonable not to disguise materials. Instead of it, we have an interest to try to create expressive forms out of the opportunities offered by the specific properties of a new material. However, a certain indulgence is recommended in this connection: "Sincerity" of materials is one thing and offend the feelings of people is another; of people having not yet learned the new "vocabulary". A couple of examples might be here interesting:

- When bridge construction shifted from stone to steel, it took a very long time to the "public opinion" to be initiated; the non-continuum character of trusses, when compared to stone arches, and the multitude of directions of their rods had produced a mixed feeling of instability and confusion. For the famous (and beautiful, for the standards of today) steel-truss cantilever Bridge at First to Forth (Fig. 4), at Scotland (1880), art critic W. Morris had written: "There never would be an architecture in iron, every improvement in machinery being uglier, until they reach the supremest specimen of all uglines, the Forth Bridge", (INGLIS, 1944).
- After all, Parthenon itself is, partly though, a translation of wood temple into stone...

Finally, the term "sincerity" of a material can not be claimed to be nonequivocal: Reinforced concrete "hides", so to say, its own reinforcements. True, some proposals have been made to "indicate" the presence of steel bars (by painting or by means of mortar rods in relief), but nobody has seriously considered such proposals. Why? What "sincerety" has become in this case? I find this question as an excellent occasion to undermine the general applicability of the guide-lines we are dealing-with here, and to subline (once again) the need for an "optimization of rules". In fact, the display of some hints of reinforcements would really have offered a visual guarantee against the very low tensile strength of R.C., but at what an incredible cost - a visual cost again: A mess of lines at several directions, superimposed to the main lines of the stru-

(a) Besides, from the standpoint of "structural accuracy and economy, the thickness of an arch must increase rapidly towards its springers but the artist may find an arch with constant thickness more appealing with respect to its environment", (TORROJA, 1967).

cture, would certainly produce a confusion; that is to say, in order to respect the rule of "sincerity" we should violate the basic rule of o r d e r...

2.- POSSIBLE DESIGN RULES

With all restrictions repeatedly mentioned along this paper, rules for a more aesthetic design of civil engineering structures do exist. That the use of these rules cannot necessarily produce a work of Art, is another thing; all the same as the use of rules of grammary and syntax can not necessarily secure the production of a good novel. The preparation of a set of such design rules is already achieved by means of the experience acquired out of the large, aesthetically successful, structures. Such is the case of rules observed and recommended by LEONHARDT, 1967, based i.a. on his personal vast experience as bridge-designer for decades, all over the world. Similar rules are suggested by many specialists-Members of the IABSE Task Group "Aesthetics and Structural Engineering". (See also WENGENROTH, 1971).
The last column of Table I is but an orderly rearrangement of well known rules, presented in c o r r e s p o n d e n c e with each aesthetic statement. In a way, these rules and many others may be systematically engendered by theorems, principles and guide-lines, in a r a t i o n a l way, partly though. Nevertheless, the short comments which follow, may offer empeirical backing to some of these design rules and show their limited value.

a) Appearence of strength and stability

Like the wife of Cesar, structures should not only be strong; they also should give the appearence of their strength. We have repeatedly mentioned the sensitivity of the aesthetic process which can not even start to function if safety is not f e l t, ("primum vivere, deinde philosophare"). Something more: We should spotaneously feel margins of safety as well. With non-perceivable upward curvatures of horizontal straight lines ("showing that they refuse to succumb to bending"), as well as with the decrease of spans near the corners, greek temples "overcome gravity and stand free", (MICHELIS, 1966). Similar visual "corrections" are systematically followed today (cambers etc). It is also appropriate to remind here that in modern bridge construction the diameters of piers' columns are sometimes disproportionately small (Fig. 5). Occasionally these structures are labelled as "not beautiful"; the subconsious feelings of unsafety might be the reason. I consider these feelings as an additional defeat of pure functionalism - since these columns are in fact strong enough, but they do not look so when compared to the impressive dimensions of the superstructure.
To end this paragraph with a more relativistic modesty, we should remind the imposing role of previous mental concepts: "Why is the column of a lamp-post much more massive and strong in shape than a flagpole (Fig. 6) which owing to wind forces has to with-stand a greater bending moment? And yet, just try to change one for the other! ", (TORROJA, 1967). Here again, Strength of Materials is not the decisive element; symbolic reasons might explain the preference: A flagpost should f i g h t and still stand - a symbol of battles where flag used to move ahead.

b) Display the statical solution

Independently of the conclusions of §1.a. against any functionalistic fanatism, the existing aesthetic potentialities of direct "statical" forms have also been made clear: Afterall, a "structural"

form possesses inherent features of a s t r u c t u r e[b] i.e. of an articulated whole of interdependent parts they obey a unifying law; consequently, such a form has already some of the aesthetic prerequisits.
Nevertheless, I feel it is my duty to remind here that, as it has been shown in §1.a., there is NOT an "automatic" correlation between statically correct and aesthetically satisfactory form.
The example of the purposeful error of Michelangelo in designing the Saint Peter's cupola should also be mentioned - an error which made necessary the strengthening of stone layers with iron: "Michelangelo knew beforehand that this was the weak point of the stability, but did not hesitate to adhere to this design, (although he did tone down this mechanical defect later)", (TORROJA, 1967).
Conclusion: Here again we will adhere to the rule without pushing to the point of another un-aesthetic formalism.

c) **Expressive proportions**

Here comes one of the most controversial and vague "rules". In TASSIOS (1980) after having discarded any esoteric power of arithmetic or geometric proportions, the aesthetic potentialities offered by some geometric figures have been theoretically reconfirmed. There are also many experimental (psychological) evidences regarding the pleasant feelings the "golden ratio" may impart to average people.
However, "it is always necessary to guard against too strongly held stereotypes: Supersonic aircraft with long thin fuselages and short tapered wings seemed out of proportion when they first appeared, largely because they were compared with more familiar subsonic types", (MAYALL, 1967).
Besides, proportions are strongly dependent on three-dimensional conditions, like the deformities because of a "wrong" angle of viewing: Compare Fig. 7a and 7b of the same bridge (Paleocastro, Crete) seen from the road or from the valley; who (and from where) is talking about good proportions?
Consequently, we have not succeded to give a concrete meaning to the usual claim for "pleasant" proportions, but we have been possibly able to forward the need for e x p r e s s i v e proportions and to underline the rather relative value of a specific rule for proportions.

3.- O P T I M I Z A T I O N

All aesthetic statements, guide-lines and rules retained in Table I have been set forth under a certain reservedness: They are not always c o m p a t i b l e to each-other; consequently, their hierarchy has to be rebuilt each time.
The task of this writer is reduced to a mere enumeration of some possible l e v e l s where such optimisation should take place:

a) **The quality of the observers**

"Appreciation of the artistic quality of modern work, demands technical culture on the part of the observer", (TORROJA, 1967). In fact, cultural standards influence the aesthetic choices of people. I have experienced a negative attitude of serious people in front of one of my first prestressed concrete bridges (Arta bridge, Fig. 8) because of its vicinity to an old bridge. "Do they not know anymore to make a nice solid bridge?". I am not sure my answer was convincing: "I am in favour of a purposeful contradiction; the

(b) Here the term is used with its broader philosophic meaning. Structural approach in the visual arts has been studied and forwarded by many contemporary scholars, like G. Kepes and others.

modern linear directeness marks-out the ancient curvilinear exaltation".
To which extent the need for compatibility of purpose (a "statical" purpose in the case of a bridge) and form, will be influenced by such social or historical considerations?
I would also like to add another example of my personal works related to a degree of "incompatibility" of form and purpose: Twenty years ago, I accomodated a large aqueduct (water section 3,5 m^2, total length 400 m) with a viaduct (Fig. 9) in such a common arrangement that does not leave the slightest reminiscences of any "hydraulic" purpose. Here the optimization went in favour of practical reasons...

b) **New materials and time-effects**

A similar incompatibility may be encountered between the need for structural sincerity (or "honesty") and the public opinion. Perception is performed through pre-existing mental schemata: The aesthetic transition from one material to another (§1b and Fig. 4) proved difficult and constitutes, again, a problem of optimization between structural sincerity and the public concept about beauty. The same pre-existing schemata, do they actually allow to appreciate the "beauty" of the newly developed pneumatic structures?

c) **Order versus a "honest" display of statical system**

In §1b we have encountered the need for "optimization or rules", in cases where the display of all structural components might violate the rule of order. Another everyday example of violation of the principle of displaying the statical system is the use of sandwich slabs covering the ribs, in favour of a clear "nice" appearance...

d) **Order and orderlines**

But, this continuous care for "order" cannot be a panacea. For KAHN "by order I do not mean orderlines". And for VENTURI, (1966), "meaning can be enhanced by breaking the order; the exception points up the rule. A building with no "imperfect" part can have no perfect part, because contrast supports meaning". Here again, we have to optimize between two extremes: "order" which satisfies our quest for unity and equilibrium, and "disorder" which, if used in an artful way, may create a "poetic tension in the architectural work" (VENTURI).

INSTEAD OF EPILOGUE

A certain rationalisation (i.e. a certain oversimplification) has made possible the drafting of some criteria for expressive appearance of engineering structures. Nevertheless, a certain incompatibility between these criteria has been noticed. Their optimization proved to be a really decisive stage, for which criteria cannot be available anymore; it seems that everything has to be played again within the "mind" of the artist!

REFERENCES

EYSENCK H.J.: "Sense and nonsense in psychology", Penguin, 1965
HUISMAN D.: "L' Esthêtique", Presses Universitaires de France, Paris, 1961
INGLIS C.E.: "The aesthetic aspect of civil engineering design", in I.C.E.series of lectures, 1944, repr. 1970, London.
LEONHARDT F.: "Aesthetics of bridge design", Journal of P.C.I., Febr., 1968.
MAYALL W.H.: "Industrial design for engineers", Iliffe Books, London, 1967.
MICHELIS P.: "L' Aesthêtique de l' Architêcture du Bêton-Armê", Dunod, 1963
MICHELIS P.: "Form in Architecture: Imitation and abstraction", in "Sign, Image, Symbol", ed.G.Kepes, Braziller, New York, 1966.
NERVI P.: "Is Architecture moving toward unchangeable forms?", in "Structure in Art and in Science", Ed. by G. Kepes, Braziller,New York,1965.
ROUGE H.: "Kunst und Kybernetik", Dumont Schauberg, 1968.
TASSIOS T.: "Encouragement of creative design in civil engineering education", VI FEANI Congress, Barcelona, 1974.
TASSIOS T.: "Theoretical attempts for the Aesthetics of Engineering Structures", Hellenic Humanistic Society, Athens, 1980.
TORROJA E.: "Philosophy of structures", University of California Press, Berkeley, 1967.
VENTURI R.: "Complexity and contradiction in Architecture", The Museum of Modern Art, New York, 1966.
WENGENROTH R.: "Bridge Engineer looks at aesthetics of structures", ASCE, Journal of Str. Div., April, 1971.

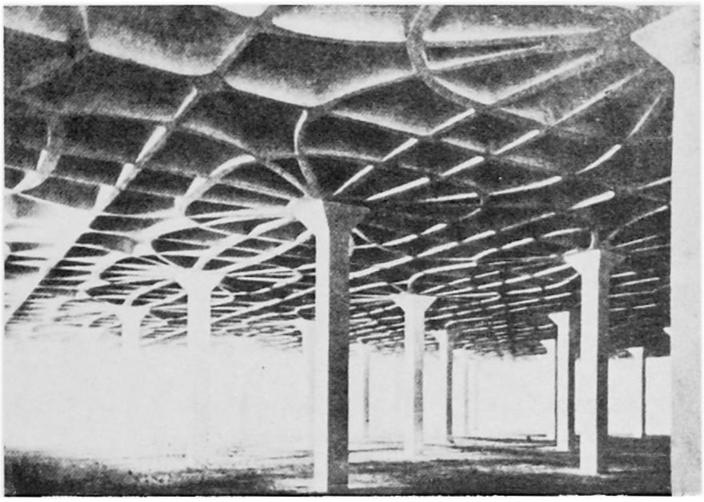


Fig. 1

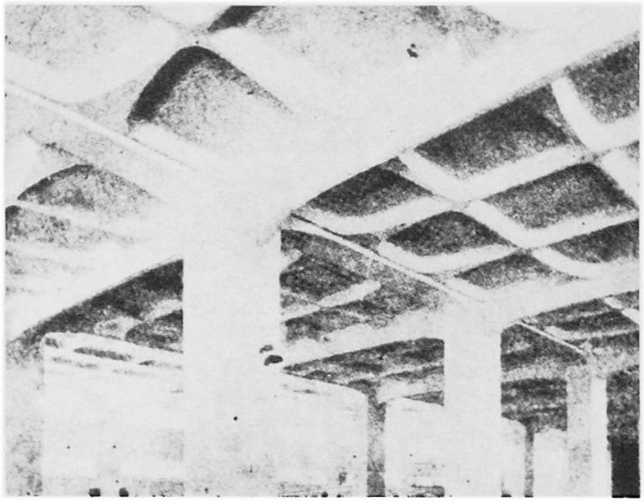


Fig. 2

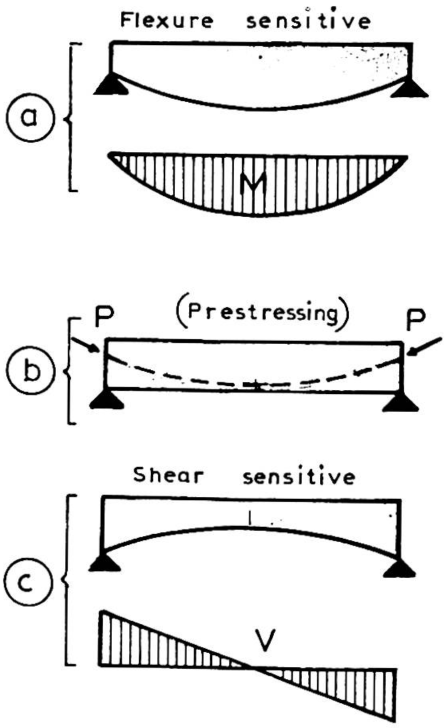


Fig. 3

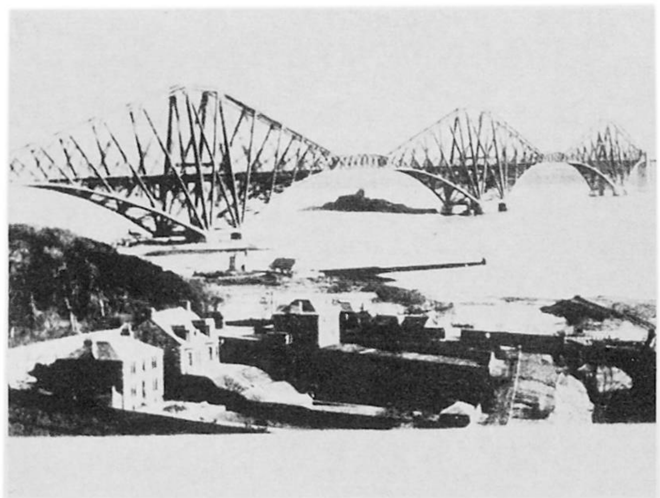


Fig. 4

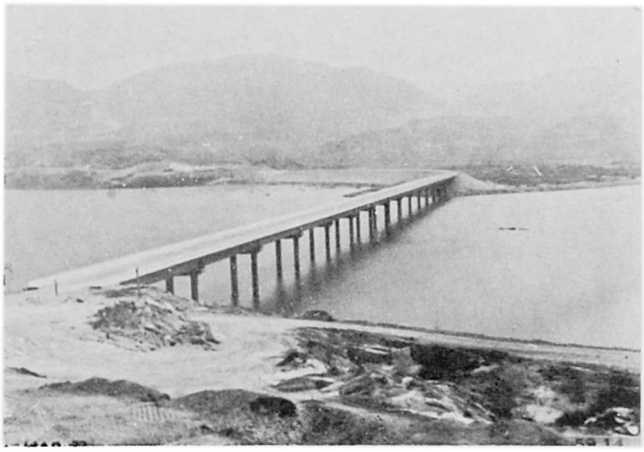


Fig. 5

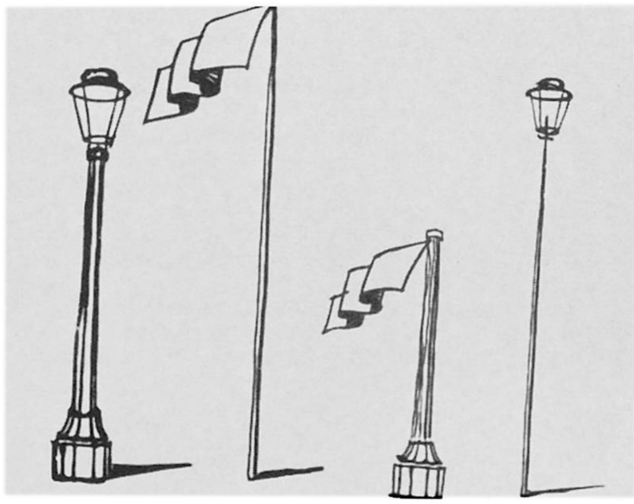
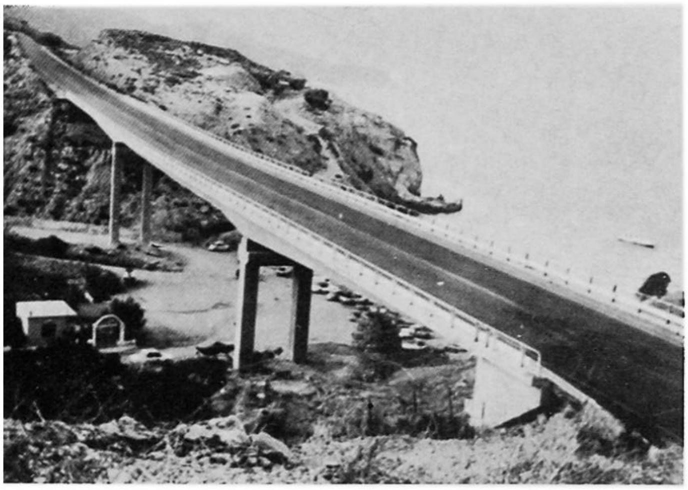


Fig. 6



'ig. 7a

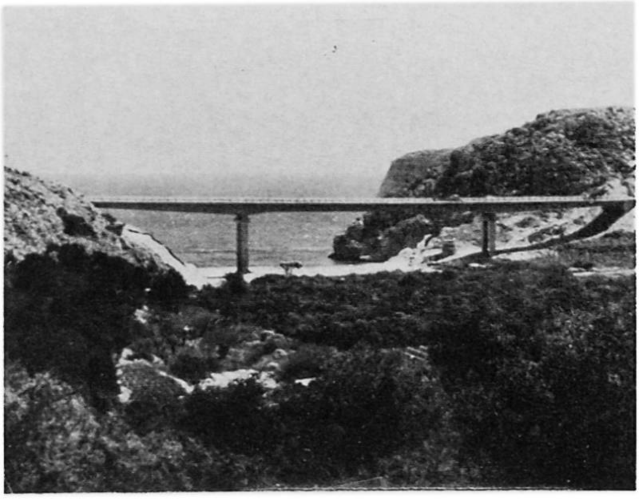


Fig. 7b

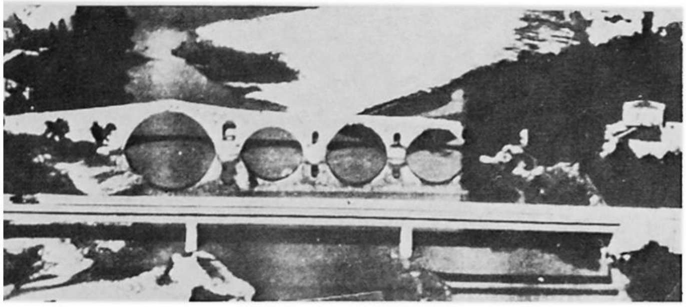


Fig. 8

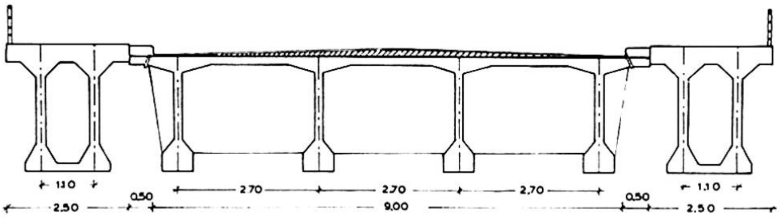


Fig. 9a

Leere Seite
Blank page
Page vide

I

Proportionen in der Natur und im Menschenwerk — wir messen, sehen und hören

Proportions in Nature and in Man-Made Structures — we measure, see, listen

Les proportions dans la Nature et dans les oeuvres humaines — nous mesurons, voyons et entendons

WALTER A. SCHMID
dipl. Ingenieur ETH SIA
Uetikon am See, Schweiz

ZUSAMMENFASSUNG
Unsere Augen gewichten Strecken oder Flächen oder Volumina unter sich. In Analogie dazu werden eine mindestens 2 400 Jahre alte Methode und das dazugehörige Musikinstrument Monochord erläutert, die uns ermöglichen, solche Gewichtungen (Proportionen) auch zu hören.

Beispiele für das sehende Hören oder das hörende Sehen führen uns von den Bauten der Antike über Dome des Mittelalters zu modernen Büro- und Brückenbauten.

SUMMARY
With our eyes, we can compare weight distances, areas, and volumes. An analogy is used to explain how it is possible to perceive auditively such weightings (proportions) with a method which is at least 2 400 years old and with the Monochord, the musical instrument employed in that method.

Examples of visual hearing or auditive seeing will lead us from the structures of antiquity to medieval domes and to modern office buildings and bridges.

RESUME
Notre oeil compare des distances, des surfaces ou des volumes. Une méthode d'au moins 2 400 ans est un instrument de musique, le monocorde, nous permettent, par analogie, d'apprécier de telles comparaisons (proportions).

Des exemples de cette audition visuelle ou vision auditive nous conduisent des constructions de l'Antiquité vers les cathédrales du Moyen Age pour aboutir aux constructions d'Immeubles et de ponts modernes.

A. UEBER DIE SCHOENHEIT ALLGEMEIN

Der französische Dichter Paul Valéry lässt in seinem Werk "Eupalinos" den Sokrates sagen:

> "Der Mensch unterscheidet drei Dinge auf dieser Welt: er findet seinen Körper, er weiss von seiner Seele, und als Drittes existiert der Rest der Welt. Es ist daher sinnvoll anzunehmen, dass das vom Menschen Geschaffene im Hinblick auf seinen Körper geformt werde, was dann als Nützlichkeit bezeichnet wird, oder im Hinblick auf seine Seele, das ist dann das, was der Mensch als Schönheit sucht. Aber auf der andern Seite hat jeder der konstruiert oder schöpferisch tätig ist mit dem Rest der Welt zu tun und mit den Kräften der Natur, die in allen Zeiten versuchen, was der Mensch geschaffen hat zu zerstören. Er muss daher ein drittes Prinzip beachten, das er seinen Schöpfungen mit auf den Weg geben muss: die Zähigkeit zu überleben. Er wird Beständigkeit und Dauer zu erreichen suchen."

Für Sie habe ich dieses Dichterwort in einem Diagramm festgehalten:

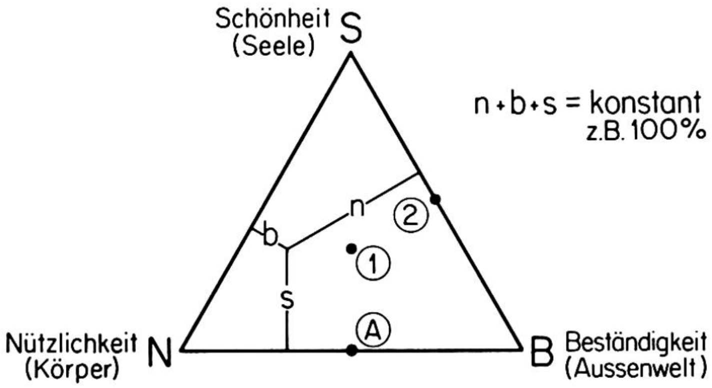


Fig. 1

Für alle Punkte innerhalb des gleichseitigen Dreiecks ist die Summe der Abstände von den Seiten konstant. Es wird möglich, drei Werte gegeneinander zu wägen.

In den Ecken ist der jeweilige Bereich des nur Nützlichen (N), des nur Beständigen (B) oder des nur Schönen (S).

Wenn Sie versuchen, Musik, Literatur, Bildhauerei und die Baukunst in diesem Diagramm zu plazieren, so fällt bald einmal auf, dass wir uns mit den Ingenieurbauwerken meistens um A (zwischen N und B) herum bewegen. Die Brücken müssen nützlich und beständig sein. Selten erheben sie sich Richtung Punkt 1, wie z.B. der Pont du Gard. Dient das Werk nicht mehr seinem Zweck, so landet die Römerbaute bei 2 (schön und beständig), während unsere Werke vielleicht nur noch beständig (Punkt B) sein werden.

Es hiesse wohl Wasser in die Donau tragen, wenn unter Technikern als Kernsatz für ihre Arbeit formuliert würde: "Alle Naturgesetze und -ordnungen sind einzuhalten." Das ist doch selbstverständlich.

Ja, nur ist es leider so, dass wir noch gar nicht alle Naturgesetze kennen. Von chemischen, physikalischen Gesetzen haben wir einen guten Schulsack voll mit auf den Weg gekriegt. In allem, was wir nach Sicherheit und Wirtschaftlichkeit bemessen, berechnen, d.h. rational zu fassen vermögen, finden wir uns einigermassen sicher. Sobald es jedoch um Seelisches geht, sind wir Stümper und dankbar für jeden hilfreichen Hinweis der Verhaltens- und Seelenforscher. Nur auf solchen Hinweisen aufbauend, gelingt es vielleicht im folgenden, der Schönheit Reverenz zu erweisen.

Während wir weder "nützlich" noch "beständig" hier zu definieren brauchen, sind doch wohl einige Worte nötig, als Antwort auf die Frage: "Wann empfinden wir etwas als schön?" Bleiben wir bei Valéry, der so klar sagt, dass die Schönheit aus der Seele entsteht, und geben kurz zu bedenken, dass Seele das ist, womit wir leben. Für alles Leben gilt der eherne Grundsatz: "Immer wird das jeweils Beste angestrebt, d.h. zu verwirklichen versucht."

Schönheit entsteht als eine Lebensäusserung. Sie ist seelischer Ausdruck. Nach einem weiteren Naturgesetz, der Eindruck-Ausdruck-Kausalität, wird die Schönheit den Empfangenden beeindrucken, und zwar positiv, lebensfördernd, etwas in ihm wird anklingen und ihn erheben, aufbauen.

Innerhalb unserer Arbeitsgruppe sind wir auch auf die Frage gestossen: "Warum empfinden wir etwas als schön?" Monochord-Versuche haben mich zur Hypothese gebracht: es sind Ur-Bilder, die in uns aufleuchten, wenn unser Gefühl sagt: "Für mich ist das schön."

Hören wir C. G. Jung:

> "Ich kann nur in tiefster Bewunderung und Ehrfurcht anschauend stille stehn vor den Abgründen und Höhen seelischer Natur, deren unräumliche Welt eine unermessliche Fülle von Bildern birgt, welche Jahrmillionen lebendiger Entwicklung aufgehäuft und organisch verdichtet hat."

B. UEBER DIE SCHOENHEIT VON BAUWERKEN

Mit Messen und Rechnen scheinen wir die Form des zukünftigen Bauwerkes in den Griff zu bekommen. Darüber werde hier nicht gesprochen. Das, was jedoch später etwas im Betrachter zum Klingen bringt und ihn "encore" rufen lässt - nochmals möchte ich das sehen, so gut tut mir das! - liegt nicht auf Verstandesebene - wir benützen höchstens später den Verstand, um uns zu verständigen darüber -, sondern das sind Qualitäten, Wertungen, dem Seelischen verhaftet.

"es muss stimmen"

Der weise, fast hundertjährige Kunstmaler Carl Roesch hat als Summe seines Kunstschaffens kurz vor seinem Tode gesagt: "Ein schönes Werk muss stimmen." Das heisst wohl, es muss in Harmonie sein. Denn so "stimmen" wir ja auch unsere Musik-Instrumente. "Stimmen" bei unseren Bauwerken muss das, was sie nützlich und beständig machen wird, das Technische, dann aber das, was sie zum Pol der Schönheit ziehen wird: die Harmonie in sich und mit der Umwelt.

Bauen in Harmonie mit der Umwelt

Sofern wir uns das Bauen in Harmonie mit der Umwelt zum Ziel setzen, können wir in folgenden Schritten vorgehen:

1) Wir finden für jede Aufgabe "Besonderheiten" sei es der Naturlandschaft oder der Kulturlandschaft. Nicht nur in der Philosophie,

auch z.B. beim Brückenbau, sind Grenzsituationen solche, die uns weiterbringen. Es sei hier an die singulären Punkte aus der Mathematik erinnert; wenn wir sehen gelernt haben, finden wir solche in Natur- und Kulturlandschaft. Vor allem: bleiben wir ehrlich und erfinden wir nichts dazu.

2) Wir bewerten diese Gegebenheiten und legen Prioritäten fest. Dies im Hinblick auf das Lebensfördernde, Erhebende, Positive.

3) Dem künstlerisch Begabten fällt auf die unter 1 und 2 erkannten und bewerteten Fakten eine persönliche Reaktion zu, die er in seinen Entwurf hineinwebt, hineinformt. Wirklich nur als Beispiele seien folgende "Reaktionen" aufgezählt:

a) Entsprechung
b) Gegensätzlichkeit, Polarität
c) Schwerpunktbildung, Akzentsetzung
d) Symmetrie
e) Asymmetrie
f) Rhythmik
g) Ruhe, Gleichgewicht

Einigen dieser Punkte werden wir bei unseren Beispielen wieder begegnen: dort, wo ihre Umsetzung in die Form zur Aussage, zum Ausdruck, wird.

Proportion und Massstab

Pro-cent heisst "vom Hundert". Pro-portion heisst "vom Teil". Wenn wir Proportionen bilden, so werden zwei oder mehr Strecken, Flächen, Volumina, Gewichte, Winkel usw zueinander ins Verhältnis gesetzt und damit relativierend gewichtet, gewogen, bewertet.

> "The effect of scale depends not on a thing in itself, but in relation to its whole environment or milieu it is in conformity with the things, "place in Nature", its field of action and reaction in the universe. Everywhere Nature works true to scale, and everything has its proper size accordingly."
> ("On growth and form" von d'Arcy Wentworth Thompson)

Was verstehen wir unter Massstab (scale)? Wir kennen die Ausdrücke "etwas wahrt den Massstab" oder "es sprengt den Massstab" oder "es ist in keinem Massstab". Diese Formulierungen lassen vermuten, dass wir mit dem Massstab nicht nur ein Verhältnis sondern ein ausgewogenes Verhältnis meinen. Wenn etwas "im Massstab" ist, dann ist es in einer wohl ausgewogenen Proportion. Die Pythagoräer haben bewiesen, dass dazu auch eine wohlausgewogene Tonfolge am Monochord gehört.

C. UEBER DIE HARMONIK ODER DIE LEHRE VOM KLANG DER WELT

Ich möchte nun eine Methode vorzeigen, die über Analogien hilft, Proportionen zu bewerten.

Erklärung des Monochords

Das Monochord ist ein Saiteninstrument, bestehend aus einem Klangkörper und mindestens einer, besser aber 13 Saiten, die alle gleich lang, z.B. 120 cm, und alle auf z.B. C gestimmt sind. Verschiebbare

Stege lassen auf jeder Saite beliebige Saiten-Abschnitte einstellen. Es ist nachgewiesen, dass Guido von Arezzo (ca 990 - 1050) seine Musikschüler damit unterrichtete. Heute wird in Japan mit ähnlichen Instrumenten noch musiziert, sie heissen KOTO.

Pythagoras (582 - 507 v.Chr.) und seine Schule haben gelehrt, dass Proportionen unserer sichtbaren Welt über Zahlen in Saitenlängen oder deren Reziprokwerte, nämlich Schwingungszahlen, sich umsetzen und als Töne zueinander in Beziehung bringen lassen.

Lambdoma der Pythagoräer

Die Pythagoräer haben die ganzzahligen Verhältnisse geordnet in einem Diagramm festgehalten, von dem Figur 2 die ersten Ansätze zeigt; dies bis zu den 8er-Rationen. Auf den Schenkeln werden 1, 1/2, 1/3, 1/4, 1/5, 1/6, 1/7 und 1/8, respektive 1, 2, 3, 4, 5, 6, 7 und 8 aufgetragen und die dazwischen liegenden Werte zum Teil ergänzt. Wir haben hier nach Hans Kayser die Tonzahlen vor uns. Zu jeder Zahl gehört ein Ton auf dem Monochord.

Unterton-
reihe
moll-
Aspekt

Oberton-
reihe
dur-
Aspekt

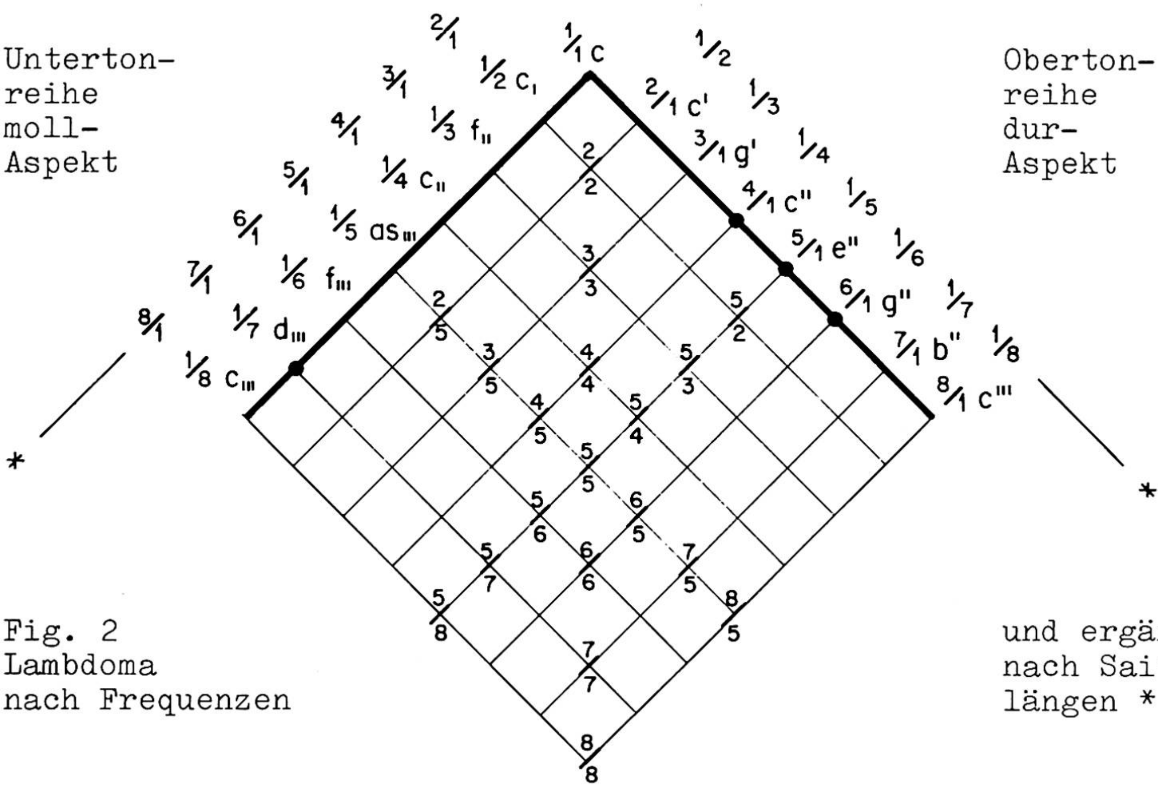


Fig. 2
Lambdoma
nach Frequenzen

und ergänzt
nach Saiten-
längen *

Versuche

Es gilt nun zu zeigen, dass sich Proportionen nicht nur sehend und messend (haptisch), sondern zusätzlich über unser Gehör, hinsichtlich ihrer Aussage verstärkt, vernehmen lassen.

Beginnen wir mit dem ersten Experiment am Monochord:

Im Versuch I wählen wir die Einheit zu 120 cm und stellen ein: 1 mal 1 Einheit, $\frac{1}{2}$ der Einheit, 1/3, 1/4, 1/5, 1/6. Hören wir diese Töne und beachten wir dazu den rechten Schenkel des λ-Diagrammes (Fig. 2). Das ist die sog. Obertonreihe. (Diese Naturtöne, und nur diese, lassen sich auf einem ventillosen Horn spielen - siehe auch Hörbild 1, Fig. 8.)

Im Versuch II wählen wir die Einheit 1 15 cm und stellen unsere Stege auf 1 Einheit, auf 2 Einheiten, auf 3, 4 usw bis 8 Einheiten, das sind 120 cm oder die Monochord-Länge. Hören wir diese Töne und beachten wir den zugehörigen linken Schenkel unseres sogenannten Lambdoma-Diagrammes (Fig. 2). Das ist die sog. Untertonreihe.

Die Naturtöne des Wassers

Sowohl Beethoven als auch Wagner haben genau auf die Besonderheiten in der Natur gelauscht: wenn sie das Wasserspiel des Baches "malen", verwenden sie in ihren Kompositionen die Töne 4/1c" , 5/1e" , 6/1 g" und 1/7d‴ . Sie finden diese vier Töne, durch Punkte hervorgehoben, im Diagramm Fig. 2 und im Hörbild 3, Fig. 8).

Das Berner Münster

Von den alten Bauhütten her kennen wir den harmonikalen Teilungs-Kanon (Fig. 3) nach dem picardischen Baumeister Villard de Honnecourt, der im 13. Jahrhundert an manchem Dombau tätig war.

Auf Fig. 4 erscheint der ursprüngliche Riss des Berner Münsters. Die "Besonderheiten", hier am Werk selber, passen nun genau auf den har-

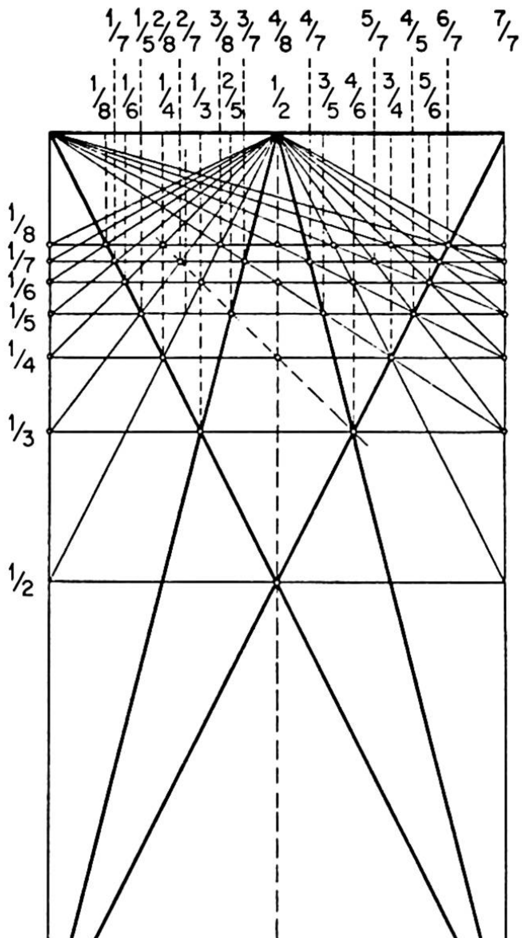


Fig. 3: Villard-Diagramm im Rechteck 2:1, die "Massgerechtigkeit" für gotische Bauten

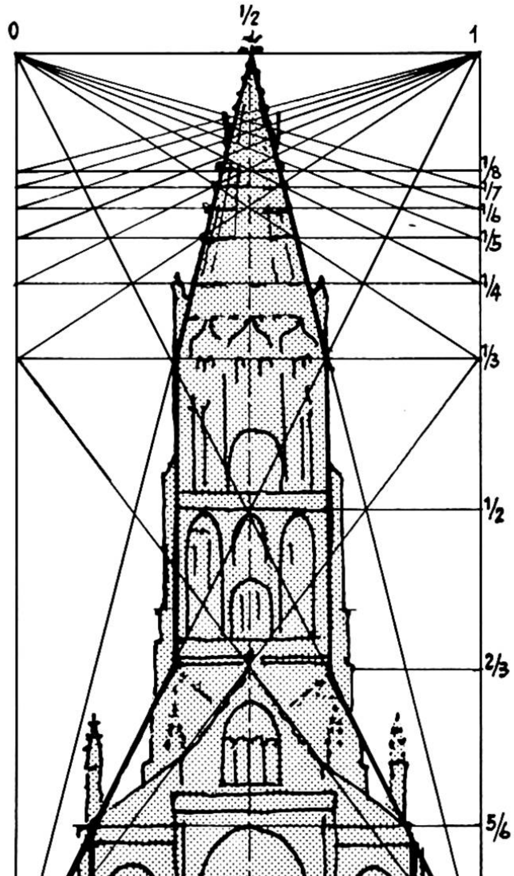


Fig. 4: Das Münster zu Bern mit dem Villard-Diagramm (siehe auch Hörbild 1, Fig. 8)

monikalen Kanon. Hören Sie das Berner Münster. Wir brauchen hier nur Versuch I zu wiederholen. Die Töne liegen auf dem rechten Schenkel im Lambdoma (Fig. 2).

Kristall (Pflanze) und Ton

Viele Forscher haben erläutert, wie sich die Formen der Natur, z.B. Blüten, Sträucher, Bäume oder Kristalle, mit mathematischen Formeln umschreiben lassen: Es sind Zahlenreihen, welche, in Proportionsform gebracht, uns den Schritt zur Vertonung am Monochord erlauben. Das werde mit Kristallen hier angedeutet.

Die Werke von Hans Kayser (1891 - 1964) über Harmonik bilden die Grundlage alles hier über Proportion und Harmonik Vorgelegten. Es sei diesem Lehrmeister gedankt, indem wir den Leser auf sein Buch verweisen: "Orpheus, vom Klang der Welt", 1926, Kiepenheuer Potsdam. Flächenentwicklung am Kristall sowie Tonentwicklung haben beide die sog. harmonische Quantelung gemeinsam, was kein Zufall sein kann und zu einer Gegenüberstellung berechtigt. Im Buch sind 21 Kristallarten beschrieben. Wir wählen hier als Muster deren zwei mit den zugehörigen Tonzahlen:

Granat:

1/3 2/5 . 1/2 3/5 2/3 . . 4/5 . . 19/20 1
f,, as,, c, es, f, as, ces, c
20/19 . . . 5/4 . 3/2 5/3 2 . 5/2 . 3
cis, e g a c' e' g'

(siehe auch Hörbild 5, Fig. 8)

Steinsalz:

1/2 3/5 . . 3/4 4/5 . . . 1 . . . . 5/4 4/3 . 5/3 2
c, es, g, as, c e f a c'

(siehe auch Hörbild 4, Fig. 8)

Der interessierte Leser hat die Möglichkeit, diese Töne auf dem Klavier sich vorzuspielen.

Auf Beispiele aus dem Pflanzenreich müssen wir verzichten. Hans Kayser's Werk dazu aus dem Verlag Benno Schwabe & Co Basel heisst: "Harmonia Plantarum".

Paestum

In Paestum, dem alten Poseidona, am Golf von Salerno gelegen, haben die Pythagoräer ca 500 v.Chr. drei Tempel errichtet. Hans Kayser hat dort unten gemessen, gezeichnet, photographiert und meditiert. So ist ein wunderschönes Buch entstanden, aus dem wir kurz uns die Melodie des Poseidon-Tempels anhören wollen (in Saitenlängen):

Tempellänge	c	1/1	grosse Säule	a''	3/20
Tempelbreite	e''	2/5	Cella Säule I	e'''	1/10
Giebelhöhe	h'	4/15	Cella Säule II	d''''	1/18
Geisonhöhe	e'	1/5			

(siehe auch Hörbild 8, Fig. 8)

Sicher hat diese Baumeister das selbe Gefühl erhoben, dem zweitausend Jahre später der grosse Michelangelo Ausdruck gegeben hat: "Was ich schaffe, ist Gott entstammt." Das wiederum können wir Heutigen übersetzen mit ".... ist auf den Sinn der Ganzheit ausgerichtet".

Das Ulmer Münster (Fig. 5)

Wir basieren auf dem Turmriss von Jörg Syrlin d.J. aus dem Jahr 1477. In der Höhenentwicklung sind singuläre Punkte, wie Aenderung der Breite des Turmes, Aussteifungs- oder Verzierungsbänder, angeordnet. Die Proportionen sind in nachfolgender Tabelle festgehalten, und zwar bereits umgerechnet auf Monochord-Länge (120 cm) = Turmhöhe.

b/H	h/H		"Höhen" cm	zugehörige "Breiten" cm	"Tiefen" ab Spitze cm	
	4/4	3/3	120	(3)	0	
1/16	3/4		90	7,5	30	(siehe
1/8		2/3	80	15	40	auch
7/50	9/16		67,5	16,8	52,5	Hör-
7/50	2/4		60	16,8	60	bild 10,
3/16		1/3	40	22,5	80	Fig. 8)
	1/4		(30)		90	
			0		120	

Die angegebenen Saitenlängen werden zuerst nach dem Pfeil nach oben für die Höhen und Breiten angeschlagen: unsere Augen ermessen bei jeder Höhe die zugehörige Breite, die sich auf jener Höhe vermindert, unsere Ohren tun das selbe. Im zweiten Gang schlagen wir die Saitenlänge von der Turmspitze her gesehen nach unten folgend an. Auch hier gehört zu jeder Tiefe die dort vergrösserte Breite (in Saitenlängen).

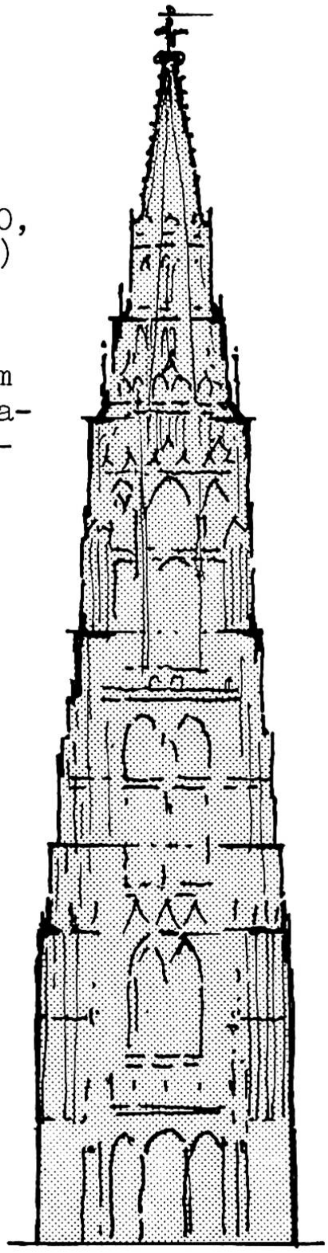


Fig. 5

Bürohochhaus zur Palme am Bleicherweg in Zürich

Dieses Bürogebäude ist von dem Schweizer Architekten André M. Studer (damals im Architekturbüro Häfeli-Moser-Steiger) entworfen worden. In allen seinen Bauten arbeitet er mit einem Modul, basierend auf dem λ-Diagramm, wobei er 30 cm als Einheit gewählt hat. Das gibt dann folgende Abmessungen, Proportionen und Töne, welche einen Dur-Dreiklang ergeben, der "im wesentlichen alle am Bau vorkommenden Grössen in ihren vielfältigen Kombinationen beherrscht" (Fig. 6). Während dem Hochhaus ein 2,40-m-Raster zugrunde liegt (8 x 1 Einheit = Oktave), ist für die Untergeschosse die zehnfache Einheit eingebaut, was dann für den Abstand der Hauptsäulen das gemeinsame Vielfache, nämlich 40 x 30 cm = 1200 cm, ergibt.

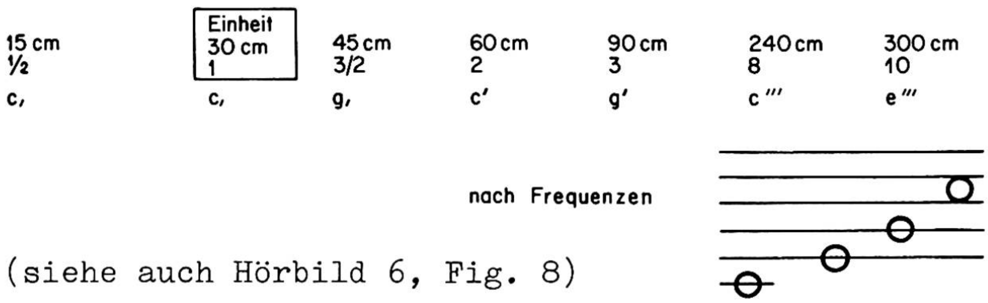


Fig. 6 (siehe auch Hörbild 6, Fig. 8)

Weinlandbrücke bei Andelfingen in der Schweiz

Vor 25 Jahren ist mit dem Bau der Weinlandbrücke über die Thur bei Andelfingen, Strasse Winterthur - Schaffhausen, begonnen worden.

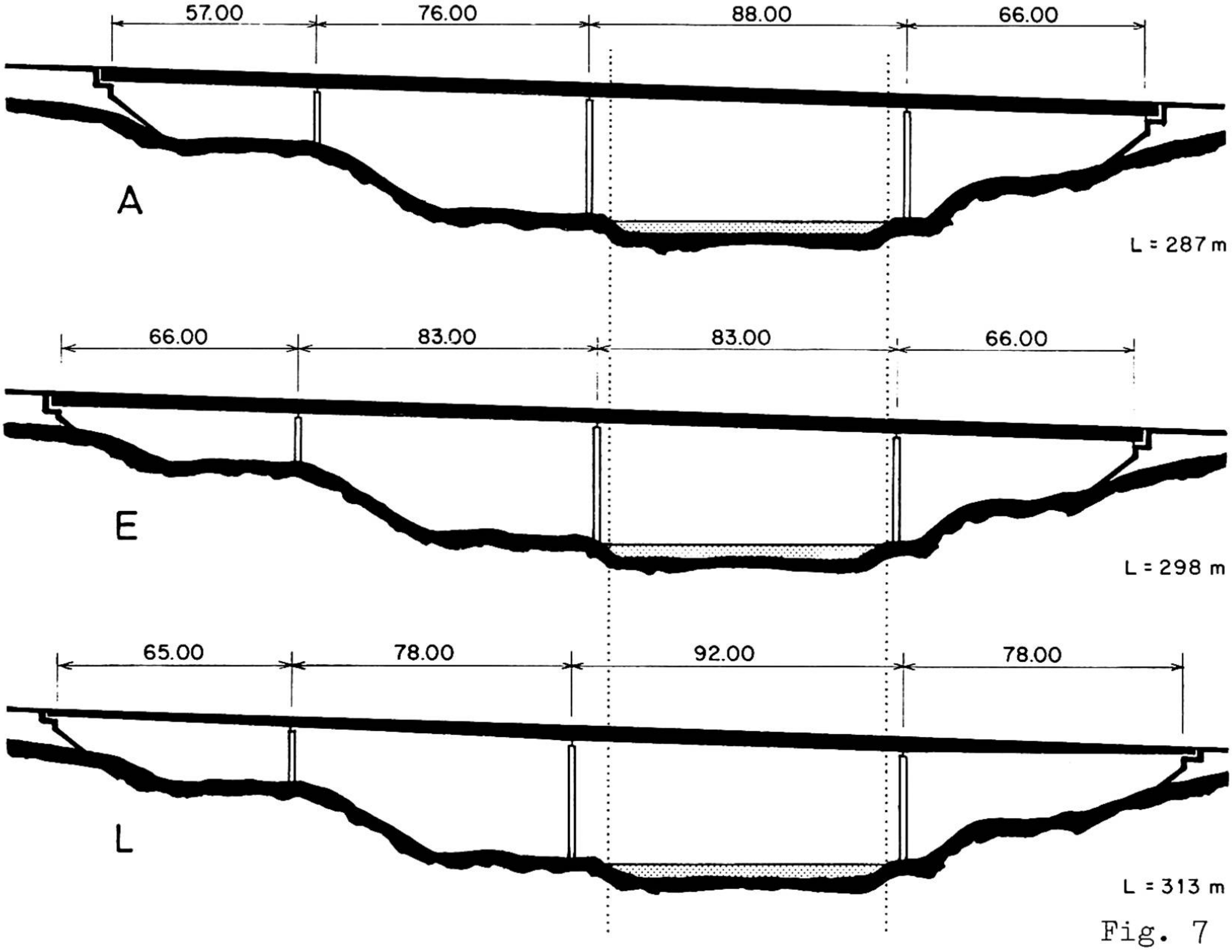


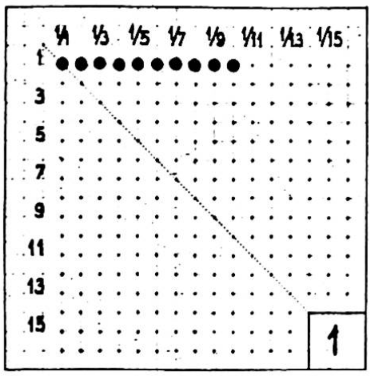
Fig. 7

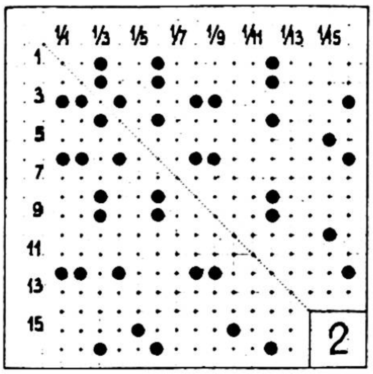
Die Zeichnungen (Fig. 7) zeigen den Schnitt Tal und Brücke flussabwärts gesehen. Die Bilder E und L zeigen die beiden prämierten Spannbetonbalken-Lösungen, Bild A die ausgeführte Brücke.

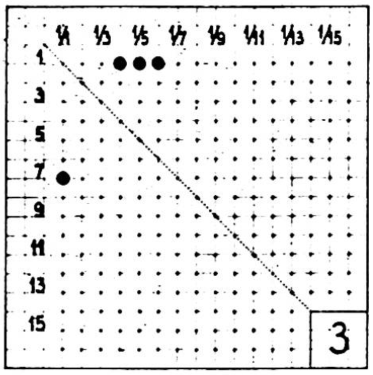
Projekt	Spannweiten					Summe Einheit	h/l_{max}	h/L
A	m'	57 e'	76 h'	88 as'-a'	66 des'-d'	287 c		
	cm-L	23,8	31,8	36,8	27,6	120		
	Prop.	29/144	38/144	44/144	33/144	144/144	4/11	1/9
	cm-f	74,5	57	49	65,5	15	f'- fis'	d''
E	m'	66 d'	83 b'	83 b'	66 d'	298 c		
	cm-L	26,6	33,4	33,4	26,6	120		
	Prop.	4/18	5/18	5/18	4/18	18/18	6/13	10/93
	cm-f	67,5	54	54	67,5	15	e' - f'	d''- es''
L	m'	65 es'	78 c'	92 a'	78 c'	313 c		
	cm-L	24,9	29,9	35,3	29,9	120		
	Prop.	5/24	6/24	7/24	6/24	24/24	5/14	1/10
	cm-f	72	60	51,5	60	15	fis'- g'	e''

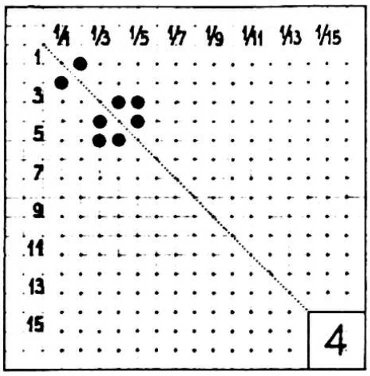
cm-L = cm am Monochord für Längenproportion
cm-f = cm am Monochord für Schwingungszahlen aus Längenproportion
l_{max} = grösste Spannweite

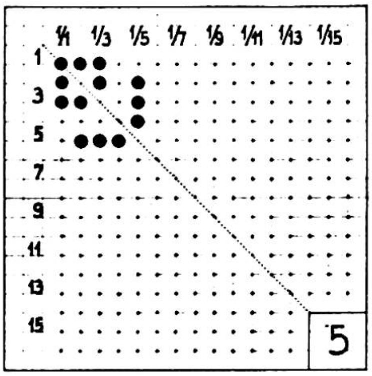
Figur 8: **Hörbilder Nr. 1 bis 12** Tonzahlen Saitenlängen 1 bis 16 resp. 1/1 bis 1/16

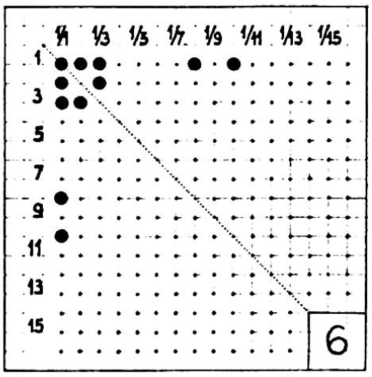

Obertonreihe u. Münster Bern

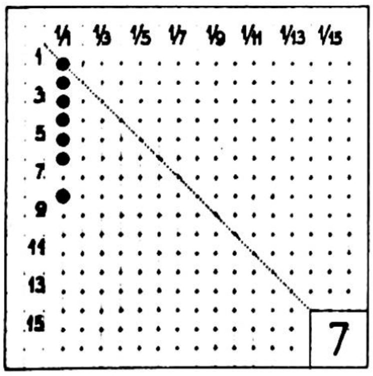

Quinten

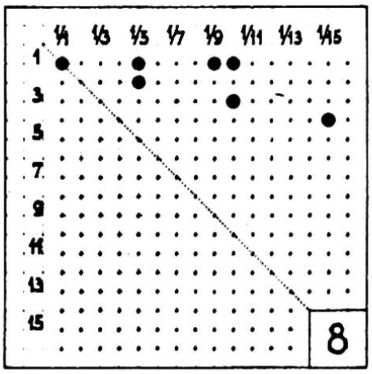

Wassertöne

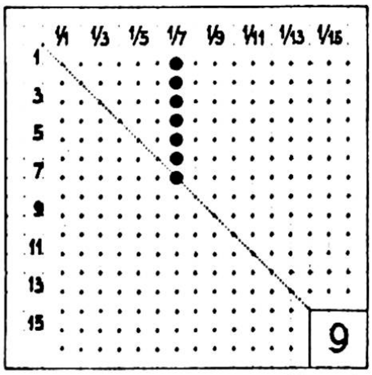

Steinsalz

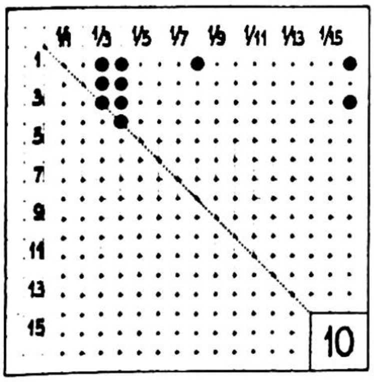

Granat

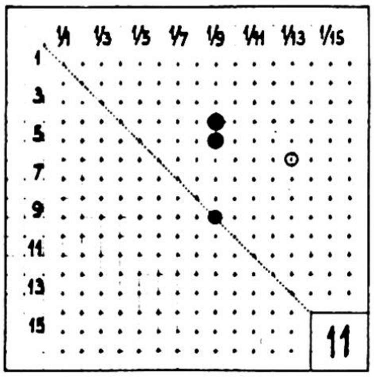

Hochhaus ‹zur Palme› Zürich

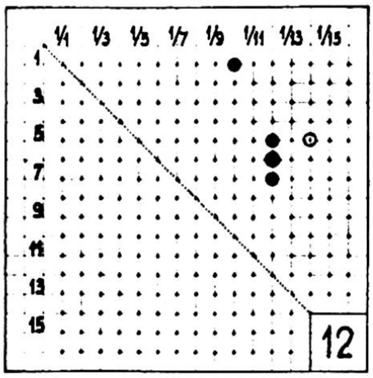

Pont du Gard


Poseidon-Tempel Paestum


Grossmünster-Türme Zürich


Münster Ulm


Weinlandbrücke Projekt E


Weinlandbrücke Projekt L

Hören wir nun diese drei Lösungen in der Reihenfolge A - E - L an.

Wir beginnen dabei jeweils mit der Proportion "Höhe über Fluss zu Fluss-Spannweite" (h/l), hören dann die Proportionen "Spannweiten zu Gesamtlänge L", dies von links beginnend, und schliessen mit "Höhe über Fluss zu Gesamtlänge" (h/L).

Wir beginnen mit A: Diese Lösung wurde ausgeführt. Den Zwang, zu sparen, sieht und hört man ihr an. Sie hat die kürzeste Gesamtlänge. Trotzdem ist es gelungen, hier wie im Projekt L, die Flussöffnung zu betonen und gleichzeitig die Pfeiler von der Grenze Wasser/Ufer ins Land abzurücken.

Wir schreiten zum Projekt E: Die auf des Statikers Vereinfachung fussende, zum linken Flusspfeiler symmetrische Ausgestaltung lässt sich auch am Monochord heraushören. Das Besondere der meisten Täler ist doch wohl sicher der Fluss, und der kommt hier entschieden zu kurz.

Zu Projekt L: Die Betonung der Flussöffnung, nicht nur durch die grösste Spannweite, sondern auch durch die symmetrische Anordnung der ihr auf jeder Seite anschliessenden Felder, ist aus diesem Entwurf gut zu hören. Mit variabler Trägerhöhe wird der Form des Tales "entsprochen".

Fig. 8 zeigt 12mal die selbe Proportionentafel. Die grossen Punkte geben Proportion und Ton zugleich an. Wir haben hier 12 sogenannte Hörbilder vor uns. Die meisten besprochenen Beispiele sind aufgeführt. Zusätzlich sind die Tonzahlen des Ponts du Gard in Südfrankreich und der Turmfassade des Grossmünsters von Zürich festgehalten.

Unsere frühere Fig. 2 wird um 45° gedreht und dann ergänzt bis auf 16 resp. 1/16. Aus Platzgründen ist in dieser stark verkleinerten Darstellung nur der Zahlenraster angedeutet. Zugehörige Töne stehen in Fig. 2 oder sind für Proportionen über 8/1 resp. 1/8 aus dem Werk von Hans Kayser zu entnehmen.

Dieser Vergleich beweist, dass über Generationen, Stilepochen, Weltgegenden, ja Völker hinweg Menschenwerk, dem wir Beachtung schenken, das wir meistens als schön bezeichnen, dem selben Grundmuster der Tonzahlen gehorcht wie die Natur. Weil der Mensch Teil der Natur ist, wählt er als Künstler, unbewusst, alles was sich gewichten lässt so aus, dass es stimmt.

Zum Schluss übersetzen wir "Grundmuster" ins Griechische: es heisst "Archetypus".

Erhorchen und erschauen wir
den Archetypus der Tonzahlen
in der Natur und im Menschenwerk

Leere Seite
Blank page
Page vide

I

L'ingénieur et l'esthétique des ponts

Der Ingenieur und die Aesthetik der Brücken

The Engineer and Bridge Aesthetics

ARNOLD A. BAGON
Ingénieur Conseil AILG C.I.C.B.
Bruxelles, Belgique

RESUME
L'auteur analyse les raisons de la dégradation de l'esthétique des ponts, se penche sur la notion de l'esthétique, de la beauté et sur le rapport entre l'homme et la beauté. L'auteur cherche à préciser ce qu'il ne faut pas faire pour éviter des erreurs. Il esquisse les grandes lignes qui doivent guider l'ingénieur, auteur de projet, dans les recherches d'une solution qui donnera un pont avec un résultat esthétique satisfaisant.

ZUSAMMENFASSUNG
Der Verfasser untersucht die Ursachen von Problemen bezüglich Aesthetik der Brücken. Er diskutiert die Begriffe Aesthetik, Schönheit sowie die Beziehung zwischen Mann und Schönheit. Der Verfasser versucht darzulegen was nicht zu tun ist, um Fehler zu vermeiden und gibt dem Ingenieur einige Hinweise, die zu richtigen ästhetischen Lösungen führen können.

SUMMARY
The author analyses the causes of problems in bridge aesthetics. He investigates notions of aesthetics, beauty and the relation between man and beauty. The author tries to specify what should not be done if mistakes are to be avoided. He gives guidelines for the designer to follow towards a good aesthetic solution.

1. Introduction

Il y a un malaise depuis quelques décennies dans le domaine des ouvrages d'art au niveau de l'esthétique.

Les destructions de la deuxième guerre mondiale et le développement des autoroutes ont créé un marché d'ouvrages d'art d'une ampleur sans précédent.

Cette situation a provoqué une approche industrielle en matière d'ouvrages d'art avec, d'une part, la recherche d'économie à outrance et, d'autre part, une concurrence sauvage des entreprises.

L'approche industrielle a rompu avec la tradition où le pont était traité avec une sorte de respect comme un temple ou un édifice de prestige, ce qui faisait dire à Séjourné : " En matière de ponts, il n'est pas permis de faire laid".

Le pont, dans la même mesure que toute activité économique, obéit à la loi énoncée dans la dialectique matérialiste, à savoir que toute activité humaine est intimement liée au rapport des forces de production. C'est ainsi qu'aux voûtes ont succédé des ponts droits.

Avec l'ère de la précontrainte et des poutres droites, on manque de passé et de références, ce qui explique les nombreuses erreurs sur le plan esthétique.

Un pont comporte deux fonctions : une fonction technique, celle de faire franchir un obstacle à la circulation et une fonction humaine, celle d'intégrer l'ouvrage harmonieusement dans le site.
Rien ne permet de dire que la seconde est moins importante que la première. Or tout se passe comme si depuis quelques décennies la seconde fonction était complètement négligée.

En résumé, c'est l'approche industrielle, avec comme seule motivation la recherche sauvage du profit, qui a fait perdre le respect dû aux ouvrages d'art avec pour conséquence le délabrement esthétique dans le domaine des ponts depuis quelques décennies.

2. Qu'est-ce que la Beauté ?

Entre l'opinion du philosophe anglais David Hume, pour qui la Beauté passe par la sensibilité de l'homme, et l'opinion d'Emmanuel Kant, pour qui la Beauté est partie intégrante de l'objet, je me rallie à l'opinion pragmatique de David Hume.

La beauté considérée comme quelque chose qui a une vie propre, est une vue de l'esprit et ne correspond à aucune réalité. Ce qui est réel, ce qui existe, ce sont des objets et des hommes, qui possèdent une sensibilité.

C'est en fonction de sa sensibilité que l'homme éprouve une émotion devant un objet ou un spectacle qu'il s'agisse d'un paysage naturel, d'un ouvrage d'art, d'une peinture, de musique ou de danse.
Cette émotion, nous l'appelons "émotion esthétique".

La relation entre la beauté et l'émotion esthétique est une relation de cause à effet. Devant un beau paysage, un beau pont, une belle sculpture ou une belle peinture, l'homme se sent bien; il ressent une émotion que nous appelons esthétique et il dira que l'objet qui a provoqué cette émotion est beau.

Inversément, il y a des ponts devant lesquels l'homme ressent un malaise alors il dira que ce pont est laid.

Il ne nous est pas possible de chercher à découvrir le mécanisme organique qui définit cette émotion, mais ce qu'on peut faire c'est apprécier l'intensité de l'émotion et par là le niveau de la beauté.
L'intensité de l'émotion peut se mesurer à son aptitude à la répétition.
Pratiquement, un pont est d'autant plus beau que nous ressentons une émotion esthétique plus intense et que nous pouvons le revoir, à la limite, indéfiniment sans nous lasser.

3. L'homme et la Beauté

L'émotion esthétique ressentie par l'homme devant un objet n'est pas nécessairement uniforme et identique pour tous les hommes.
C'est ce qui justifie l'adage romain : "De gustibus et coloribus non dispudandum est". Ceci est le phénomène micro.

A l'échelle macro, il se dégage des éléments qui permettent de postuler certaines vérités éternelles.

L'émotion esthétique est souvent associée à l'émotion religieuse.
Déjà les hommes de la préhistoire ont manifesté ce besoin d'émotions esthétique et probablement religieuse par les peintures comme celles des Grottes de Lascaux.

Partant de là, toute l'histoire de l'humanité est jalonnée par des oeuvres grandioses d'une beauté éternelle. De là une proposition : "Tout homme de caractère normal ressent une émotion esthétique de même nature devant le même spectacle".

4. Les voies et les moyens pour réaliser de beaux ponts.

Ce chapitre doit être précédé par quelques réflexions générales.

A l'époque actuelle, faire un beau pont ne veut pas dire faire un pont et puis le décorer. Pourquoi ?

Certains ponts d'une époque révolue, comme le pont Alexandre à Paris, comportaient une décoration qui se mariait très bien avec l'environnement.

Pourquoi ce qui était vrai pour le pont Alexandre n'est plus vrai aujourd'hui ? C'est toujours en vertu du principe que j'ai déjà évoqué plus haut que notre activité est en relation de dépendance avec le rapport des forces de production.

Le coût élevé de la main-d'oeuvre et l'absence pratiquement d'une armée d'ouvriers-artistes (artisans), fait qu'il ne viendrait à l'idée de personne de construire aujourd'hui une cathédrale comme au Moyen-Age.

Car c'est un fait, qu'il s'agisse d'un meuble ou d'un bâtiment comportant de la pierre de taille, la beauté de ces objets puise sa source dans le fait que chaque objet porte la griffe de l'artiste (artisan ébéniste ou tailleur de pierres).

Dans les ponts anciens, chaque pierre de taille travaillée par l'homme est une source de beauté.
Dans les ponts modernes, il y a passage de la griffe micro de l'artisan à la griffe macro de l'artiste qui est l'ingénieur, auteur du projet.

La morale de l'histoire, c'est que l'auteur du projet d'un pont doit agir dans le sens de l'évolution de l'histoire économique et certainement pas dans le sens contraire.

Il existe un préjugé qu'il faut écarter. Un beau pont n'est pas nécessairement plus cher qu'un pont laid.

J'ai dit plus haut que dans les rapports entre l'Homme et la Beauté l'émotion esthétique est souvent associée à l'émotion religieuse.
Je voudrais ajouter la réflexion suivante :"Ce qui distingue spécifiquement l'Homme des autres créatures, c'est sa propension à créer".

Cela est dû probablement au fait que l'Homme est aussi la seule créature à être consciente qu'il n'est pas éternel.

C'est ainsi que le désir de créer lui est dicté par les pulsions les plus profondes de l'âme qui exprime ainsi sa volonté de lui survivre.

5. Que faut-il faire pour construire un beau pont ?

Je pense qu'il faut d'abord poser la question inverse.

Que faut-il ne pas faire ?

Il faut, en effet, d'abord éliminer les erreurs à ne pas commettre.

1° Il ne faut pas mentir. Si l'ouvrage n'est pas fonctionnel, on est sûr de commettre une erreur sur le plan esthétique.
L'inverse n'est pas vrai : le fait d'être fonctionnel ne donne pas nécessairement de la beauté. Pour illustrer ce qui précède, il y a assez de châteaux d'eau qui, tout en étant parfaitement fonctionnels, sont aussi parfaitement laids.

D'un autre côté, si on donne au château d'eau un aspect d'un château-fort, ce qui n'a rien de commun avec sa fonction, on est sûr de commettre une erreur.

Un autre exemple :

Un pont en construction avec des colonnes très élancées. Ces colonnes sont bétonnées par le procédé des coffrages glissants. Il y a des joints de reprise et, pour éviter l'inconvénient esthétique de ces zones de reprise, l'ingénieur accepte la proposition de l'entrepreneur de créer de véritables joints, tout se passe comme si la colonne était réalisée en maçonnerie de gros blocs de béton ayant 2 m de haut et posés l'un sur l'autre.

C'est une erreur car une telle maçonnerie ne pourrait jamais assurer la stabilité. En faisant croire que c'est une maçonnerie alors qu'en réalité c'est tout autre chose, on crée un malaise et une faute grave sur le plan esthétique.

2° Un ouvrage d'art tel qu'un pont est par définition un ouvrage qui doit donner une impression de pérennité, de durée infinie.

Dès lors, il faut tout mettre en oeuvre pour éviter les outrages du temps.

D'autre part, un pont requiert un aspect sérieux; il n'accepte pas de fantaisies comme on pourrait imaginer dans un édifice destiné à une exposition qui, par définition, est éphémère.

Je reprends la question :

Que faut-il faire pour obtenir un beau pont ?

Il était plus facile de cerner avec précision ce qu'il ne faut pas faire que de définir ce qu'il faut faire. La première raison et la plus importante, c'est que pour faire un beau pont il faut du talent. Cela n'est pas donné à tout le monde; c'est la raison pour laquelle les noms des auteurs de projets célèbres à travers l'histoire se comptent sur les doigts de la main : Paul SEJOURNE, NERVI, MAILLART, FINSTERWALDER, FREYSSINET.

La fourchette entre un beau pont et un pont laid n'est pas toujours très grande. Prenons un autre exemple, un homme de 1,60 m est petit, un homme de 1,80 m est grand, entre les deux il y a 20 cm, à peine 10 %. Ces 10 %, ces derniers 20 cm, suffisent pour transformer un homme petit en un homme grand.

Il en est de même du choix de proportions d'un ouvrage, où c'est la sensibilité de l'auteur du projet, son talent qui aboutissent à une oeuvre réussie, un chef-d'oeuvre ou au contraire à un échec.

A l'époque actuelle, la beauté d'un pont ne peut en aucune façon procéder d'un habillage ou d'une ornementation. La beauté résulte d'une expression claire et bien formulée par celui qui vit l'aventure technique, c'est-à-dire l'ingénieur, auteur du projet. C'est le cerveau de cet ingénieur qui tient la clef du succès de la conception du pont.

Après ces quelques réflexions préliminaires, je vais essayer de dégager quelques principes généraux qui doivent guider l'ingénieur, auteur de projet dans la conception d'un pont.

A. Ce n'est pas dans les manuels d'Université que l'ingénieur trouvera les éléments pour l'aider à créer un beau pont. C'est plutôt dans sa formation générale, dans sa sensibilité, dans ses acquis de culture.

Il se souviendra notamment de trois unités du théâtre grec, l'unité du temps, du lieu et de l'action. Il les transposera à son pont en essayant d'y réaliser l'unité de conception, des matériaux et de la technologie. Cette unité a été réalisée dans le Viaduc de Beez.

Unité des matériaux : toute l'infrastructure est en béton, toute la superstructure en acier.

Unité de forme : la superstructure a une section extérieure constante sur toute la longueur du pont, malgré la différence entre la grande travée de 151 m et les travées d'approche qui ont 80 m.

Unité de technologie : qui est constante d'un bout à l'autre de l'ouvrage. C'est la technologie du caisson métallique soudé.

B. L'auteur du projet d'un pont n'oublie pas qu'un pont gagne à être sobre.

L'Homme a une déplorable tendance, par une espèce de vicieux dérapage, à sophistiquer ses créations. Ce qui me fait dire que rien n'est plus difficile que de rester simple.
L'ingénieur, auteur de projet, se souviendra que rien n'est plus difficile qu'une ligne droite, aussi bien dans la conception que dans la réalisation. Pourquoi ? Parce que la ligne droite est sans pitié, elle n'accepte aucun défaut.

C. L'auteur du projet ne perdra pas de vue le comportement du pont dans le temps. Par définition, un pont de qualité doit être pratiquement éternel. Il faut donc se pencher sur la morphologie du pont pour lui éviter des maladies ultérieures. On ne se contentera pas pour le pont des mêmes règles que pour le bâtiment.

Alors que dans un bâtiment, on accepte des dalles en béton armé de 10 cm d'épaisseur, on exigera pour les dalles de platelage d'un pont un minimum de 20 cm d'épaisseur. De même on veillera à ce que les recouvrements des armatures soient suffisants aussi bien sur le dessin que sur le chantier.

Quant aux ouvrages en béton précontraint, on ne prendra jamais assez de précautions pour éviter le stress-corrosion.
Un autre défaut à éviter, c'est les joints de dilatation qui constituent toujours une amorce de dégradation du pont. Personnellement, dans tous mes ponts, comme celui de Beez, les joints de dilatation sont supprimés sur le pont lui-même et sont rejetés à l'entrée et à la sortie du pont.

D'une manière générale, l'ingénieur se souviendra que l'ordre est expression de beauté et qu'inversément le désordre crée un malaise. Il se souviendra des beaux poèmes de Baudelaire qui chantent l'ordre et la beauté. En respectant ces quelques idées générales, l'ingénieur fera un pont acceptable, s'il y ajoute du talent, il fera un beau pont et s'il y ajoute quelques grains de génie, il fera un chef-d'oeuvre.

I

Gibt es Regeln für Aesthetik?

Are there any rules for aesthetics?

Y-a-t-il des règles d'esthétique?

WOLFDIETRICH ZIESEL
Prof. Dipl. Ing. Dr. techn.
Hochschule Akademie der bildenden Künste
Wien, Österreich

ZUSAMMENFASSUNG
Die Probleme und Fragen im Zusammenhang mit Aesthetik sind uralt und viele Künstler und Philosophen haben sich damit auseinandergesetzt. Es wird versucht, den Ursachen des Unbehagens in unserer Zeit im Zusammenhang mit den Aesthetikfragen nachzugehen und alle jene Massnahmen zusammenzufassen, die zu einer Verbesserung der Gestaltung unserer Ingenieurbauten führen können.

SUMMARY
The problems and questions arising in connection with aesthetics are age-old and many artists and philosophers have probed them. An attempt is made to trace the causes of discomfort which we are experiencing in our times in connection with the questions of aesthetics, and to discuss all the measures which could lead to an improvement of the designs of our engineering buildings.

RESUME
Les questions ayant trait à l'esthétique sont très anciennes et beaucoup d'artistes et de philosophes en ont traité. On essaye de rechercher les causes du malaise de notre époque en ce qui concerne les questions esthétiques, et de récapituler toutes les mesures qui pourraient amener une amélioration de la forme de nos ouvrages d'art.

Die Frage lautet: Gibt es Regeln für Ästhetik? Es ist sehr schwer, wenn nicht unmöglich, ohne Partner anderer Disziplinen R e z e p t e und einfache R e g e l n für das Entwerfen ästhetisch anspruchsvoller Ingenieurbauten aufzustellen. Außerdem sind Bauten, die nach Rezepten errichtet werden, meistens monoton und ohne Ausdruckskraft. Der amerikanische Architekt VENTURI sagt zum Beispiel in seinem Werk, das sich um eine Debatte über Ästhetik bemüht, "Komplexität und Widerspruch in der Architektur":

. Architekten, die sich an keine Regeln halten, sind schöpferischer als jene, die der Sintflut von Funktionalismus und Purismus unterliegen. Schließlich ist man bei neuen Problemen und Veränderungen flexibler, wenn man nicht ausschließlich an Regeln gebunden ist.

. Man muß den Mut haben, Regeln zu mißachten.

. Regeln entbinden Durchschnittliche von kreativen Überlegungen und ermuntern so zum Mißbrauch.

Architektur und Baukunst ist nicht nur Bauen und Konstruieren, sondern auch eine k u l t u r e l l e A n g e l e g e n h e i t. Ganze Stilrichtungen - auch im Konstruktiven - wurden von Architekten und Künstlern geprägt (Konstruktivismus - Organik - etc.). Viele interessante und ästhetisch wertvolle Konstruktionen wurden von Architekten entwickelt, wogegen im großen und ganzen die Fortschritte (Stilrichtungen) im Ingenieurbau nur von wissenschaftlichen und wirtschaftlichen Kriterien geprägt werden. So entstehen immer kühnere Bauwerke, ohne daß man fragt, ob sie noch dem natürlichen und menschlichen Maßstab entsprechen.

Man kann nicht generell sagen, daß die Fragen der Ästhetik bei den Architekten in schlechten Händen sind. Die, die viel (zuviel) bauen, sind sicherlich durch den heutigen Zeitgeist - nämlich eine extrem ökonomische und materialistische Lebensphilosophie - verdorben. Es gibt aber noch immer viele, die auch über die Probleme der Ästhetik und Gestaltung nachdenken und einiges dazu zu sagen haben (Venturi, Lukačs, Fonatti, Bruno Zevi, Leonhardt u.v.a.), gar nicht zu sprechen von den Aussagen vieler Philosophen über die Schönheit.

Die Wahl und der Entwurf eines Tragwerkes ist nicht nur eine Sache der Wissenschaft, sondern auch besonders eine der K u n s t und I n t u i t i o n, was viele Architekten und Ingenieure bewiesen haben. Als berühmte und bekannte Ingenieure seien beispielsweise Maillart, Torroja, Morandi und Nervi genannt. Ebenso sind die Architekten Wright, Gaudi, Corbusier, Mangiarotti, Castiglioni, Soleri, Michelucci, Aloisio, Sant'Elias auf diesem Gebiet hervorgetreten. Es kommt meiner Meinung nach auf dem Gebiet des konstruktiven Entwerfens der Kunst eine ebenso große Bedeutung zu wie der reinen technischen Wissenschaft. Wenn diese Kunst und Intuition fehlt, nützen auch die besten Rezepte nichts. Vieles Schöne wird oft nach den herrschenden Regeln gar nicht sofort als schön empfunden, sondern erreicht erst später unabhängig von Mode und Geschmack seinen wahren Wert.

Es stimmt leider nicht, daß eine gute Konstruktion schon gute Architektur ist. Es ist sicherlich so, daß ein schlechtes Tragwerk oft häßlich ist, aber es ist nicht zu beweisen, daß die Ästhetik eines Bauwerkes allein auf dem Tragwerk beruht. Die Richtigkeit und Ausgewogenheit einer Tragkonstruktion ist wohl meistens eine Vorbedingung für die Schönheit, jedoch noch keine

Garantie dafür. Im Gegenteil: Oft können Dinge, die keinerlei konstruktive Logik besitzen, große ästhetische Reize entwickeln. Zum Beispiel werden - wenn ich das hier erwähnen darf - oft Konstruktionen über- oder unterdimensioniert, um perspektivische und räumliche Wirkungen zu erzielen. Ebenso sind Formen der Gegensätzlichkeit (auch qualitativ) wichtig, um Spannungen im Bauwerk oder dessen Umgebung zu erzeugen. Ein starker Bau verträgt leicht das Anbringen von Ungereimtheiten, wogegen manche moderne Bauten in ihrer Wirkung schon durch einen einfachen Zigarettenautomaten zerstört werden.
In unserer Zeit sind auch Ingenieurbauten in einem funktionell - ästhetisch - ökologischem Umfeld zu sehen und können daher von den Ingenieuren nicht mehr allein bewältigt werden. Auch Ingenieurbauwerke müssen in ihrer Gesamtheit menschliche Aufgaben erfüllen. Die Fragen des Städtebaues, der Soziologie und der menschlichen, künstlerischen und natürlichen Umwelt haben oft viel mehr Bedeutung, als die der reinen Tragwerksästhetik (das schönste Tragwerk nützt nichts, wenn es die Umweltbedingungen zerstört). Weil, wie das bisher Gesagte zeigt, für Schönheit keine allgemein gültigen Regeln und Erklärungen aufzustellen sind, ist es besonders notwendig, Menschen mit intuitiver Schaffenskraft an den Entwurfsprozessen zu beteiligen. Sicherlich werden sich die Gewichte der einzelnen Disziplinen verschieden verteilen. Es gibt jedoch heute kein Bauwerk mehr, dessen Planung einer allein - mit wenigen grundsätzlichen Regeln ausgestattet - beherrscht.

Man sollte daher anstelle der Aufstellung von Regeln einmal alle jene T h e m e n zur Sprache bringen, die unmittelbar oder am Rande mit ästhetischen Fragen verbunden sind.
Es ist doch zweifellos ein U n b e h a g e n gegenüber den neuen Ingenieurbauten vorhanden, sonst würde sich wohl kaum über diese Frage ein eigener Arbeitskreis gebildet haben. Die Ursachen hiefür sind sicherlich wert analysiert zu werden.

- Da sind einmal die Zusammenhänge zwischen den nicht rational erfassbaren Begriffen Ästhetik, Ethik und Moral und zwar bei all denen, die am Entstehen eines Bauwerkes beteiligt sind wie Bauherren, Allgemeinheit, Benützer und Bauschaffende. Dabei führt das Bedürfnis nach einer Stellungnahme zur Kunst zur Einführung von moralischen Werten wie richtig und falsch. Moralische Werte werden eingeführt, um Formen, die nicht mehr intuitiv verstanden werden können, mit Bedeutung auszustatten, damit sie angenommen werden. Der Moralist in der Kunstbetrachtung hat Angst und ist seinen Sinnen gegenüber skeptisch, woraus Restriktionen entstehen. Es wird in der Praxis ein Purismus entstehen, der in Repressionen, Dogmen, Fanatismus und Ablehnung mündet.

- Es ist daher die W a h r h e i t von Axiomen zu untersuchen. Ich erinnere beispielsweise daran, daß Adolf Loos gesagt hat: "Das Ornament ist ein Verbrechen", oder Otto Wagner behauptete: "Was unpraktisch ist, kann nicht schön sein", und ihre Zeitgenossen haben das sehrwohl geglaubt, weil sie sofort eine Relation zwischen Moral und Schönheit herstellten, um dadurch die Freude an der Schönheit rational zu rechtfertigen. Man müßte daher darangehen, alle heute gültigen Aussagen über Ästhetik auf ihren Wahrheitsgehalt hin zu überprüfen.

- Häßliche Bauten haben s o z i o l o g i s c h e F o l g e n, weil der Mensch nicht nur physische, sondern auch psychische Bedürfnisse hat. Notwendig ist, daß man sich auf ein umfassendes Menschenbild besinnt; ein Menschenbild, das dem Menschen nicht nur körperliche, sondern auch seelische und geistige Erwartungen, Bedürfnisse und Ziele zuspricht.

- Es ist sicherlich eine Überbewertung des Technisch-Ökonomischen in allen Bereichen des täglichen Lebens vorhanden. So fehlt manchmal bereits das Bewußtsein, daß die Technik dem Menschen untertan zu sein hat und nicht umgekehrt. Sonst könnte es sicherlich nicht immer wieder passieren, daß Bauwerke der technischen Infrastruktur gewaltig überbewertet werden gegenüber jenen der menschlichen Umwelt. Andererseits gibt es aus den verschiedensten Gründen auch einen Verlust an Respekt gegenüber großen Ingenieurleistungen. Diese Gründe sind sicherlich unter anderem auch im allgemeinen Unbehagen gegenüber dem Überhandnehmen der Technik zu suchen.

- Es ist offensichtlich, daß unsere Versuche, Bau- und Herstellungsverfahren zu rationalisieren und damit zu schematisieren, zur Eintönigkeit und Unattraktivität des Gebauten geführt haben. Es ist in diesem Zusammenhang auch zu fragen, ob die gesetzlichen Grundlagen des Denkmal-, Landschafts- und Naturschutzes ausreichen, um Zerstörungen unserer Umwelt zu verhindern.

- Schließlich hätten wir es heute nicht mehr notwendig, den Begriff der Quantität vor jenen der Qualität zu stellen. Sicherlich waren nach dem Krieg und in den Tagen der raschen Wirtschaftsentwicklung große Bedürfnisse vorhanden und daher die Herstellung von großen Bauvolumina notwendig. Diese Zeiten sind doch nun wohl vorbei.

Die Frage der Bewertung der Bedeutung der Konstruktion in einem Bauwerk ist ungeheuer wichtig. Sie ist z.B. bei einem Einfamilienhaus geringer als bei einer Brücke. Wenn man hiefür versucht, allgemein gültige Regeln aufzustellen, wird man erkennen, daß der Anteil von Intuition verkehrt proportional dem Anteil an Ingenieurwissenschaft ist. Es gibt jedoch viele Projekte, bei denen Bauwerke mit verschiedener Bedeutung der Konstruktion ineinander übergehen. Man denke nur zum Beispiel an Planungen von Sant'Elias, die Hochbauten mit Brückentragwerken kombinieren. Hier ist eine Bewertung der Bedeutung der Konstruktion besonders wichtig.
Es muß die Frage nach dem optimalen Bau- und Tragwerk für wen gestellt werden. Eine Brücke hat z.B. einen Benützer (den Autofahrer), einen Betrachter, einen Bauherren und eine Gesellschaft, die sie baut. Jede dieser Gruppen beurteilt diese Brücke nach anderen Gesichtspunkten und man soll daher die Bewertung der Bedeutung dieser Gruppen sehr gewissenhaft vornehmen. Darüber hinaus gibt es natürlich auch noch Interessen der Allgemeinheit, die ebenso wichtig sind. Zum Beispiel hat ein Bauwerk oft mehrere Wirkungen: die auf die unmittelbare Umgebung oder die auf die ganze Stadt oder das ganze Land.

Ganz besonders hervorzuheben sind die Fragen der Ökonomie, die nach verschiedenen Kriterien Bedeutung haben:

- Jedes Bauwerk hat eine bestimmte Bedeutung seines repräsentativen Wertes. Je größer dieser Wert im Bewußtsein der Beteiligten wird, umso geringer wird die Bedeutung der ökonomischen Frage.

. Der ökonomische Wert ist auch von den Benützern abhängig - es muß Unterschiede geben zwischen einer Schule und einem Gefängnis.

. Die allgemeine Bedeutung eines Bauwerkes beeinflußt ebenso seinen ökonomischen Stellenwert. Die Frage "Wo liegt eine Brücke und von wie vielen wird sie gesehen und benützt" wird die wirtschaftliche Frage sicherlich mitbestimmen.

. Technische Fragen, wie die der geplanten Dauerbeständigkeit, des Anteiles der Konstruktion an den Gesamt- und Folgekosten, dem Verhältnis von Lohn- und Materialkosten oder geforderter Bautermine, sind im Zusammenhang mit Wirtschaftlichkeitsüberlegungen von großer Bedeutung.

. Es erscheint mir auch in diesem Zusammenhang besonders wichtig, die Abhängigkeit der Planer genau zu untersuchen. Die Arbeit für ausführende Firmen und nicht für den Bauherrn und die Allgemeinheit hat sicherlich schon viele gute Lösungen verhindert.

Ich bin mir jedenfalls sicher, daß nach Reihung und Diskussion aller Probleme im Zusammenhang mit ökonomischen Fragen sich herausstellen wird, daß diese meistens maßlos überbewertet und als Ausreden verwendet werden für technisch und ästhetisch mißlungene Ingenieurbauwerke.
Was kann man also tun? Ich würde einen Maßnahmenkatalog zur Bewältigung der Ästhetikfrage aufstellen, der folgendermaßen aussehen kann:

. Fachleute sollten angeführt werden, die unbedingt am Entwurf eines Ingenieurbauwerkes beteiligt sein müssen: Architekten, Künstler, Ingenieure, Stadtplaner, Soziologen, Ökologen etc. Es soll versucht werden, ihre Wertigkeit im Entwurfsprozess zu definieren und festzulegen.

. Wichtig erscheinen mir folgende Schwerpunkte in der Ausbildung von Architekten und Ingenieuren:
Gründung von Instituten für Grundlagen der Ästhetik (Vorschlag Leonhardt): Dabei ist auch Allgemeinbildung über kulturelle Dinge zu vermitteln, ebenso wie der Hinweis wichtig ist, daß Erziehung, Kindheit, Elternhaus für die Heranbildung eines ästhetischen Empfindens grundlegend sind.
Bewußtseinsbildung über den Unterschied von Intuition und Ratio.
Bewußtseinsbildung über die Bedeutung von Zusammenarbeit vieler Disziplinen und Verantwortung gegenüber Gesellschaft und Natur.
Architekten sollen Ingenieurprojekte machen und umgekehrt. Gemeinsame Lehrveranstaltungen zwischen Architekten und Ingenieuren haben stattzufinden, um die Probleme und Planungsprozesse des Partners kennenzulernen. Wichtig ist dabei die Erkenntnis der Sachzwänge des anderen.
Gute und schlechte Beispiele für die Zusammenarbeit müssen bekanntgemacht werden. Aus schlechten Beispielen lernt man oft viel mehr, weil gute zur unkritischen Nachahmung ermuntern.
Außerdem ist eine kritische und genaue Analyse vorhandener Bauwerke notwendig. Dinge, die auf den ersten Blick als schlecht zu bezeichnen sind, stellen sich oft erst bei genauerem Studium als gut durchdacht heraus.
Hinzuweisen ist auf den Zusammenhang zwischen Natur und Technik und Modellstudien sollten gemacht werden anstelle langwieriger mathematischer Abhandlungen.

- Besonders wichtig ist die Information und Aufklärung von Bauherren, Politikern, Öffentlichkeit und zwar:
  Erklärungen über das vorher Angeführte bezüglich ökonomischer Fragen.
  Hinweise darauf, daß Kompromisse auf wirtschaftlichem Gebiet ein oft nicht in Zahlen ausdrückbares Wohlbefinden und ästhetisches Erfolgserlebnis bewirken, daher darf für eine nur minimale Gestaltung niemals die Forderung nach Wirtschaftlichkeit als Begründung dienen.
  Schließlich sind die Ergebnisse aller übrigen Diskussionen, soferne sie von öffentlichem Interesse sind, bekanntzumachen, wie zum Beispiel die Frage der Abhängigkeit der Planer.
- Die im Einführungsbericht und von den anderen Vortragenden angeführten Kriterien zur Erreichung einer höheren ästhetischen Qualität sind zu bewerten. Man sollte einen Katalog aufstellen, wessen Mitarbeit bei welchen Fragen notwendig ist und mit welcher Bedeutung. Dieser Katalog hat selbstverständlich Unterschiede zu machen bezüglich der Gewichtigkeit der Konstruktionen in einem Bauwerk (Unterschied Einfamilienhaus - Brücke).
- Es sollten genaue Definitionen aufgestellt werden, für wen welche Bauwerke besonders schön zu sein haben (Benützer, Betrachter, Bauherr, mittelbare Umgebung, Stadtbild oder Landschaft usw.). Dies wird nämlich dazu führen, daß man bei Ingenieurbauwerken ästhetische Schwerpunkte setzt.
- Über alle Ingenieurbauten müßten Wettbewerbe abgeführt werden und zwar nicht von Baufirmen bezüglich der Ökonomie und Bautermine, sondern von Architekten, Ingenieuren und anderen Fachleuten wegen menschlicher, ästhetischer und konstruktiver Fragen. Für diese Wettbewerbe müßte man Richtlinien ausarbeiten und vorschlagen.

Ich möchte zum Abschluß versuchen, sechs allgemeine Grundsätze für die moderne Ingenieurbaukunst zu formulieren, so wie es für die moderne Architektur beispielsweise Bruno ZEVI in seinen Schriften getan hat:

1) Ablesbarkeit der statisch funktionellen Erfordernisse - die Konstruktion als Erscheinungsform der Bauaufgabe.
2) Richtige Relation zwischen Dimension und Aufgabe - Klassifizierung der Bedeutung der Konstruktion und richtige Wahl des Ausführungsmaterials.
3) Kreativität und nicht ausschließlich Routine - ständige Weiterentwicklung (Strukturen etc.).
4) Integration Bauwerk - Stadt - Territorium (Konstruktionen in der Landschaft und im städtischen Raum sowie ökologischen Zusammenhang).
5) Sicht des Tragwerkes als Gesamtaufgabe und keine Spezialisierung - Gesamtheit als eine Einheit.
6) Keine ausschließlich materielle Betrachtungsweise - das Billige ist nicht immer das Beste.

I

On Aesthetics in Structural Engineering

Sur l'esthétique dans le génie civil

Über die Aesthetik im Ingenieurkonstruktionsbau

MILCHO NESHEV BRAINOV
Professor
Vice-President of the State Committee of Culture
Sofia, Bulgaria

SUMMARY
The item treats the subject, object, setting, solution etc. of the problem. It finds its solution by formulated aesthetical components, through structural forming and detailing, based on two functions of the structures – carrying purpose and aesthetical effect, under definite ,,requirements, unavoidability and riteria''.

RESUME
L'article examine l'objet, la matière et la solution du problème. Il trouve sa solution dans la présence des composants esthétiques formulés, par une forme structurale et des détails constructifs sur la base des deux fonctions d'une construction: fonction structurale et fonction esthétique.

ZUSAMMENFASSUNG
Der Aufsatz betrachtet das Objekt, den Gegenstand, die Grundlagen, die Lösung und andere Komponenten dieses Problems. Das Problem kann gelöst werden mit Hilfe formulierter ästhetischer Komponenten, konstruktiver Formgestaltung und Detailierung und aufgrund der zwei Funktionen des Bauwerks: Tragverhalten und Aesthetik.

All material things with a definite form and appearance in space have become possible and function reliably due to their immutable and moulding carrying structure. This comprises the global basic and material conditions and media for life and work of people, for the existance and development of society (all buildings, bridges and other building and architectural equipment,all equipment and installations of technologies, all machines and products of the industry, all modes of transportation, etc. The structures ensure (1) their own spaces and forms - according to the functions and purposes, (2) their rationality and effectivity - according to the requirements and conditions and (3) their availability and reliability - in general. The structures (in the conditions of limited stresses and deformations) carry and balance all loads and influences (on the buildings, equipment, etc) which arise due to their functional purposes and external conditions. With all this the structures represent themselves the highest form of functional organization of the structural materials. Their creation is on of the most supreme manifestation of the human creativity - the structural creativity.

Besides their utilitarian purpose the material things also have aesthetical effect and perception with their (1) volumetric-spaced form and (2) externally detailed appearance. This form and appearance are their fundamental visual "aesthetic components"[1]

The Aesthetics in Structural Engineering presupposes: consicusly set up requirements for aesthetical effect and perception of that which (1) is created by man, (2) possesses the aesthetical components form and appearance, (3) moulds these aesthetical components with the participation of the structure.

The matter of the problem Aesthetics in Structural Engineering is valid especially for the buildings, bridges and structural equipment, which possess an exceptional diversity and individuality and which have the mark of uniqueness and creativity as a product of architects and structural engineers.

For all of them the volumetric-spaced form, as first aesthetical component, is formed up always and immutably with the participation of their carrying structure. As regards bridges, other structural equipment, buildings, etc., by and large whenever and wherever the structure is visible, this also refers to the second aesthetical component - externally detailed appearance. [1],[2]

The treatment of the problem Aesthetics in Structural Engineering obtains, therefore, not some independent "Aesthetics of Structures", but "Aesthetics of Buildings, Bridges, etc.", which aesthetical components Form and Appearance are the result of their immutable structure. Any structure is determined objectively on the basis of some form, corresponding to certain function, complying with the relevent technical and economic possibilites, etc. Of course, the opposite is also taken into consideration, particularly the strong and even determinative influence of the structure on the form. [3]

In a historic aspect, the development of the structures (and structural materials) has determined (to one or another degree), the forms and the appearance of the buildings, bridges, etc. - not only with their utilitarian purpose, but also with their aesthetical effect and perception. Naturally, this development has always been based on a dynamic and constantly perfecting unity of "function - form - structure", of "architecture - structure - industrialization", of "settlement - buildings - building szstems - structural szstems", etc.

The structures are product of structural creativity and creative structuring on the basis of the constantly developing science and theory of the structures. We shall note in this respect the analogy to the musical creativity, which is also based on the theory of music (for harmony, counterpoint, rhythm, etc. [3]

The Science and the Theory of the Structures reveal the regularites and create knowledge for organizing and structuring of the structural materials in carrying-structural forms and szstems - structures. They are vast and complex science and theory, because the creation of one structure requires knowledge and experience (science and theory) in many scientific and technical fields and directions. [3]

It is easy to understand, when it is a question of Form and Appearance of the structures, that they are product and result mainly of the creative processes and activites: "structural forming" and "structural detailing". These are complicated complex multicyclic creative processes, starting from "primary functionally-technological form", going through the "possibilites of the structural cross-sections", in order to obtain the "final structural form and appearance", with their two functions: (1) primary carrying purpose and (2) secondary aesthetical effect. [3]

In the process of actualizing the first function (the primary carrying purpose) two basic objective criteria are acting simultaneously. The first one is the "material criterion" - for minimum expenditure of material. It is a permanent one in the sense, that for all times and under all conditions it leads to respectively determined structural forms and detailing of the structures. The second one is the "technological criterion" - for minimum expenditure of labour and energy. It is a dynamic one in the sense, that for all times and even for each separate case it leads to respectively different forms and detailing of the structures.

Here we would like to note that the technologies are developing towards satisfying the "material criterion". In this way the structural engineering is approaching a structural perfection: creation of structures with minimum expenditure of material,labour and energy. Many actualizations and achievements are well known, when the "final structure", subordinated exactly to the requirements for minimum expenditure of material, labour and energy, has determined the "final forms and appearance" of the buildings, bridges, etc. with indisputable and aesthetical qualites that have stood the test of time.

It can be also definitely claimed, that the architectural and structural styles of the buildings, bridges, etc. of each epoch are the result exactly of such structural forms and detailing.[1]

Up to this point we have outlined everything in order to justify the position: that after the optimum actualization (on the basis of the above mentioned objective criteria) of the first function of the structures (primary carrying purpose) it follows that their second function (secondary aesthetical effect) should be actualised, too.

We are on this position because we take the liberty to see that the structural knowledge and feelings (theory and creativeness) which leads towards form and appearance of the structures, subordinated to the above mentioned objective criteria, have always formed and are forming man's basic criteria for an aesthetical effect and perception. [4]

We shall take the nature as an objective example. Everything in nature, which has immutable carrying and forming structure is created, in general, as a result of unavoidable objective (1) "necessity" - for some function and purpose, (2) "requirements" - for some balance and stability, (3) "criteria" - for some optimum expenditure of material and energy. And in this case, man is well aware of the "beauty in general" of nature, which has been created not on the basis of some "preliminary" human aesthetical criteria for its effect, but which, in fact, has created "resultant" human aesthetical criteria for its perception. We do underline "beauty in general", because from man's aesthetical point of view in the world are existing not only beautiful, but also unpleasant things, but they will be an unavoidable result of some objective "necessity", "requirements" and "criteria".

We do underline also the "resultant human aesthetical criteria", because a man's unavoidable objective "aesthetical adaptation" to nature is available too.

On the other hand, every thing that is man's product, which again has immutable carrying and forming structure, is a result of the same unavoidable objective "necessity", "requirements" and "criteria". And here, from a man's aesthetical point of view will exist also and unpleasant material human works, but they must be result also of the same unavoidable objective "necessity", "requirements" and "criteria". Towards them the man behaves himself with the respective "aesthetical tolerance" or "aesthetical adoptability".

It is exactly on this point that the cardinal question has to be put: what should man's subjective aesthetical estimation be?

A supplementary one to the above mentioned unavoidable objective "necessity", "requirements" and "criteria", or such that should be established mainly on their basis? And our answer is: man's aesthetical estimation is formed (or should be formed) following the forms and appearance, according to the mentioned objective "necessity", "requirements" and "criteria". This opinion of ours becomes, however, difficult to be contradicted, if in the function (purpose) we include not only "objective utilitarian", but also "subjective aesthetical" requirements. But in this case the aesthetical requirements must have some established and durable determination and justification with a character of social objective categories and criteria, such as have not been determinated up to now.

Evidently, there will be things not beautiful from the point of view of man's subjective aesthetical criteria. But they should be the result also only of a respective "established (immutable) necessity", in the presence of a respective "objective (explicit) unavoidability". But it is possible also, that they are simply an expression of one subjective estimation from the positions of old (of the past) aesthetical criteria, etc. [1]

Asserting that, we have in mind the historical dynamic formation of man s aesthetical criteria for perception: from antique columns to modern space-ships, from old arc bridges to contemporary hanging bridges, from the first domes to the modern hanging roof structures, etc. [4]

We would like to refer to two well known truisms.

The first one is - "beauty must be also justified". And we shall add: in what other way, than by the unavoidable objective "necessity", "requirements" and "criteria"?

The second one is - "man is something great, because is something adaptable". And here too we shall add: to what should man adapt his aesthetical criteria, if not again to those forms and appearance, resulting from the same unavoidable objective "necessity", "requirements" and "criteria".

In this respect it is necessary to have in mind that man's emotional and rational nature are always in some unity, having in mind, that every "emotional effect" is always accompanied by a "rational perception", which on its part is based (historically and naturally) also on the forementioned objective "necessity", "requirements" and "criteria".

The Aesthetics in Structural Engineering has its objective dynamically developing laws and regularites, which do not depend on some "preliminary" emotional notions and postulates but are the result of some rational structural logics and approach. Following this structural logics and approach the structural engineers are creatively looking for new structural decisions - forms and appearance - thus provoking and affirming new understandings and criteria for beauty and aesthetics. /3/,/4/

B i b l i o g r a p h y

1. BRAINOV,M. - "Aesthetics in Structural Engineering". Newspaper "Narodna cultura", No. 49 and 50, Sofia, Bulgaria, 1979
2. BRAINOV,M. - "Human Settlements, Tall Buildings, Structural Systems - Architecture, Structures, Industrialization". Publ.House "Technica", Sofia, Bulgaria, 1979
3. BRAINOV,M. - "Structures - Science, Theory, Creativeness". Under publishing by Bulgarian Academy of Sciences,Sofia, Bulgaria, 1980
4. BRAINOV.M. - "The Scientific-Technical Creation and the Future". Daily Newspaper "Rabotnichesko delo", No 25,Sofia, Bulgaria,1980

Leere Seite
Blank page
Page vide

I

On the Manual for Aesthetic Design of Bridges

Manuel pour la conception esthétique de ponts

Manual für den Entwurf ästhetischer Brücken

YASUJI TAHARA
Consulting Engineer
Japan Bridge and Structure Institute Inc.
Tokyo, Japan

YOSHIO NAKAMURA
Prof. Dr. Eng.
Tokyo Institute of Technology
Tokyo, Japan

SUMMARY
The Manual for Aesthetic Design of Bridges is presented and commented. It contains some illustrations of archetypal configuration for the aesthetic design of bridges and the general aspect of the feeling of aesthetic consciousness which must be indispensable for the design.

RESUME
Le Manuel pour la conception esthétique de ponts est présenté et commenté. Il illustre la configuration de l'archétype esthétique des ponts et le concept général de l'esthétique, élément indispensable dans la conception.

ZUSAMMENFASSUNG
Das Manual für den Entwurf ästhetischer Brücken wird vorgestellt und diskutiert. Es illustriert Archetypen zur Gestaltung ästhetischer Brücken und bespricht den allgemeinen Aspekt ästhetischen Bewusstseins, das bei der Gestaltung unerlässlich ist.

1. INTRODUCTION

1.1 Foreword

It is undeniable that we had received an obvious indication of keen interest in 'Aesthetics in Bridge and Structural Engineering' from the general treatise delivered by Prof. F. Leonhardt at the closing session of the 10th Congress in Tokyo and the warning thesis by Prof. L. Beedle against the biased view of overemphasizing of materialism spreading over the recent world. It has been decided that the purpose of our Manual should be planned in the first place to upgrade to any small extent the average aesthetical level of bridges in Japan so that at least any distastefulness of bridge in appearance should be removed from our sight and the guideline should indicate by examplified cases the methods aiming at a more flexible use and practical quick-effect approach. Under such consideration, it is aimed at also filling up the shortcoming in the design concept arising from the too much dependancy on the mere technical learning of the guideline and hence to awakening the general and basic attention to the preparation of mental or sensuous attitude of those who are going to engage themselves in the design of truly beautiful bridges.

1.2 Aesthetics in Engineering Product

There is an old saying in the West, 'Ploughing the field and forgetting the seeds'. That means, any creative work must be consecrated with his own spirit of the creator. A bridge is also a creation of man after all. If any aesthetic consciousness is contained in a creative object, and when it is introduced into the mind of those who contemplate this object and awakens the feeling of aesthetic consciousness, then this beauty has obtained universality and ubiquity, and has gained an objective beauty.

Viewing this in terms of bridge, the contemplation of a beautiful bridge not only gives many of these people in the society living with such a bridge happiness and blessings, but also is effective to promote and enhance their vitality to live tomorrow and lessen their distress and agony of life. This is, indeed, the real value and usefulness of beauty. In other words, the usefulness of beauty is always linked with its contribution to the fulfillment of man's life and to enhancement of the total value of human character. But, the fact is that the beauty exists not merely in such a engineering product like as a bridge but also in natural things or in work of art. However, there may be noticed some differences between the beauties of engineering product and artistic article or natural things in the basic recognition of the pure aesthetic value and of the incidental aesthetic value intensive in the purposeless or purposeful pertinence in principle. Therefore, the judgement of values in art and in nature may be considered to be independently determined by the differences in the human attitude whether he takes the approach of aesthetic contemplation of the object or whether he takes the approach of utilizing it for his own selfish purpose. On the other hand, in the case of such engineering aesthetics as the case of bridges, the first and topmost demand for a bridge is the intrinsic value which is the value of purposeful pertinence whereby it can perfectly serve for the useful demand of the tranist of goods and people.

Then, based on this conception, when the technical function is expressed in a most rationalized, simplified and refined Gestalt, and when the beauty which is incidental to the so-called effective and useful function and which also reveals itself naturally from its Gestaltung captures the heart of those people who contemplate on it, then this bridge shall be appreciated as an aesthetic object indeed and the beauty of such sort, of engineering product, we call it

Technical Beauty. While, the category of such technical aesthetics in bridge structure may be judged as existing only when the origins of form, and function of the structure, and the origin of structural materials and their textures are composed into one integral of the Structural Gestaltung in a complete harmony so that its concrete exterior appearance may invite the aesthetic judgement or taste of those who contemplate on it. However, looking at the materials and texture of a bridge, they generally consist of steel, concrete or stone and nothing else nowadays. Moreover, its functional formation is fundamentally of the style of beam, arch, rigid frame or cable structural type which is all rationalized in terms of unitary statical basis of the structure as a rule. That is, as for Gestaltung of its own appearance of bridge, it is doomed to have a narrow limited range of choice in expressing its technical aesthetics so far as the aforementioned three basic origins of these materials or textures, forms and function are concerned.

But, in the genre of technical aesthetics as in the case of bridge, the object in a certain set environment is expressed more or less connected with or responding to such environment and is generally contemplated in one setting of Gestaltung with the environment. This naturally enhances the beauty of both the bridge and the environment in one setting. From this viewpoint, for the origins composing the object of technical aesthetics, it must add, besides the earlier described three basic origins, all such important relations as social environment including those of the surrounding landscape, the history and legend of the bridge location as well as other poetic natural scenery and features. Thus, the diversity which no longer is the diversity of only the said three basic origins for the artificial product of technology, but is the diversity so intricately and delicately interwoven with the origins of natural and humanistic environment, has the same effect as that of the creation of so-to-speak a total beauty as if various different tones of voices join in a chorus of the new synthetic.

1.3 Basis of Aesthetic Design

The fundamental of creation is the consecration of spirit into beauty as mentioned at the out set of the above 1.2. In other words, by concrete expression of one's inner thought or feeling into a Gestalt of an object, let the contemplators aquire by themselves the comprehension of the technical process of expression for introducing the aesthetic thought or feeling of the creator himself. The aesthetic feeling by empathy is inherently held by man and loved by him. But its extent and degree may change due to his inherent nature or due to his posteriori surrounding formed by his living environment, education and experience of life after his birth. It must not be ignored that the materialization of aesthetic bridges may really begin with freeing our heart and mind from the distorted civilization caused by the tendency that economy alone should be almighty as it was during the post-war era.

The guideline shown in this paper claims for the cultivation of the feeling of beauty as its just preference. Similarly, the number of approaches of guideline shown below are no more than some examples of partial or fragmentary aesthetic expression of itself in case by case and they are so-to-speak a list of archetypes which are often showed in the Manual. Speaking in terms of the Japanese Judo, these are the archetypes of art which will be cultivated and polished up by the ceaseless exercise and practice of ordinary training. In an actual fight, it is necessary to add to the physical technique the spiritual art of Judo, namely the human spirit. The true essence of Judo may be well demonstrated only when and if each basic archetype or its variation of Judo are freely applied to a upmost form individually or in combination according to the necessity of cases and timing during the fight. And it must be noticed too that this may be successful only when the player is free from all worldly thoughts and intentional contrivance for getting the victory. Therefore, together with the learning and digesting of the basic technique as shown in the guideline, here it becomes necessary above all to have applied training of mental feeling e.g. 'Zen' to the actual design with linkage to the cultivation of aesthetic consciousness and its upgrading at all times. A genious can create a master piece with no much labor and effort, while a layman may acquire and digest a creative feeling to some extent by hard training and self-striving. Thus it may be possible for him to built and create a really beautiful bridge.

2. GUIDELINE

2.1 Principle of Guideline

The purpose of Guideline is to find design conventions in bridge form. In other words, we try to find some archetypal cognition about bridge appearance.

We should try to find this type of cognitions as many as possible and give names to them. When we try to do it, we would be surprized at the proverty of our vocabruaries about bridge appearance.

The structural pattern of build environment more or less reflects our unconsciously conditionned recognition system, i.e., linguistic system. While a culture enjoys abundant and expressive vocabruaries about snows, the others not. While there are cultures provided with plenty of vocabruaries of colors; others may be very poor in this regard. This seems to reflect or even motivate the difference of cultural patterns. Once we give a name to a phenomenon not designated so far, we would be directed to increasing our sensibility to it. It is truely said by linguists that our image about the world is perfectly controlled by our own language.

So, in our case, we understnad that what is needed first is to develop widely acceptable language system for bridge appearance before setting up standards.

Our language system should be of following nature.

(1) Bridge appearance language system provides a guideline as a whole. But it is not design standard. It only suggests various important aspects in bridge appearance.
(2) The main purpose of it is to furnish us with common words to talk about bridge appearance.
(3) Giving a name is in itself highly evaluative action. Further evaluative discriptions are not necessarily required.
(4) In order not to spoil our rich visual experiences, the text should discribe phenomena as they are seen with modest theoretical comments. Our approach may be called rather phenomenological.
(5) Text should contain as many illustrated examples as possible including past ones.
(6) Quotations from other environmental design experiences are recommendable.
(7) Comparative or juxtaposed illustrations are recommendable.
(8) Lost or dead terminologies about bridge visual experiences are recommended to be recollected. This is because a historical approach, together with a synchronous approach, is also expected to provide an important objective tool.

2.2 Tentative terminologies

Tentatively about 70 terms have been proposed and classfied into three categories, i.e. Bridge Configuration, Bridge in Landscape, Color and Texture. These are arranged in hierarchical order shown in Table 1.

Table 1: Proposed terms

- 1 Bridge configuration
- 2 Girdir configuration
- 3 Slenderness
- 4 Hunch
- 5 Girdir cross section
- 6 Visual continuity
- 7 Seamy side of girdir
- 8 Pier configuration
- 9 Slimness
- 10 Section shaping
- 11 Pier articulation
- 12 Orderly pier arrangement
- 13 Abutment configuration
- 14 Abutment volume
- 15 Abutment-girdier interface
- 16 Pier-girdir interface
- 17 Direct support
- 18 Indirect support
- 19 Semi-direct support
- 20 Flying lateral beam
- 21 Non symmetrical pier-beam arrangement
- 22 Major structure silhouette
- 23 Emphasized major silhouette
- 24 Spans articulation
- 25 Disturbing minor members
- 26 Emphasized vertical silhouette
- 27 Proportion
- 28 Excessive perspective curvature
- 29 Hazardous utilities
- 30 Parapet
- 31 Major structure -deck interface
- 32 Sheltered bridge
- 33 Cumber silhouette
- 34 Bridge in landscape
- 35 Bridge view
- 36 Horizontal visual angle
- 37 Vertical visual angle
- 38 Angle of elevation
- 39 Distance
- 40 Viewpoint field
- 41 Terrain-bridge interface
- 42 Abutment-terrain interface
- 43 Pier-water interface
- 44 Pier-terrain interface
- 45 Bridge site
- 46 Approach road
- 47 Footstep access
- 48 Silhouette interference
- 49 Doubled bridge silhouette
- 50 Landscape interference
- 51 View from bridge
- 52 On-bridge balcony
- 53 Bridge ends plaza
- 54 Under bridge view
- 55 Bridge as land mark
- 56 Garden bridge
- 57 Bridge naming
- 58 Color and texture
- 59 Light and colors
- 60 Color semantics
- 61 Bridge colors and site
- 62 Lights
- 63 High lit surface
- 64 Foot lighting
- 65 Road surface lighting
- 66 Texture and materials
- 67 Textured surface
- 68 natural texture
- 69 Texture contrast
- 70 Weather proof steel
- 71 road pavement
- 72 Wooden bridge

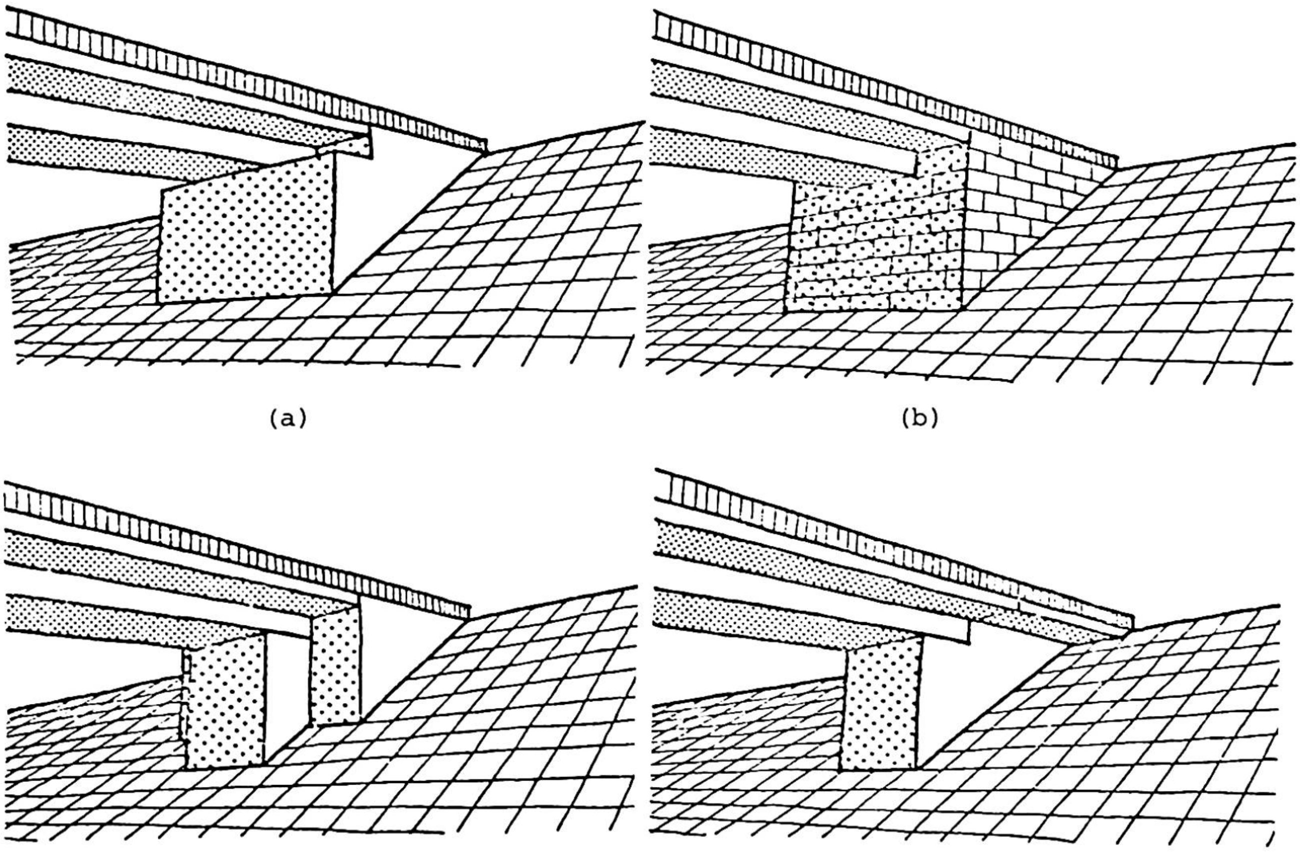
2.3 Brief introduction of some examples

(1) Abutment-girdir interface (No. 15)

The first example is picked up from "Abutment Configuration" which is included in Bridge Configuration.

The most primitive arrangement is shown in Fig 1-(a). The problem of its appearance is caused by the small odd space between the slab and the abutment uppersurface with the summit corner of which giving very hazardous impression. The abutment width, further, being wider than that of the beam results in looking somewhat idle or needless. A retreated abutment with a longer or a side span may be one of the possible solutions. But the type (b) is also possible if the above solution is not applicable. The solution (b) looks much simple in configuration and decisive or static in impression. Fig. 1-(c) shows an another solution. This seems more complicated than type (b), but its shape is producing much strained muscular sensation. While in type (a) the girdir seems to be put loosely on the abutment, type (c) is giving birth to such an impression that the abutment is supporting up the girdir. The later effect may be emphasized with more designed abutment. Type (d) again shows a more simple but sophisticated design example.

On the other hand, type (b) may cause problems in maintenance of shoes and expansion joints compared with type (a). Type (c) or (d) is better in this regard. Consequently, if maintenance free rubber shoes and expansion joints can be applied in case of short spans, type (b) may be good. In case of longer spans with steel shoes, type (c) or (d) becomes worthy of consideration.



(a) (b) (c) (d)

Fig. 1: Abutment-girdir interface

(2) Pier-terrain interface (No. 44)

How a bridge is integrated with terrain context is one of the most critical issue in "Bridge in landscape". This aspect of design is picked up as "Terrain-bridge interface". Among this, here is shown "Pier-terrain interface" (Fig. 2). This concerns how a pier-foot should be arranged. In many aspects of human environmental design, feet of vertical elements such as buildings, trees, columns seem to be of critical importance. In some cases as exemplified in isolated trees in western landscape gardens, foot of tree tends to be kept cleaned leaving no mischelaneous objects besides. This type of treatment allows to let the silhouette of tree trunk very impressive. On the other hand, feet of trees are apt to be slightly hiden by trimmed small bushes or stones in Japanese garden design convention, which produces some nuanced depth impression. Both solutions are quite meaningful and this princple can be applied to bridge design. The top case in Fig. 2 gives some hazardous impression compared with the other two cases. A hazardous column foot may cancell all the efforts to create a good bridge configuration.

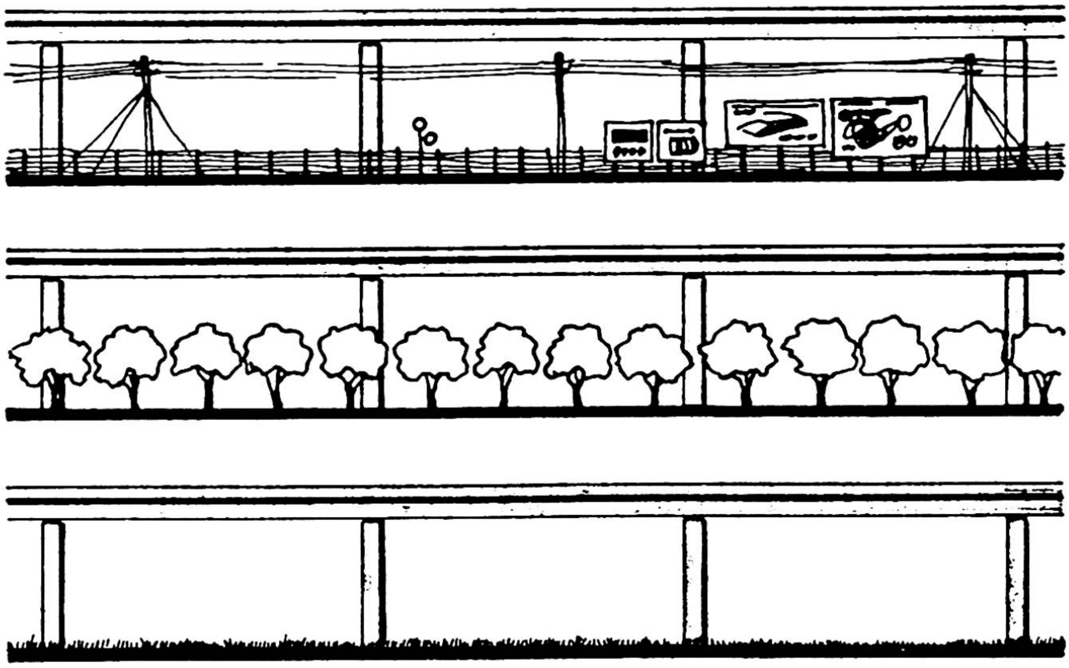


Fig. 2: Pier-terrain interface

(3) Silhouette interface (No. 48)

One of the principles in landscape design is apparently to be attentive to the relationship between the object in question and the other objects in a visual field. To keep the silhouette of a bridge unspoiled avoiding the visual interference with other objects is an elementary condition in this respect. Fig. 3 shows an example where two bridges are visually disturbing each other. This often happens when the two bridges are designed independently by different authorities. Fig. 4 is an another type of pattern in this category. Here, a bridge in the top interfere with a background natural landscape. The bottom case intends to improve this fault.

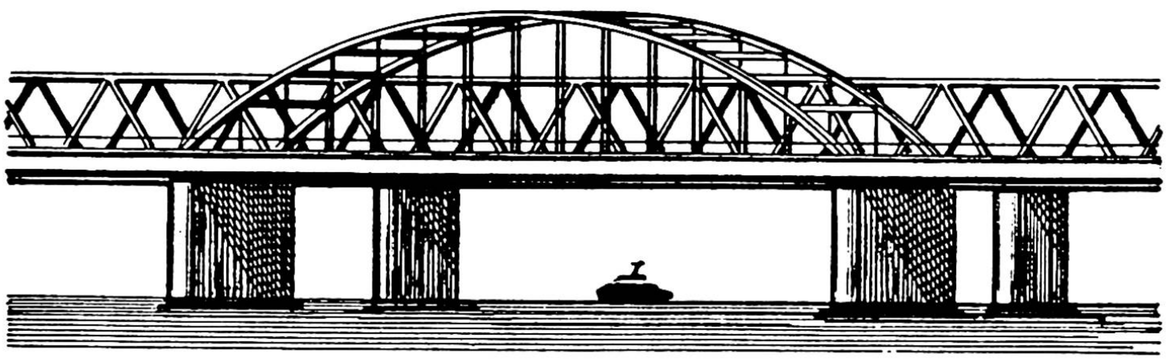


Fig. 3: Doubled bridge silhouette

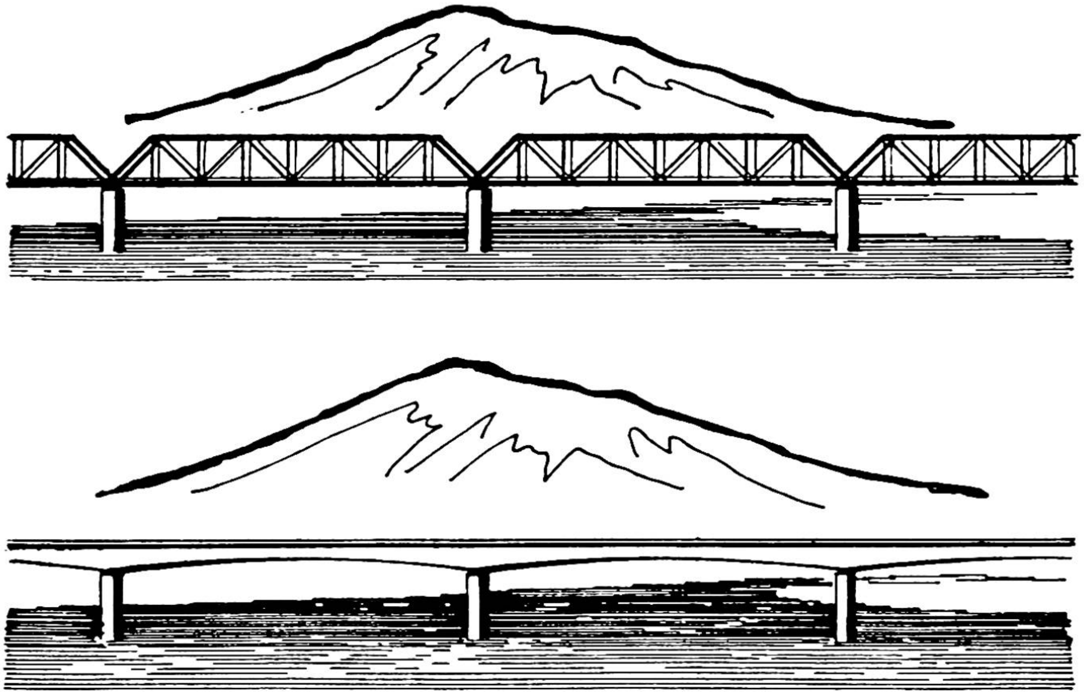


Fig. 4: Landscape interference

(4) Under bridge view (No. 54)

"View from bridge" (No. 51) is also a very important factor in "Bridge in landscape". It gives us an impressive chance for landscape enjoyment. Therefore, "On-bridge balcony" (No. 52) and "Bridge-ends plaza" (No. 53) are worthy of comments. At the same time in this connection, "Under bridge view" cannot be forgotten. A classic example is given in Fig. 5. A bridge here plays a role of an interesting frame for distant landscape. Again in such case "Seamy side of girdir" (No. 7) is important. This kind of attention is especially requested in case of bridge planning in waterfront recreational places.

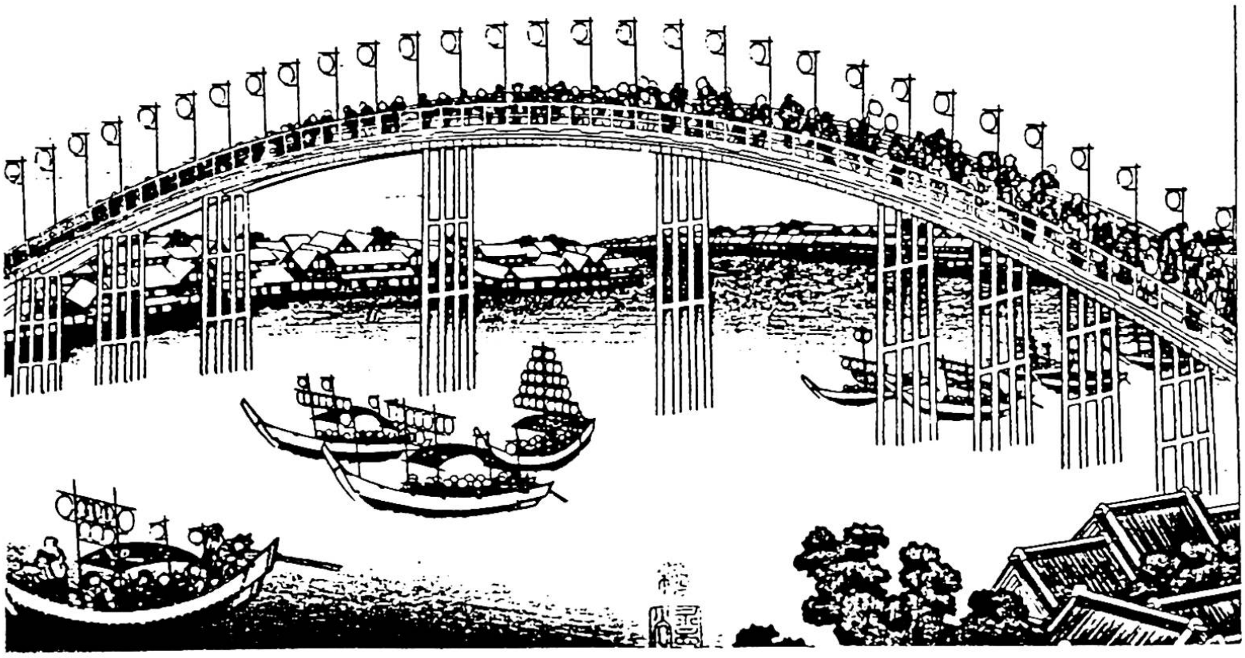


Fig. 5: Under bridge view

I

Methodology of Colour Selection for Steel Girder Bridges

Sélection de la couleur pour des ponts à poutres en acier

Farbauswahl für Stahlträgerbrücken

MANABU ITO
Professor of Civil Eng.
University of Tokyo
Tokyo, Japan

YUKIHISA TAMURA
Engineer
Japan Highway Public Corp.
Tokyo, Japan

TETSUO YANASE
Chief Researcher
Japan Colour Research Inst.
Tokyo, Japan

SUMMARY
Aesthetics of structure is described in terms of its form and colour. Aiming at establishing rational colour selection procedure for steel bridges, the use of landscape colour-mesh technique and photo colour-simulation technique was investigated. The case studies with girder-type bridges suggested the practicability of these methods.

RESUME
L'esthétique des structures est exprimée en termes de forme et de couleur. Pour établir un procédé rationnel de sélection de la couleur pour des ponts en acier, un réseau de paysages-référence et une simulation photographique des couleurs sont examinés. L'étude du cas du pont en acier a montré la praticabilité de la méthode.

ZUSAMMENFASSUNG
Der ästhetische Eindruck der Konstruktion wird von der Form und der Farbe beeinflusst. Mit Hilfe der Landschaft-Farbmaschentechnik sowie einer farbphotographischen Simulation wurde versucht für Stahlträgerbrücken eine ästhetische Farbwahl zu treffen. Einige Beispiele von Versuchen an Trägerbrücken zeigen die Anwendbarkeit der Methode.

1. INTRODUCTION

Aesthetics of structure is described in terms of its form and colour, and assessed in view of beauty of the structure itself and harmony with the surrounding landscape. In general, steel structures can be artificially coloured by painting. The colour selection of these steel structures has been usually relied on individual taste of engineers and technological aspects of paints.

The present contribution is extracted from the committee report, of which the first author was a chairman and aims at establishing more objective and universal colour planning procedure for steel highway bridges to select the colour harmonizing with surrounding landscape.

2. METHODOLOGY OF COLOUR PLANNING

The colour selection procedure is shown in Fig. 1, in which

1) Zoning: although a highway route passes through different landscapes, the use of different colour for each bridge results in lack of uniformity and increase of maintenance cost. It is then recommended to select a bridge colour for a landscape zone.

2) Policy of colour selection: it is preferable to establish basic image, such as harmony or contrast, for the interaction of structure and landscape according to the site, scale and type of the structure.

3) Landscape colour is recorded by either photographing or direct colour measurement from appropriate points of sight. The change of landscape colour due to seasons, weather and so forth should be taken into account.

4) Selection of assessment technique is concerned with the work just mentioned above. In this study the practicability of the four techniques shown in Fig. 2 was investigated. Although the photo-montage method has many advantages, it is relatively laborious and expensive. The result of the landscape colour-mesh technique is as shown in Fig. 3, which is useful to describe the composition of landscape colours from direct measurement at the site and find objectively the basic colours of the landscape.

5) Selection of several proposed colours will be done by one of the following methods:
(a) personal decision by the experts concerned
(b) use fo psychological assessment techniques in combination with photo-colour-simulation
(c) use of colour matching practice, referring to Table 1 where the public reactions to bridge colour from semantic differential test are reflected to.

6) A bridge colour to be adopted is finally selected from those mentioned above, on the basis of technological aspects of painting and judgments of engineers and colour experts.

3. HUMAN RESPONSE TO BRIDGE COLOUR

In order to investigate the applicability of the foregoing procedures, the case studies were conducted with the following two multi-span plate girder bridges under planning:
1. To-ne River Bridge with a total length of 627 m, which is located in the landscape incluing wide water surface surrounded by flat terrain
2. Kosuge Viaduct located in hilly fields with scattered water surfaces.

The colours selected for the former are listed in Table 2. Image survey due to the semantic differential test was conducted with the colour slide projection of the photo-montage of To-ne River Bridge and the synthetic photograph of Kosuge Viaduct, together with other two girder bridges already constructed in this area according to similar colour planning technique. The number of subjects who are not the experts in this field was 30 combining equal number of males and females, college students and adults, respectively.

The mean rating and the standard deviation of human response to the samples as a whole were calculated from the results of the above test. Further a factorial loading for each adjective scale was obtained as shown in Table 3. The results suggest that the connotative meaning of bridge colours in the present case is primarily measured along the evaluative and activity dimensions. The concept of bridge colours could then be plotted in two-dimensional semantic space as in Fig. 4. Although the present case studies were confined to the girder bridges located in rather flat terrains, which resulted in very small contribution of potency dimensions, location of the colours in semantic space is respectively different in both model bridges.

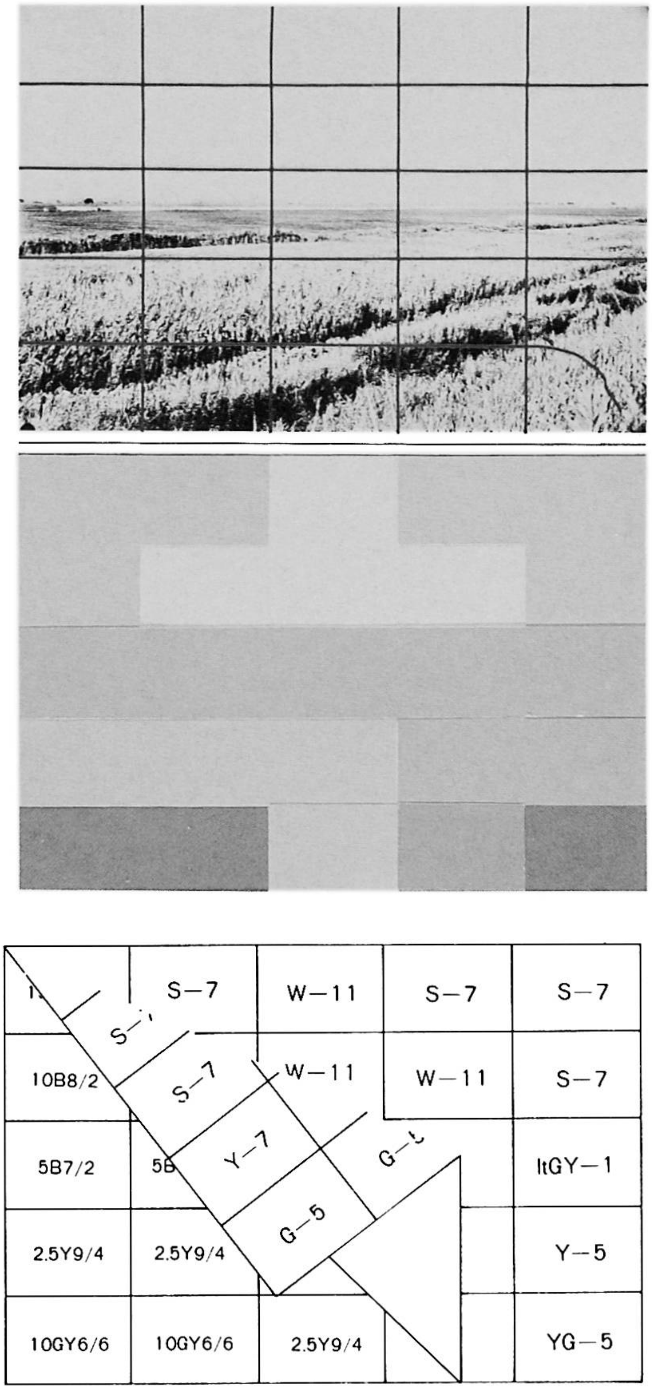


Fig. 3 Example of Colour Mesh Data

The investigation was repeated with different kinds of people, that is the group of bridge engineers and colour designers, respectively. The results are as shown in Table 2, where it is noted that the colours given high appraisal were mostly not those selected from the resembling landscape colour-simulation technique. Clean and vivid colours seemed to appear in the landscape colour-mesh technique, while colour processing affects the results from the photo-colour-simulation methods.

Table 1 Colour Matching in Bridge Design

Semantic dimention	Govering scales / Pattern of matching	Same		Resemblance		Contrast	
		hue	tone	hue	tone	hue	tone
Evaluative	Harmonious with ladnscape	o	o				
	Blameless		o				
	Beautiful			o	o		o
Activity	Gay and showy					o	o
	Individual				o	o	o

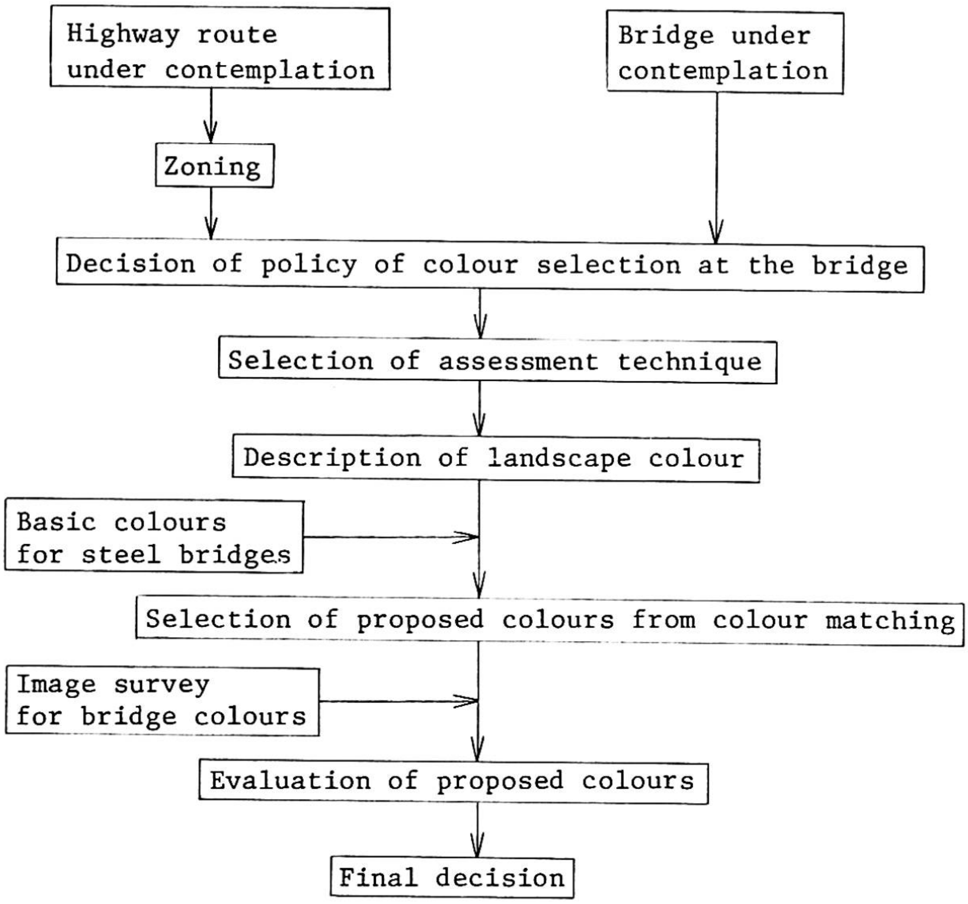


Fig. 1 Flow Chart of Colour Selection Procedure

Table 2 Colours selected for To-ne River Bridge

Colours	Method used*			Appraisal**			Image of bridge colour	
	A	B-1	B-3	P	E	C		
Bright yellow green	o		o	o	o	o	harmonious	
Light purplish blue	o		o	o		o		
Deep purplish blue	o			o	o			
Light blue			o	o				
Light grey	o		o	o	o	o	blameless	
Vivid purplish blue	o	o					beautiful	
Bright yellow	o	o						
Bright greenish yellow	o		o	o	o			evaluative
Bright greenish blue	o					o		
Bright blue	o			o				
Bright purplish blue	o	o		o				
Light yellow	o		o	o	o	o		
Light greenish blue	o		o	o				
Vivid blue		o	o		o			
Light green			o	o		o		
Vivid yellow green	o						showy	activity
Coral			o	o				

* see Fig. 2, ** P: non-experts, E: engineers, C: colour experts

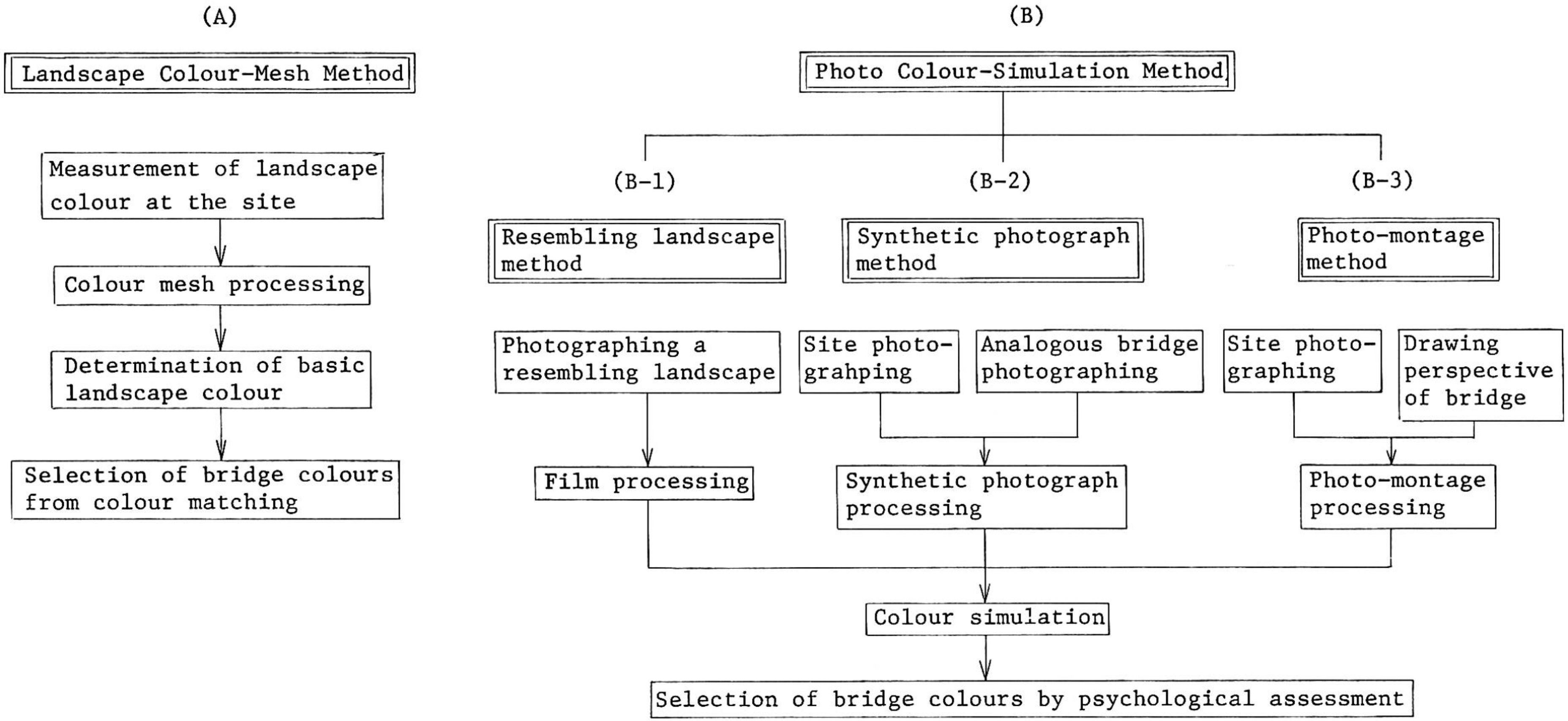


Fig. 2 Colour Selection Methods for Steel Bridges

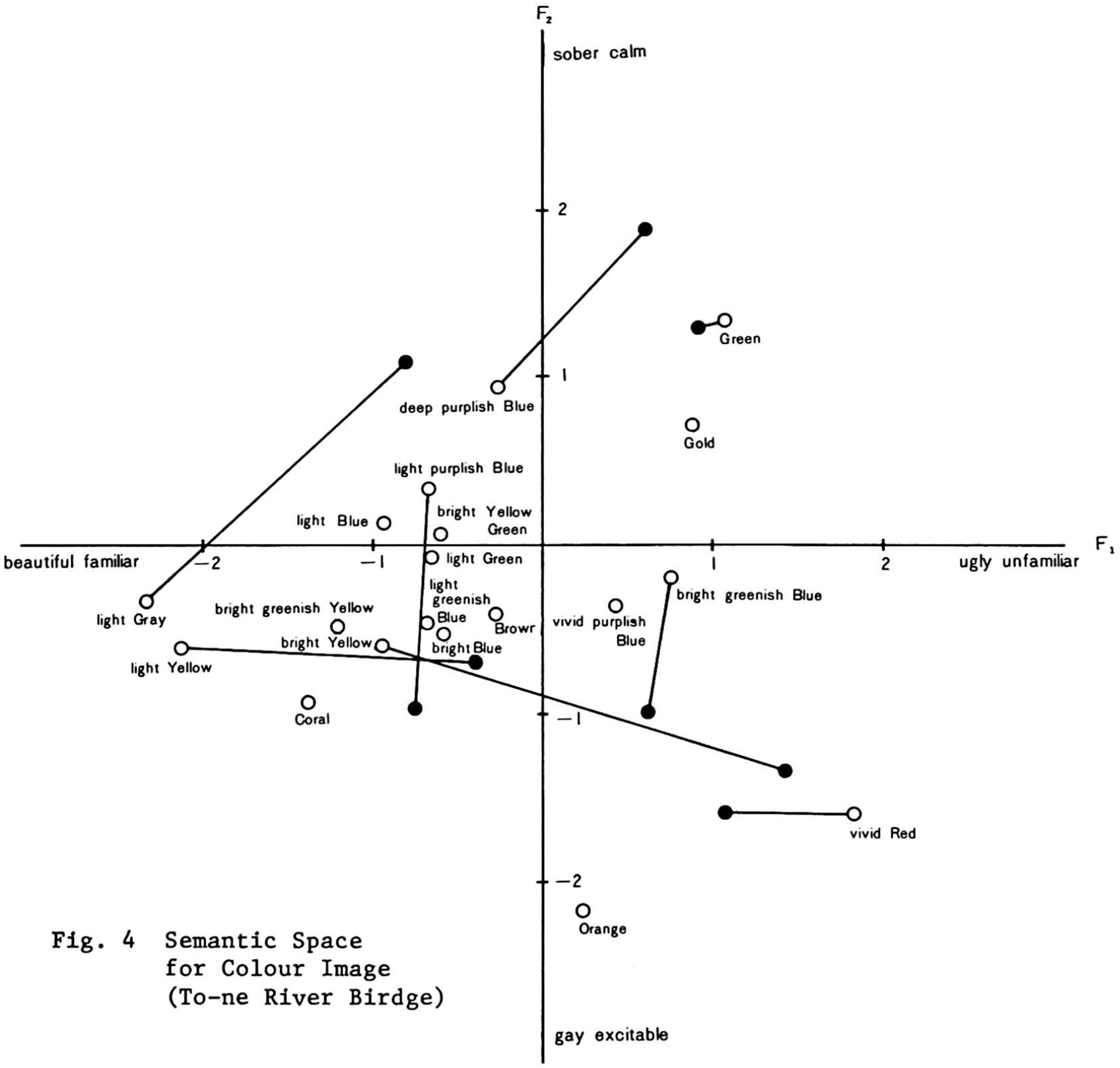


Fig. 4 Semantic Space for Colour Image (To-ne River Birdge)

Table 3 Factorial Loadings for Scales of Meaning

Scales	Factor I (Evaluative)	Factor II (Activity)	Factor III (Potency)
1. beautiful	0.941	-0.107	0.065
3. dislike it	-0.899	0.331	-0.177
10. good	0.851	-0.438	0.191
6. familiar	0.769	-0.496	0.282
2. factitious	-0.672	0.626	-0.031
9. dissonant	-0.663	0.602	-0.303
4. spacious	0.599	-0.270	0.331
5. gay	-0.250	0.910	-0.261
12. excitable	-0.265	0.849	-0.269
8. placid	0.484	-0.800	0.145
11. individual	-0.324	0.752	-0.495
7. simple	0.232	-0.427	0.701

I

Bridge Aesthetics

L'esthétique des ponts

Brückenästhetik

R.E. SLATER
Consulting Architect
Bognor Egis, England

SUMMARY
The importance of space control in the design of bridges is considered with some aesthetic problems and suggested solutions.

RESUME
L'importance du contrôle de l'espace dans le projet des ponts est examinée. Quelques problèmes esthétiques et leurs solutions sont présentés.

ZUSAMMENFASSUNG
Der Einfluss des räumlichen Erfassens beim Entwurf einer Brücke wird diskutiert. Es werden Probleme der Aesthetik und Vorschläge zu deren Lösung aufgezeigt.

When considering the aesthetics of a bridge design it is normally the form and detailing of the structural elements that are discussed. The spatial proportions and patterns are either overlooked, or ignored entirely. This may be due to a lack of perception in these matters, but more often an awareness of the background of limiting factors which render complete freedom in design impracticable. Deck levels will be fixed by the Highway Engineer, pier positions limited by ground conditions under the guidance of the Soils Engineer and choice of structural form influenced by practical and economic parameters. However, it is rare to encounter a set of conditions permitting only one possible solution and experience shows that often a more satisfying aesthetic solution, at very small extra cost and labour, can be obtained by small adjustments in span arrangement and structural detailing. It is a fact that more often than not the essential character of a bridge is determined by its voidal shapes and proportions.

To digress briefly, in the architecture of Buildings, the prime purpose of the Architect is to provide "enclosed spaces" for functional enjoyment by the Client. Unfortunately, only a few modern Architects appreciate the aesthetic importance of these "space boxes". Space boxes (halls, rooms etc.) are defined by boundaries - floors, walls and ceilings - and are usually "open-ended" in part by fenestration. It may be noted that the surface treatment of these planes can contribute slight apparent variations in the essential spatial proportions. For example vertical patterns on walls give an apparent increase in height, horizontal patterns on walls give apparent increase in length, ceilings may appear higher by careful choice of colour and texture. In good design there must be a delicate balance between the voids and masses accompanied by sympathetic detailing. We cannot simply ignore the spatial forms, in which, as someone has said, we live, move and have our being.

Bridges do not, as a rule, enclose space. They organise and regulate spatial flow. The voidal shapes which they produce, often quite complex, may be pleasing to the eye and may often be in sympathy with the landscape. But just as one sometimes finds badly proportioned rooms - in which one cannot relax with ease - there are to be found ugly and even aggressive voidal forms in bridges, and too often voidal forms entirely at variance with the environment. I am not aware of any Rules which one can apply for visual aesthetic enjoyment - Engineers must exercise individual perception and develop individual awareness of aesthetic form. A few examples will reveal the importance of good spatial proportion.

1. Bridges in relation to the landscape. Good manners in Architecture require due consideration for neighbours - in this case the environment. Bridges which by reason of unsympathetic form, materials or detailing are seen to be in harsh contrast with their surroundings will provoke dissatisfaction - leading even to aggressive feelings towards the structure.

A gently rolling pastureland cannot withstand the impact of a monumental structure. Its peace will be destroyed by the focal drama of the intrusion. There will be a conflict between horizontal and vertical forms. The environment requires the maintenance of the quality we call "repose". On the other hand an extensive river estuary may be relieved of monotony by the intrusion of a focal point - such as a large suspension, or stayed girder bridge.

A high embankment crossing a river valley will inevitably tend to bisect the valley spatially. A massive viaduct may have a similar effect, but if a viaduct of suitable scale and proportion is substituted, it is possible that the essential spatial character of the valley will be hardly disturbed.

As well as dignity, lightness and delicacy are essential qualities in Bridge Architecture and voidal patterns contribute greatly to these qualities.

2. Bridges with multiple approach spans. As the number of spans increases, individual span proportion and detail are absorbed into the overall pattern and texture. Large central spans, if provided, reduce the risk of monotony by contributing a dominant element to the composition. It often occurs that these larger spans require somewhat differing structural forms from the side spans. This presents no aesthetic problems if dealt with sympathetically. The horizontal deck lines, including soffit structural members, should flow easily, without punctuation, from one form of construction to the other, and any change in material should be carefully detailed in texture and colour to avoid any suggestion of fragmentation. One of the first principles in Architecture is Unity of Composition. The technique of proportionally reducing the span ratio towards each abutment can give a useful improvement in perspective, provided deck lines and ground converge. The key to success lies in the formation of similarly proportioned trapezoidal voids. Where ground and deck lines are nearly parallel it is better to preserve the rhythm of equal spans right up to the abutments.

In townscapes, where building skylines break up the ground lines destroying the void pattern, it seems better also to maintain equal span rhythm.

3. Bridges on the Motorways. The sense of spatial flow becomes very obvious where high speed traffic is involved. Where a motorway runs in a cutting the continuity of the bank slope is an important spatial element. Massive abutments to overbridges constitute unpleasant "stops" to the flow pattern. It is much better to permit the bank slope to flow under the bridge by providing additional side spans. It may be observed that there is also a flow pattern across the overbridge, i.e. across the motorway. Massive abutments will also prevent the easy flow of deck lines into the ground. This integration of flow lines into the environment is an important element in good design. Nature is diverse in character and does not easily accept the simple geometrical land shapes created by the economics of highway engineering. Careful attention to additional land shaping, supplemented by tree and shrub planting will help to restore harmony with natural forms and should always be considered essential to the completion of the motorway contract. The character of space is defined by its boundaries.

4. Arch Rib Bridge Forms. These structures pose some interesting spatial problems which are only rarely solved in a pleasing manner.

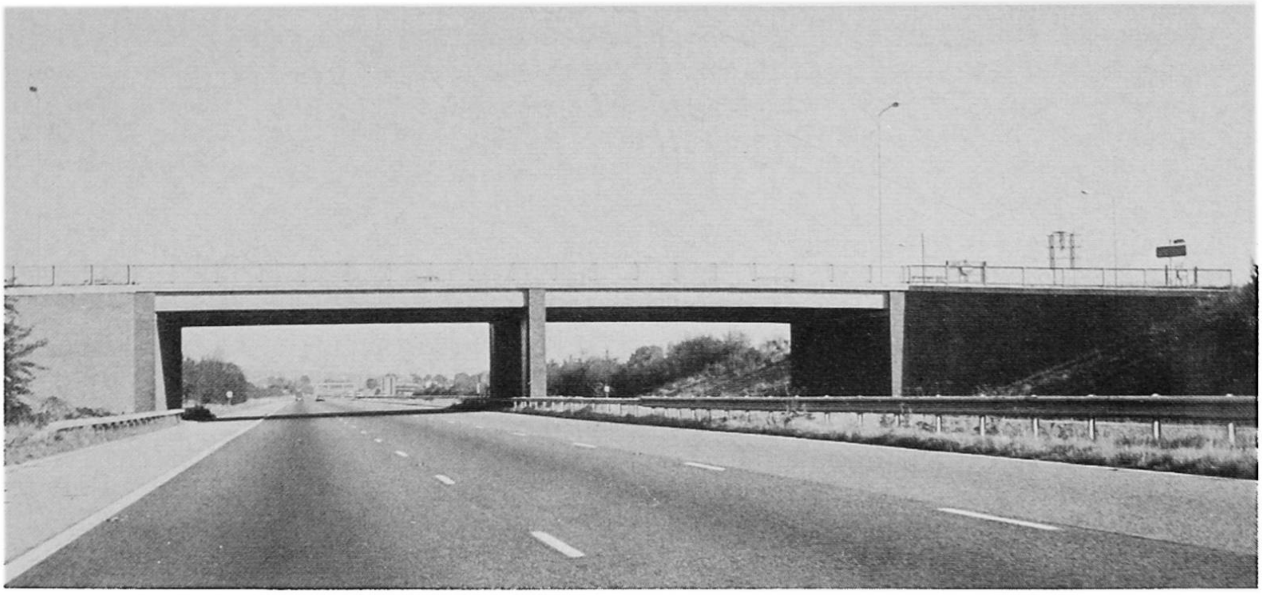
The void under the arch provides an observer at ground level with an almost ideal "frame" for a vista. The curved soffit of the arch is infinitely more relaxing to the eye than a comparable rectangular form provided by beam and pier constructions. The actual shape of the curve is of some interest. Modern structural analysis often requires a parabolic form, but the limits of peripheral vision prefer a shape more approaching the elliptical. Probably the best compromise would be segmental. Another visual defect of the parabola is in the acute perspective view - when a bridge is viewed from a position near an abutment the curve of the parabola tends towards the monumental - containing two straight lines and a segmental crown.

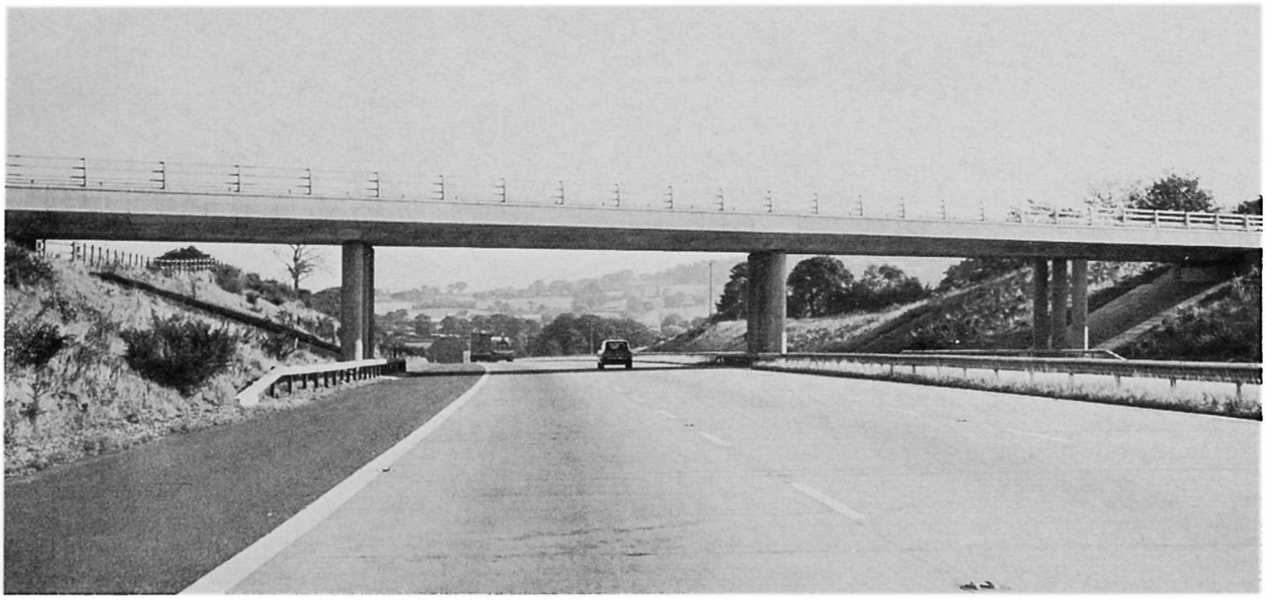
Interesting problems in form occur between the straight lines of the deck and the arch curves and these are greatly influenced by acute angled triangular voids in the spandrels. Feelings of tension and aggression can be reduced by spandrel struts which increase the dominance of the central void. The three dimensional aspect of space must be remembered and large slab wall struts here will have a disastrous effect on the composition.

Finally, as an example of the strength of the void in aesthetics we may examine the effect of duality in bridge design.

Briefly, duality is simply the intrusion of two identical focal shapes which cause the interested observer to compare each with the other, back and forth, endlessly until the observer suffers fatigue from irritation and distraction. It is the anti-thesis of Unity in composition and the defect is well known to Artists and Architects alike.

A two-span bridge whose voids are both identical may generate duality. Even a powerful motif on the central pier will not prevent this. It is possible that the two voids enclose dual vistas - be that as it may, it is not possible for the central pier to hold the composition together. On the other hand, a three-span bridge, though it has two piers, is devoid of this defect, particularly when the side spans exhibit smaller voids than the central span. In these instances it will be seen that the voids dominate the masses. The phenomenon would seem to apply less to motorway bridges however where the alternate traffic flow coupled with the effects of traffic speed reduce the distraction noted above. Nevertheless, in the Author's view, three span motorway bridges are more pleasing than two span types.





I

Recherche sur l'esthétique des ponts-types

Forschung über Aesthetik der Standardbrücken

Research into Aesthetics of Standard Bridges

HENRI GRELU
Ingénieur en Chef des Ponts et Chaussées
S.E.T.R.A.
Bagneux, France

ANNE BERNARD-GELY
Ingénieur des Ponts et Chaussées
S.E.T.R.A.
Bagneux, France

MICHEL LAURAS
Ingénieur des Travaux Publics de l'Etat
S.E.T.R.A.
Bagneux, France

RESUME
La majorité des ponts construits en France actuellement sont des ouvrages de taille modeste, dont le projet est élaboré à partir d'éléments standardisés proposés par le S.E.T.R.A. Pour ces ouvrages-types, la recherche esthétique est incluse dans la méthodologie même de l'étude de l'ouvrage: choix du type et composition des éléments -types.

ZUSAMMENFASSUNG
Die meisten der heute in Frankreich aufgebauten Brücken sind mittelgrosse und nach Standardelementen geplante Brücken. Diese Elemente wurden von S.E.T.R.A. entworfen. Bei diesen Standardbrücken ist die Forschung bezüglich Aesthetik in der Projektierungsmethode berücksichtigt worden: Wahl des Brückentyps und Zusammensetzung der Standardelemente.

SUMMARY
At the present time most of the bridges built in France are of middle size, the draft of which is made from standard elements proposed by the S.E.T.R.A. For these standard bridges, aesthetic research is included in the very methodology of the structure study: selection of the type and composing of the standard elements.

Nous ne parlerons pas des grands ouvrages pour lesquels le Maître d'Ouvrage peut confier l'étude technique et architecturale ainsi que l'exécution à des personnes (projeteurs, entreprise, ...) compétentes, car le coût autorisé n'est en général pas trop limité.

Nous parlerons plutôt de ces ouvrages anonymes, de longueur modeste, que l'on construit chaque année à plus de 1 000 exemplaires en France. Pour ces ponts, le Maître d'Ouvrage ne dispose que d'une somme d'argent ne dépassant pas un plafond limité et n'a donc qu'un seul objectif, outre le respect de la sécurité : construire au moindre coût. C'est pour ces ouvrages que le S.E.T.R.A., en analysant d'un point de vue fonctionnel les différentes parties d'un pont, a développé pour chacune d'entre elles une méthodologie d'étude avec programmes de calcul et dessins automatiques associés et a rédigé des dossiers-pilotes d'éléments-types standardisés. La combinaison de ces dossiers-pilotes permet de projeter des ouvrages dans leur totalité depuis les fondations jusqu'aux équipements, en résolvant les problèmes sur mesure grâce à la souplesse du calcul et du dessin automatiques : ce sont les ponts-types ; ils représentent environ 60 % des ponts construits actuellement en France.

Leur étude architecturale est donc différente de celle des grands ponts. Est-il possible de projeter un ouvrage agréable d'aspect, s'insérant correctement dans le site tout en étant à la portée d'une entreprise de technicité moyenne, de préférence locale ? C'est pour répondre à cette interrogation qu'a été élaborée une méthodologie de l'étude de ces types de ponts.

1. METHODOLOGIE D'UNE ETUDE D'OUVRAGES COURANTS

Nous distinguerons trois phases :

- recueil des données y compris celles qui seront déterminantes pour un choix esthétique ;
- choix d'une structure répondant aux contraintes techniques, esthétiques et économiques ;
- composition des différents éléments standard et étude de détail de chaque élément.

a) Recueil des données

Le projeteur doit tout d'abord recenser le maximum de données qui, d'ailleurs, ne sont pas forcément indépendantes :

- données relatives à la destination de l'ouvrage lui-même : largeur, charges, équipements, ... ;
- données relatives à la nature des obstacles franchis : dimensions de la brèche, zones où les appuis peuvent être disposés, dimensions du gabarit à respecter, obligation ou non de conserver le trafic au cours des travaux, ... ;
- données géotechniques : quel type de fondations à adopter ?, peut-on bénéficier des réactions horizontales du terrain ou pas ? ... ;
- données relatives à l'environnement : deux ouvrages semblables et de mêmes dimensions n'auront pas la même apparence suivant qu'ils seront construits au sein d'une ville industrielle ou au milieu de la campagne. La texture urbaine d'une ville industrielle peut rendre acceptable, voire même agréable, un ouvrage qui serait choquant en rase campagne. D'autre part, les ouvrages doivent être étudiés à partir de points de vue qui peuvent être considérés comme très probables. Généralement, l'usager de la voie portée par l'ouvrage sera peu concerné par son aspect ; par contre, dans le cas d'ouvrages hors agglomération, le point de vue à considérer sera celui des automobilistes circulant au niveau inférieur ; quant aux ouvrages urbains, il y a lieu d'envisager des points de vue variés.

b) Choix d'un type de structure

La seconde phase consiste à inventorier, à l'aide de silhouettes, les différents types de structure techniquement envisageables et à choisir celle qui répond le mieux aux résultats de l'analyse faite lors de la première phase.

Il y a lieu de remarquer que le choix du matériau prédominant (béton ou métal) est déterminant pour l'aspect final de l'ouvrage. En effet, dans le cas du béton, il y a unité de la matière dans l'ensemble de l'ouvrage alors que, dans le cas de l'acier, il y a diversité de la matière et grande latitude dans le choix de la couleur.

c) Composition et étude de détail des éléments de la structure

Le projeteur pourra ensuite composer la structure avec les différents éléments, par exemple les éléments-types proposés par le S.E.T.R.A. dont le calcul est automatisé et étudier la façon d'harmoniser les formes de ces différents éléments : il y aura corrélation, par exemple, entre la forme de la pile et le profil transversal de la dalle, entre le profil transversal de la dalle et celui de la corniche, ...

Il faudra également étudier les proportions de chaque élément, puis des éléments les uns par rapport aux autres. Les dossiers-pilotes ne donnent pas une forme figée à l'élément-type considéré (tablier, appui, corniche, garde-corps, ...) mais propose différentes formes acceptables au gré du projeteur. Par exemple, le dossier PSI.DP (passage supérieur ou inférieur en dalle précontrainte) a permis de construire des ponts-dalles à intrados courbe dans le sens transversal.

C'est à ce stade de la conception de l'ouvrage qu'aucun détail ne devra être oublié : étanchéité, écoulement des eaux, choix des parements, ..., car un oubli peut nuire de manière importante à l'aspect ultérieur de l'ouvrage.

On voit donc que le projeteur peut combiner le choix du type d'ouvrage avec la souplesse de l'agencement des éléments-types en fonction des impératifs techniques de l'ouvrage. De plus, la méthodologie présentée ici concerne l'étude complète de l'ouvrage et pas seulement l'étude esthétique ; c'est ce type de méthodologie qu'un bon projeteur sera amené à suivre.

2. EXEMPLE

Pour illustrer la démarche présentée ci-dessus, nous allons étudier un cas classique : celui d'une autouroute à 2 fois 3 voies en site rural.

a) Recueil des données

- l'ouvrage devra porter une voie départementale d'une largeur utile de 10 m ;
- l'autouroute à franchir est pratiquement au niveau du terrain naturel ; la largeur de plate-forme est de 34 m (terre-plein central de 5 m) et le biais de franchissement est peu accusé ; le gabarit à dégager est de 4,85 m ;
- le sol sera supposé de qualité moyenne : grave compacte à 2 m de profondeur ;
- le site est rural et le relief peu accusé. Pour ce genre de site, la silhouette est déterminante : l'ouvrage devra être de forme simple ; il sera souhaitable de ménager de larges ouvertures pour dégager la perspective.

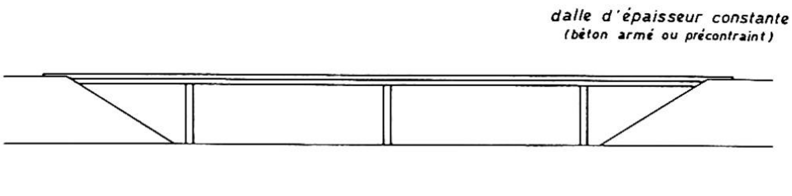
b) Choix d'un type de structure

Cette deuxième phase consiste à recenser les différentes structures techniquement envisageables et à choisir celle qui paraîtra la mieux adaptée.

Nous envisagerons successivement des ouvrages à 4, 3, 2 et 1 travées, les ouvrages à 5 travées et plus pouvant être écartés compte tenu de la largeur modérée de la plate-forme.

– 4 travées

Cette structure, très courante, ne présente aucun problème technique du fait de la longueur modérée des travées. De plus, la largeur du terre-plein central permet sans difficulté l'implantation d'un appui. Du point de vue de l'aspect, elle a l'inconvénient de trop fragmenter l'espace et de ne bien dégager ni la plate-forme, ni les abords. Cette solution est intéressante lorsque le respect du gabarit et des cotes des voies conduisant à limiter l'épaisseur du tablier. En outre, elle est compétitive économiquement.



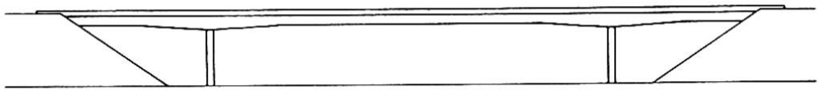
– 3 travées

Nous examinons maintenant le cas d'un ouvrage à 3 travées (avec travée centrale de longueur voisine de 30 m). Du fait que l'ouvrage ne comporte pas d'appui sur le terre-plein central, son choix serait justifié si une largeur réduite de ce dernier ne permettait pas l'implantation d'un appui : ce n'est pas le cas ici.

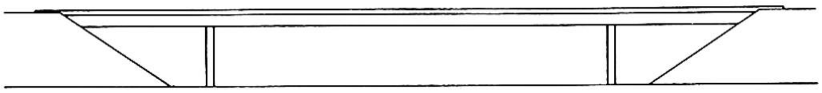
Tablier en béton : dans le cas d'une dalle pleine, celle-ci doit comporter des goussets sur appui ou bien être de hauteur variable ; la solution de la dalle nervurée de hauteur constante peut être aussi envisageable. Pour des raisons mécaniques (risques de soulèvement des abouts), les travées de rive doivent avoir une longueur minimale parfois supérieure à la longueur strictement nécessaire géométriquement.

Ces solutions ne posent pas de problèmes d'exécution et ont l'avantage de dégager toute la partie centrale de la plate-forme. Mais, compte tenu du gabarit et des caractéristiques géométriques de la brèche considérée ici, elles ne sont intéressantes ni du point de vue technique, ni du point de vue économique (leur surcoût par rapport à la solution à 4 travées serait important).

dalle avec goussets sur appuis



dalle d'épaisseur constante ou tablier en ossature mixte

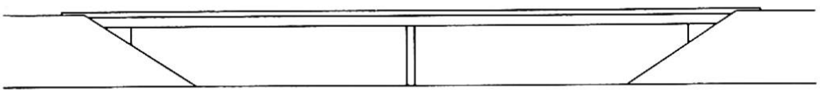


Tablier en ossature mixte : cette structure a les mêmes limites d'emploi que précédemment mais présente par contre l'avantage d'être construite sans échafaudage. De plus, du point de vue esthétique, elle permet des jeux de couleurs. Du point de vue économique, cette solution n'est pas intéressante isolément mais peut l'être dans le cas de lots assez importants.

– 2 travées

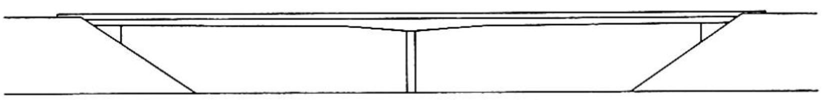
Ces solutions, comparées aux solutions à 3 travées, sont d'autant plus intéressantes que l'on peut réduire la longueur du tablier en avançant les piles-culées (voir schéma). La largeur suffisante du terre-plein central permet, sans difficulté, l'implantation d'un appui central.

dalle d'épaisseur constante



Ces structures, permettant un élargissement ultérieur de la plate-forme, sont également intéressantes du point de vue esthétique car elles ménagent de larges ouvertures et assurent une excellente visibilité (ce qui est particulièrement intéressant lorsque le tracé de l'autoroute est incurvé).

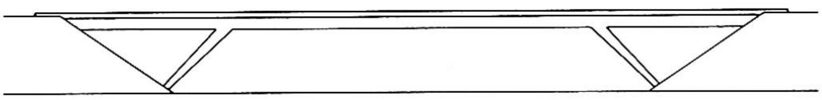
dalle avec goussets sur appui central



– 1 travée

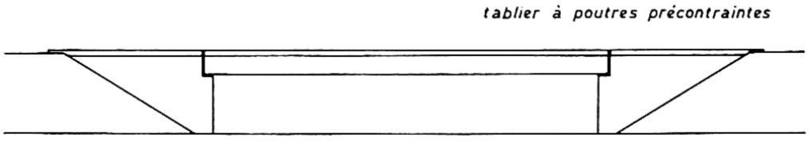
Cette structure ne peut être employée que sur des sols pouvant encaisser des réactions horizontales (en général sols rocheux). Du point de vue de l'esthétique, la silhouette est particulièrement élancée et permet un très bon dégagement de la plate-forme. Cette structure, qui diffère des autres structures courantes, sera d'autant plus appréciée de l'usager qu'elle sera bien en vue, par exemple près d'un point singulier du tracé (point haut, grand déblai, ...) et relativement isolée.

pont à béquilles



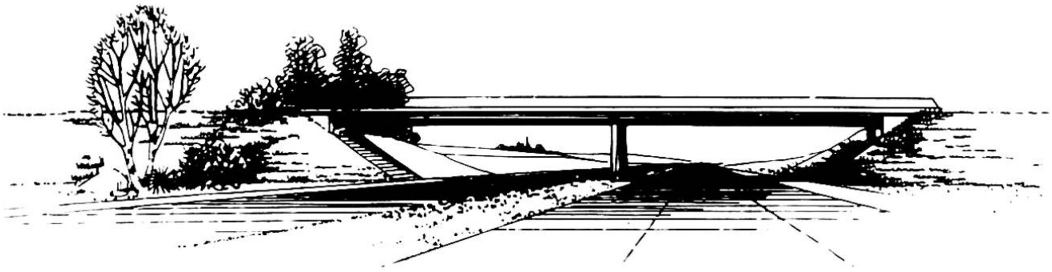
Du point de vue esthétique, cette structure peut être réussie. Du point de vue économique, elle peut être compétitive, si les caractéristiques du sol sont favorables (ce qui n'est pas le cas ici).

Cette structure, malgré sa simplicité technique de réalisation, est à écarter dans le cas présent en raison de l'épaisseur relativement élevée du tablier, d'où surcoût important des remblais d'accès et lourdeur d'aspect.



– *Solution retenue*

De la comparaison des différentes appréciations à la fois d'ordre technique, esthétique et économique, la solution à 2 travées en dalle de béton précontraint d'épaisseur constante parait bien adaptée au type de franchissement étudié. En effet, tout en ne posant aucun problème particulier au point de vue technique, elle semble répondre au mieux aux souhaits esthétiques définis précédemment.



c) Composition et étude des éléments de la structure

On a retenu une section transversale trapézoïdale (voir schémas). Cette disposition, de forme simple et d'exécution facile, figure au dossier PSI.DP ; elle a été choisie d'une part pour son aspect esthétique, et d'autre part pour sa bonne intégration dans l'ensemble de l'ouvrage.

Du fait des encorbellements de la section transversale, l'appui intermédiaire doit être disposé en retrait des bords libres de la dalle. Pour des raisons d'aspect, l'épaisseur de la pile doit être suffisante pour ne pas donner une impression de maigreur ; d'autre part, pour des raisons mécaniques, la pile doit avoir une longueur suffisante à sa base. Cet ensemble de considérations a conduit à adopter un des modèles du dossier P.P. (fruit positif aux extrémités, vide central pour aérer l'ensemble).

Les appuis d'extrémités sont des piles-culées apparentes, décrites au dossier-pilote P.P.

La corniche retenue est une corniche préfabriquée à fruit positif dont le modèle figure au dossier G.C. Le garde-corps est d'un type simple (S 8) adapté aux ouvrages en site rural, et faisant partie des modèles proposés par le dossier G.C.

CONCLUSION

Il ne saurait être question pour le projeteur de faire une étude particulière détaillée pour chaque pont courant. C'est pourquoi, le plus souvent, il est amené à choisir une solution standardisée parmi celles proposées par les dossiers-pilotes. L'étude architecturale est donc différente de celle des grands ouvrages et s'apparenterait plutôt à l'esthétique des objets industriels. Elle doit être entreprise dès le début de l'élaboration du projet et pour cela il faut, bien sûr, que le projeteur soit motivé : elle consiste essentiellement dans le choix du type d'ouvrage et dans la composition de ses différents éléments à partir de ceux présentés dans les dossiers-pilotes. De belles réalisations sont toujours possibles : les exemples ne manquent pas !

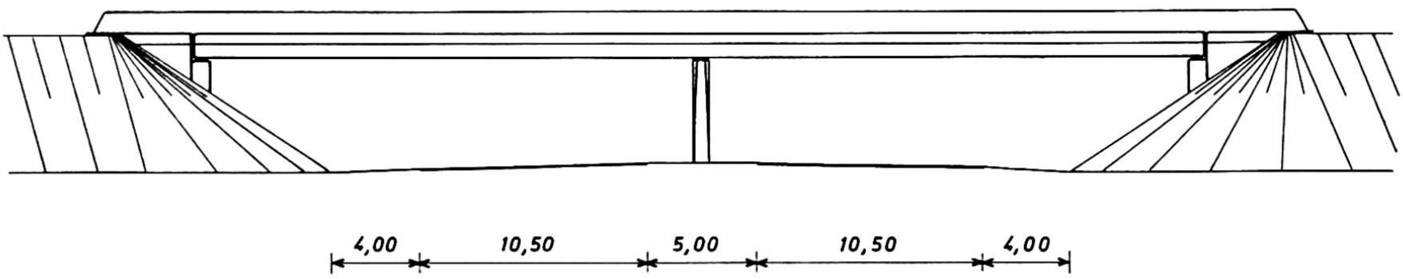
Bibliographie

- Conception des ponts, de G. GRATTESAT (chapitre V-1)
- Guide d'Esthétique pour ouvrages d'art courants (GUEST 69) - S.E.T.R.A.
- Les ponts-types du S.E.T.R.A. (1980).

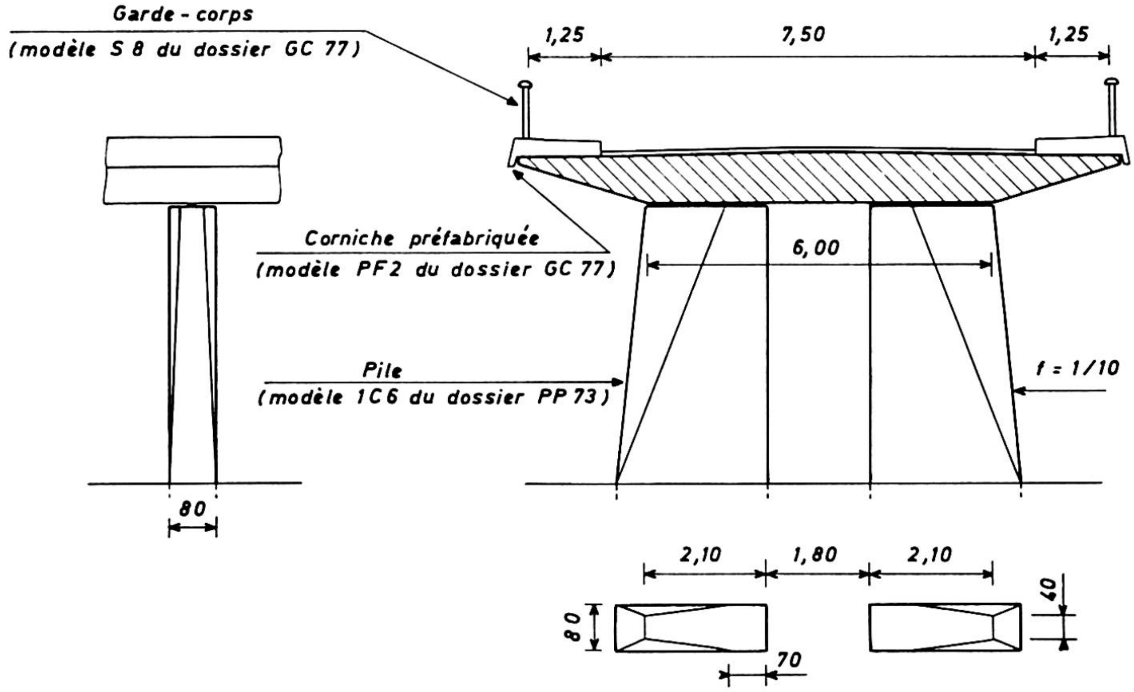
DESSINS RELATIFS AU PROJET RETENU

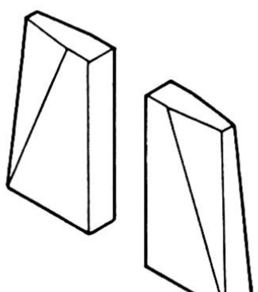
(exemple proposé au § 2)

ÉLÉVATION



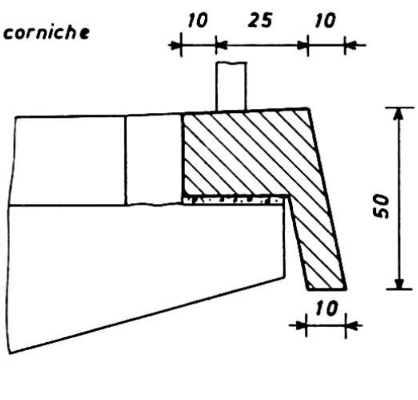
COUPE TRANSVERSALE





Vue perspective de la pile

Détail de la corniche



I

The Farø-Bridges in Denmark: aesthetical considerations

Considérations esthétiques sur les ponts Farø au Danemark

Farø-Brücken in Dänemark: Überlegungen bezüglich der Aesthetik

ERIK VILLEFRANCE
Architect M.A.A.
Rungsted, Denmark

SUMMARY
The political influence on the project and alternative solutions of two highway bridges in Denmark are mentioned. The development of the tender design was based on an aesthetical principle and on the respect for coastal scenery. An aesthetical evaluation is made of two alternatives proposed by tendering contractors. The author presents his reflections on the Danish system of tender and the working conditions of an aesthetical advisor.

RESUME
L'article mentionne l'influence des politiciens sur le projet et les variantes de deux ponts routiers au Danemark. Le concours de projets était basé sur des principles esthétiques et sur le respect du paysage côtier. Un jugement esthétique est porté sur deux variantes. L'auteur présente ses réflexions sur le système de concours au Danemark et sur les conditions de travail d'un conseiller en esthétique.

ZUSAMMENFASSUNG
Der Artikel bespricht den Einfluss der Politik beim Brückenbau anhand von zwei Varianten. Beim Wettbewerb mussten die Aesthetik und der Landschaftsschutz berücksichtigt werden. Der ästhetische Eindruck wurde anhand zweier Varianten ermittelt. Der Autor spricht über seine Eindrücke bezüglich des Wettbewerb-Verfahrens in Dänemark und beschreibt die Arbeitskonditionen eines Beraters in Aesthetik.

1. INTRODUCTION.

The E 4 motor road connects Haparanda, in Northern Sweden with Lissabon in the South. It passes through Denmark from Helsingør with the ferry connection to Sweden, to Rødby with the ferry connection to Germany. (fig. 1.)

The Farø-bridges shall carry this road across Danish domestic waters between Sjælland and Falster via the islet Farø, hence the name of the bridges. On the islet is an interchange with connection to the local road system serving the other islands in the region, in order that the motor road and the bridges may further needed development in the area.

Fig. 1 E4 In Denmark

Up to now the project is one of the largest projects in Denmark. The size of the project and the fact that the bridges are located on an international road endow it with national pride. The importance of both technical and aesthetical qualities of the structures of the bridges and the road alignment is indispensable and demands utmost attention.

The decennium, however, during which the project has been under way has in Denmark, as also in other countries, been characterized by both political and economical instability. The politicians, in search of objects for saving money and gaining votes have influenced the progress of the project causing:

- Review of prior decisions with regard to the alignment of the road.
- Analysis of stagewise execution of both the road and the bridges.

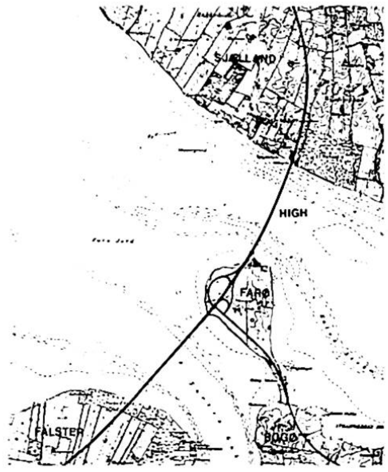


Fig. 2 Bridge alignment

As a matter of fact the project has been the cause of debates in the Folketing right up to the afternoon of 14th May, when the contracts for execution of the project were signed.

The alignment for the bridges via Farø originated in 1963, from civil engineer P.L. Hee (fig. 2).

Work on the project commenced in 1970. Christiani & Nielsen was engaged by the Road Directorate as consultants in order to end up with a tender project.

2. HIGH OR LOW LEVEL BRIDGE:

A navigation channel is located close to the coast of Sjælland and the immediate conclusion was, that the bridge between Sjælland and Farø should be a high level bridge.

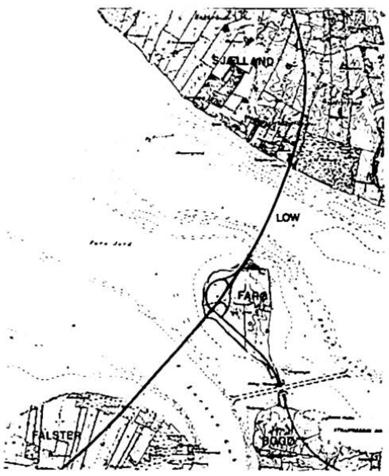


Fig. 3 C&N proposal

An early Christiani & Nielsen proposal substituted this high level bridge with a low level bridge combined with a dredged channel between Farø and the island Bogø (fig. 3). The proposal was good and revealed how an effort to solve functional problems with fantasy instead of traditionally, can succeed. Besides the overall cost of the project would be reduced. Such deviation is, however, often met with opposition from the establishment. So, such a chance for better technical and aesthetical qualities are often subdued, as it also happened in this case.

Let us compare a high level bridge with a low level bridge between Sjælland and Farø from an aesthetical point of view.

In general horizontal and vertical lines in a drawing on the drawingboard are dominant lines, which reveal the deviation and gradients of other lines in the drawing.

In the nature the trees indicate the vertical, whereas the horizontal can only be perceived where there is a watersurface.

In a coastal area where the watersurface is dominant the deviations from the horizontal will be revealed clearly. Harmonious longitudinal profiles across a watersurface are important. Viewing a stretch of water between two coasts, the spontaneous perception is that the depth is greater in the middle. The location of the navigation channel close to the coast of Sjælland causes an oblique, longitudinal profile for the high bridge. The level of the road over the coastline of Sjælland is 27 m and at the abutment at Farø 7 m. This is not spontaneously understandable for an observer and leaves the impression of an awkward, slanting bridge for which there is no direct, logical answer. Besides:

- The high level bridge is conspicuous in the coastal surroundings. (fig. 4).
- Going North, the more close you get to the coast of Sjælland the higher is the level of the road, which appears unusual, and the traveller on the bridge will hardly get in visual contact with neither land nor sea.
- The switchback effect is obvious.

Fig. 4 High level bridge.

- The low bridge does not interfere drastically with the coastal areas. (fig. 5)
- The traveller on the bridge will get in close contact with both sea and land giving him an exciting experience of the coastal scenery.
- The switchback feeling is eliminated.

Fig. 5 Low level bridge.

The aesthetical qualities of the low level bridge had, however, less political backing than the yacht clubs aversion against changing existing sailing conditions, which would be least curtailed by a high level bridge. So, a high level bridge it shall be.

3. TENDER DESIGN.

3.1 Legislation.

In 1976 the Folketing passed legislation authorizing the execution of the Farø-bridges as two high level bridges, one between Sjælland and Farø and another between Farø and Falster, 1.6 km and 1.7 km long respectively.

The navigation span in the Farø-Falster bridge with a clearance, 260 m wide and 26 m high, carried by a cable-stayed structure, not previously built in Denmark.

3.2 Landscape.

Both fig. 6 and fig. 7 might give an idea of the beautiful and characteristic Danish coastal scenery, where the bridges are to be built.

High embankments built out in the water have often been introduced in order to minimize construction cost by reducing the length of the actual bridge construction. But not only do such embankments add alien elements to the façade of the bridge, they also destructively interrupt the continuity of the coastline.

The artificial, dominant shape of embankments is incoherent with the coastal scenery. Only by close co-operation with the environment authorities has it in the Farø project been possible to dispose of embankments, in spite of increased cost, to the benefit of the impression of a simple transition between land and bridge and of the present recreational value of the coastal area. It adds greately to the simplicity and elegance of the bridges that there has been a mutual understanding on this question.

3.3 Persuit of an Aesthetical Principle.

The statical solutions of a structure, considered by the engineer, implies the embryo for the development of aesthetical qualities in the final structure.

It soon became evident that in order to create the impression of the bridge connection between Sjælland and Falster as one continuous structure, it was necessary to bring about a coherence between the high level bridge from Sjælland to Farø and the approach spans to the cable-stayed spans of the Farø-Falster bridge. Their structures were to be alike.

In order to follow the same intention, uniformity should be accentuated by using the same material from coast to coast. The tender project assumed a re-inforced concrete construction. (fig. 6).

Also it was decided to use structural elements of uniform nature and to reduce their numbers to a minimum.

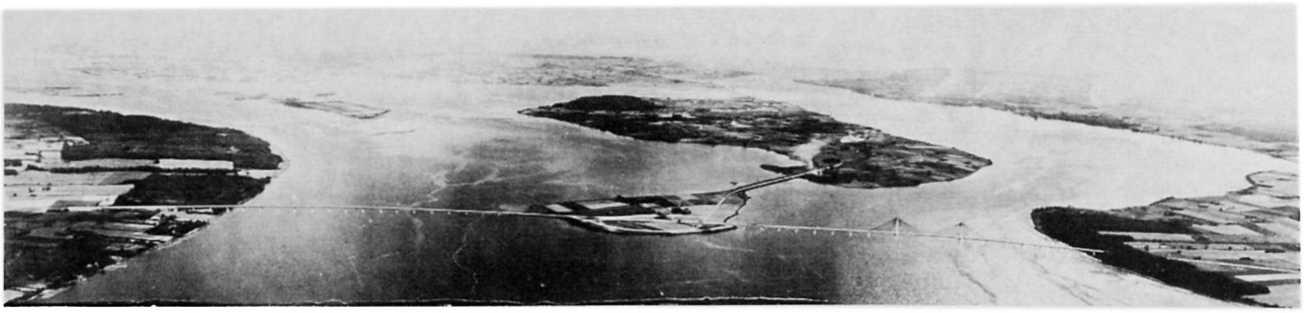


Fig. 6 Airial view of tender project.

Out of these considerations evolved the principle of using the same bridge girder of constant height as the primary element of continuity, and the supporting structures, the piers and the pylons, as the secondary elements.

Naturally the design of the cable-stayed section of the Farø-Falster bridge was by far the most interesting, but it is also the most aesthetically important, single element of the bridge connection to solve. The pylons are prominent and dominant features of the structure. They are exposed to views from wide areas. (fig. 7).

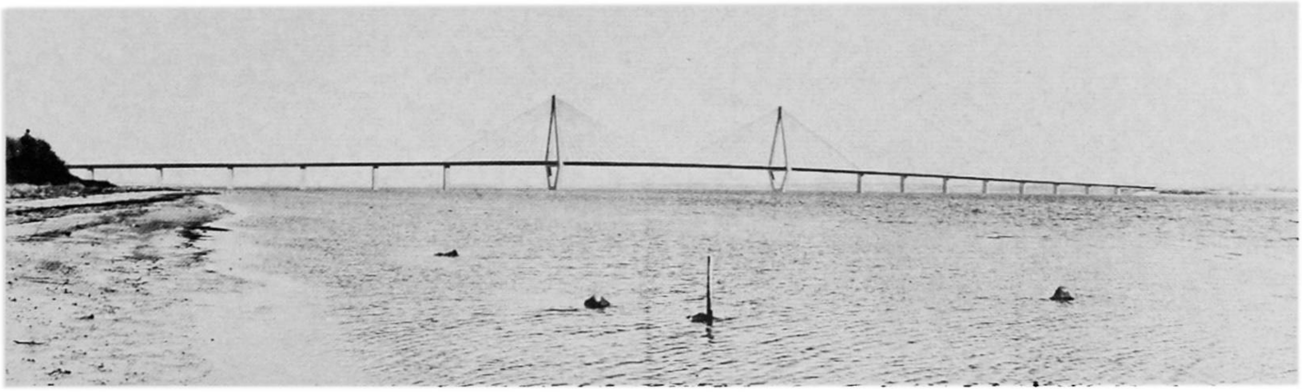


Fig. 7 Bridge Farø-Falster tender project.

As expert advisor for the cable-stayed section Christiani & Nielsen secured the co-operation of professor dr. ing. Fritz Leonhardt. The statical solution of the suspension of the bridge girder in the pylons was precious and furthering for the aesthetical qualities of this important detail. The bridge girder was suspended in stays and is, at the passage through the pylon, only stabilized by bearings, thus giving the structure elegance by the impression of the bridge girder floating freely through the pylons. (fig. 8 & 9).

The A shape of the pylon is chosen after an analysis of other types of pylons, such as center pylon, frame pylon and their suitability with regard to the arrangement of the stays i.e. suspension along the edge or in the center line of the bridge girder. The cross section of the bridge girder favoured the suspension in the center line.

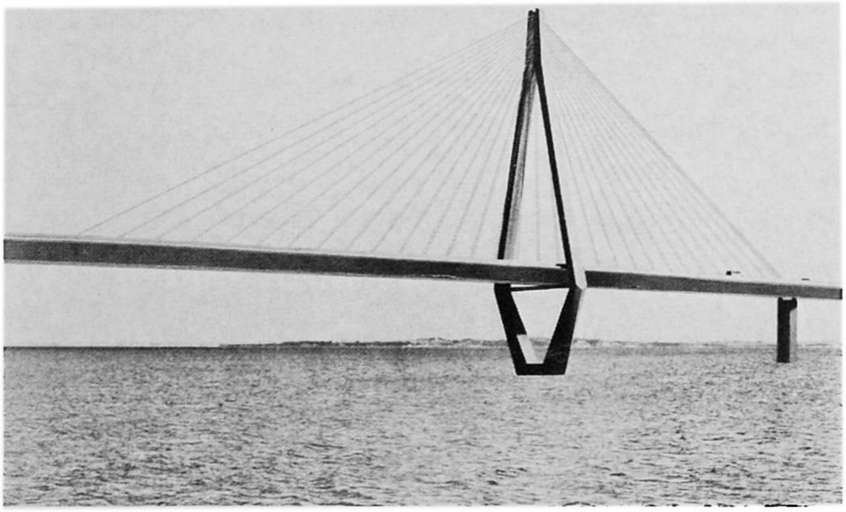


Fig. 8 Pylon of tender design.

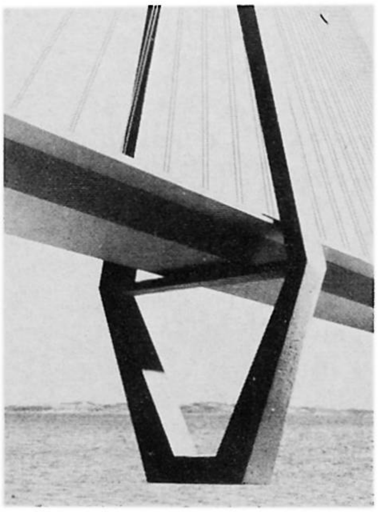


Fig. 9 Detail.

The upper A-shape of the pylon was a suitable and also an economical solution compared with a center pylon, which of course would require a wider cross section of the bridge girder.

The upper part of the pylon is supported by the lower parts slanting legs, hereby reducing the dimensions of foundation, and by the same time in a simple manner establish the, in Danish waters, necessary provision of a sharp edge to break the ice, thereby reducing pressure on the pylon.

All piers are given a similar "ice knife" in their cross section. In order to follow the principle of simplicity the cross section of the piers is continued through the watersurface, instead of introducing a special icebreaking footing.

4. FINAL DESIGN.

4.1 Tender Results.

Tenders were opened on 1. November 1980. Amongst the alternative projects produced by the bidders, two were of special interest, due to their price. One was a re-inforced concrete construction and the other a combination of a superstructure in steel and a substructure in re-inforced concrete.

4.2 Aesthetical Evaluation of Alternatives.

Both projects had another statical principle of the cable-stayed structure than that of the tender project. The pylon and the bridge girder were in both alternatives solidly built together.

The deviation from the statical principle of the tender project is destructive for the elegance of the structure. The continuity of the bridge girder is interrupted, and the impression, that the girder floats through the pylon has disappeared. From an aesthetical point of view an inconsiderate disposition.

The pylon of the concrete project (A) is apparently given a shape deriving entirely from technical demands without considerations of proportions, characteristics and contrasts. (Comparison fig. 10 & 11).

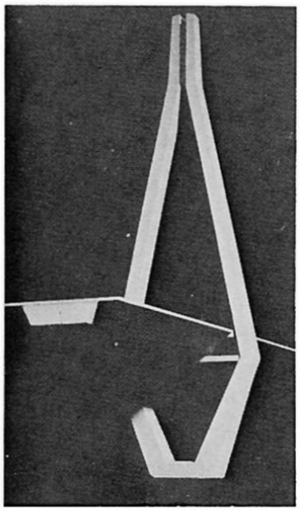


Fig. 10 Tender proj.

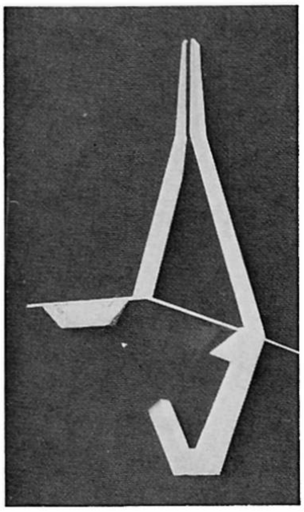


Fig. 11 Project A

The clear seperation of elements in the tender project, the supported and the supporting members, is destroyed. The girder becomes part of the pylon and vice versa.

Also the height of the pylon is reduced to 95 m compared with the tender projects 102 m. The height of the pylon is important with regard to monumentality and proportion in relation to the entire length of the bridge. (ref. fig. 7).

The pylon of the combined steel and concrete project (B) is divided in an upper steel section and a lower concrete section. This appears to be destructive for the coherence and shape of the most dominant element of the bridge connection. (Comparison fig. 12 & 13).

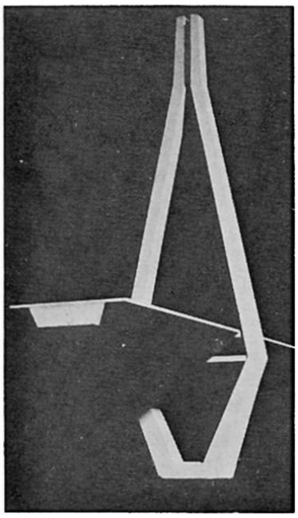


Fig. 12 Tender proj.

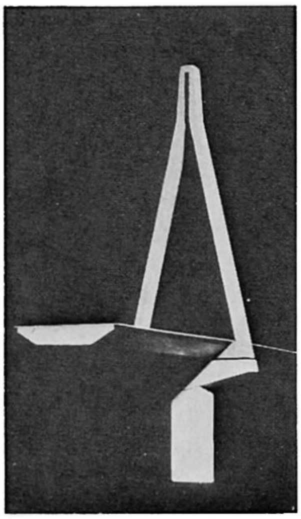


Fig. 13 Project B

Also in this alternative the impression of the continuity of the bridge girder has disappeared, as well as the clear separation in the supporting and supported members of the structure.

The height of the pylon is reduced in this case to 92 m., so the same comments as stated for project (A) are relevant.

The use of different materials with different properties may look acceptable in a drawing, but their different nature and character may be less acceptable in reality.

Painting the steel to look like concrete or painting the concrete with the colour of the steel does not solve the problem. It is a too obvious falsification.

4.3 The Chosen Design.

The bridges shall now be constructed as a combination of the two alternatives i.e. the superstructure with a box girder of steel and the substructure including the pylons to be constructed in re-inforced concrete. (Comparison fig. 14 & 15).

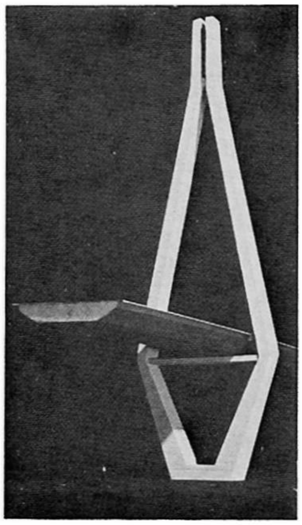


Fig. 14 Pylon Tender project. Steelgirder project B.

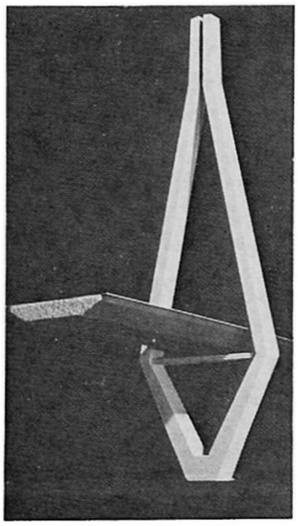


Fig. 15 Pylon proj. A. Steelgirder project B.

5. REFLECTIONS.

It is apparent, that the Danish system of tendering, allowing for alternatives from the contractors - who have only comparatively short time for the design- might result in the abandonment of thoroughly studied aesthetical qualities, if money can be saved.

The arguments for technical qualities are not so easily disposed of, because they deal with realities, which can be proved, contrary to aesthetical qualities, which are of an abstract nature.

Working as an aesthetical advisor, my experience is, that unless arguments for aesthetical values can be combined with a good technical solution and acceptable economy, the chances of their influence will be small.

However, even if a solution is found which fulfils technical, economical and aesthetical aspects, it must be realized that such a solution may not be politically acceptable, and up till now there are, alas, too many examples of "selling out" of aesthetical qualities.

It appears, however, that people are increasingly interested in the more abstract values of life. In this respect, man made structures of any kind in any place are important parts of our environment. So, a carefull and thorough analysis of their aesthetical and environmental qualities appears to become indispensable.

We ought to consider more the importance of making structures in which we can take pride, and which will be enjoyable also for future generations.

How to convey this to our politicians and decision makers, so that they may act with integrity and responsibility ?

Leere Seite
Blank page
Page vide

I

Structural Aesthetics in Architecture and its Social and Technological Relevance

Esthétique structurale en architecture et ses implications sociales et techniques

Aesthetik der Architektur und ihre soziale und technische Bedeutung

FAZLUR R. KHAN
Partner
Skidmore, Owings and Merrill
Chicago, IL, USA

SUMMARY
Structural engineering is primarily based on logic, reason, mathematics and the understanding of the properties of building materials and finally the forces of nature. There is very little room for a structural engineer to indulge in romantic aesthetic forms. But reason in nature has its own inherent aesthetics. Each building material when used in an efficient, simple and sensitive way leads to structural solutions which have its visual strength and presence.

RESUME
L'activité de l'ingénieur civil est basée essentiellement sur la logique, la raison, les mathématiques, la compréhension des propriétés des matériaux de construction et bien sûr les forces de la nature. L'ingénieur a très peu de liberté pour se livrer à la recherche de formes esthétiques romantiques. Mais la nature a ses raisons qui sont liées intimement à l'esthétique. Tout matériau de construction utilisé de façon efficace et sensible contribue à des solutions structurales qui sont également esthétique.

ZUSAMMENFASSUNG
Das Ingenieurwesen basiert auf der Logik, dem Verstand, der Mathematik, den Materialwissenschaften und den Naturgewalten. Der heute projektierende Ingenieur hat wenig Freiheit zur Realisierung romantischer ästhetischer Formen. Aber die Natur an sich hat ihre eigene Aesthetik und jedes Baumaterial kann, wenn es praktisch, einfach und richtig verwendet wird, zu ästhetischen Lösungen führen.

INTRODUCTION

Structural engineering is primarily based on logic, reason, mathematics and the understanding of the properties of building materials and finally the forces of nature. There is very little room for a structural engineer to indulge in romantic aesthetic forms. But reason in nature has its own inherent aesthetics. Each building material when used in an efficient, simple and sensitive way leads to structural solutions which have its visual strength and presence. The aesthetics of a well designed structure is indeed inherent in its very existence and therefore, when visually expressed clearly and honestly makes its own aesthetic contribution.

The structural engineer as a specialist did not exist until very recent times. He was indeed one of many personalities of the historical masterbuilder. From the beginning of civilization when man began to establish urban settlements and up to the middle of the Nineteenth Century; buildings, edifices and monuments have reflected the work of the masterbuilders who responded to the social, political and religious needs of their time with their aesthetic creativity on one hand and the technical and management excellence on the other. The masterbuilder was a man who was taught by one or more masterbuilders of the generation before him and during his training had to demonstrate his own sensitivity in aesthetics, his thorough knowledge of various techniques and methods of construction, his deep understanding of social needs and economic limitations, and finally his capacity to direct and manage all phases of construction of a building. The one man masterbuilder with his assistants could indeed grasp all aspects of planning, design and construction of projects because the form, the method and the material for construction was very much defined by the limits of tradition of the time. Furthermore, the technology itself was relatively simple and did not require the total energy and time of a man to master it. There was indeed no distinction between structural aesthetics and architectural aesthetics. Interestingly, in many languages, the term engineer included all who were engaged in the art and science of designing anything from bridges to buildings.

The traditional role of the masterbuilder began to change with increased sophistication of technologies in the Nineteenth Century, particularly in the second half of it. From mathematics the theories of structures and applied mechanics were slowly developing to be used as specialized tools for predicting the behavior of different types of structures and thereby refining the design to its optimum and most efficient level. This required specialization and those who specialized in these areas of technology were to become the Civil Engineers, later to be even more specialized as Structural Engineers. The buildings, on the other hand, required better and more sophisticated control of internal environment, services and facilities. To design these services and facilities required thorough mastering of two other specialized engineering fields of Mechanical and Electrical Engineering. The masterbuilder, as a single person, could no longer master all these specialized fields of technology. So he was gradually forced to take a new role and a new name - the contemporary "architect" who takes the leadership in coordinating all aspects of planning and technology while being primarily responsible for the aesthetic quality of a building project.

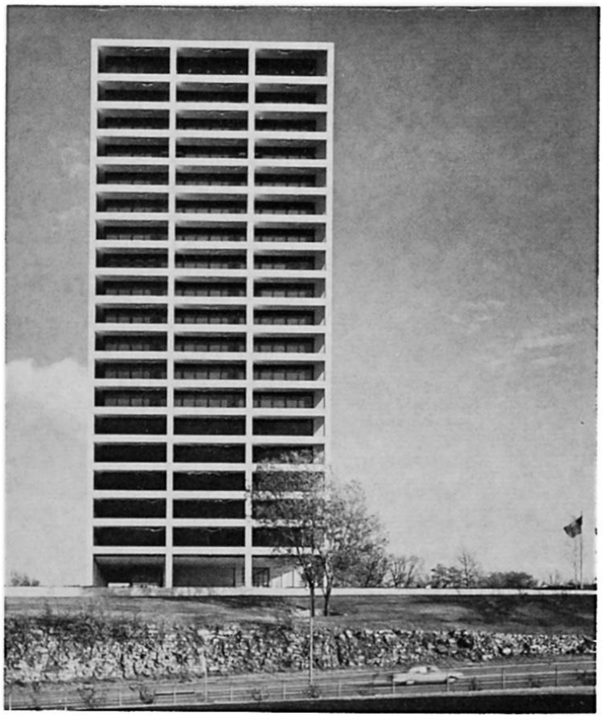
The aesthetic aspect of a building was inherently tied with the technology and material of construction in the earlier times. Unfortunately the evolution of the architect in the modern sense of the word split that overall creative responsibility to different specialists, namely, the architect, to see to the planning and aesthetics and the engineers to see to the strength, stiffness and functioning of the building. This unnatural separation of roles has been responsible for many incongruities between the form and aesthetics on one hand and the function and technology on the other. Aesthetics often became more a question of an arbitrary concept of beauty rather than the inherent beauty that exists in the total concept of a project.

The building profession as a group is beginning to recognize the need to correct this unnatural architect - engineer dichotomy through a fresh reevaluation of the essence of design itself. Aesthetics and technology need to be reunited again by replacing the single person masterbuilder with the team of specialists working together in a complementary spirit to create the right solution, sociologically, aesthetically and technologically.

The author has had a fortunate role in designing a number of significant building structures in the last twenty-five years. Only by working closely with his architectural counterpart could he successfully express these structures and integrate them with the overall architecture. In some of these buildings, the structure, expressed clearly and honestly without any conscious effort to mold it into "art," contributed to the overall architectural strength and beauty at the same time. The author feels that only when architecture and structure become one and the same, the structure can achieve its aesthetic objective. The following examples are presented to support this point of view.

AESTHETICS OF STEEL STRUCTURES

Clear and honest expression of a structure designed to carry the loads without any redundancy can have a visual and architectural impact by itself. Many of the early highrise buildings were designed by architects with preconceived ideas of the exterior of the building based on the Greek, Roman, Gothic and other medieval heavy stone and masonry expression. Because of this a-priori concept of the facade, most of the early steel and concrete frame buildings were not only clad with masonry or stone but also were given visual expressions unrelated to the structure within. The Chicago school of architecture under the leadership of such men as LeBaron Jenney was the first to question these classical exterior expressions. It was indeed the first serious effort to explore more consistent expression of the exterior facade relating to the form and proportions of the structure of the building. The buildings such as the Leiter Building and the Carson Pirie Scott Building in Chicago built around the turn of the century, are indeed excellent examples of the aesthetics of reason achieved by integrating the proportions of the structural frame with the architectural elevation. This bold step set the stage for further purification of the facade's expression in the last few years. The strength, proportion and elegance of the frame construction showing the beams and the columns interacting and providing the basic framework for the building reached a high point in excellence of expression in the BMA Insurance Building in Kansas City completed in 1962 (Fig. 1). In this 20-story all welded rigid frame building, the columns and the exterior beams were clearly, honestly and articulately expressed by moving the glass line six feet (1.8 m.) behind the face of the building. The inherent aesthetics of a well designed rigid frame was emanated from the most optimum design of the steel columns and beams. Their dimentional slenderness and their proportions achieved through high level of structural efficiency were the two essential ingredients for making a convincing and yet pristine aesthetic statement. The structural steel frame itself if left totally exposed could of course make the clearest aesthetic expression. However since it is not possible to do so because of the requirements of fire protection, white marble was chosen for encasing the exposed frame thereby expressing the natural aesthetic of a slender and efficient structural frame. After almost twenty years this building still remains one of the most elegant expressions of structural frame in contemporary architecture.



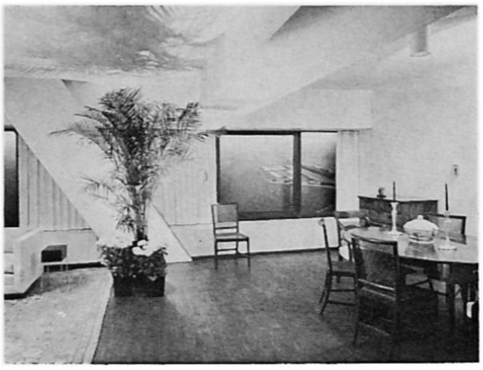
1. BMA Insurance Building in Kansas City, Kansas

2. John Hancock Center in Chicago, Illinois

The 100-story John Hancock Center in Chicago (Fig. 2) on the other hand achieves its structural aesthetics through a visual recognition of its strength and stability through the interplay of horizontal, vertical and the diagonal members. For the design of the 100-story John Hancock Center, the truss-tube concept is based on the interaction of the exterior columns, spandrels and the diagonal members which simulates a hollow tube consisting of the entire exterior perimeter of the building. The diagonals in this building were not designed as wind bracing in the classical sense, but as inclined columns which also distributes the gravity loads uniformly to all vertical columns. This integral structural composition of the exterior of the building which was responsible for its unusual economy had an inherent aesthetic quality. The visual quality of the structure was the reason why it was decided to express the structure without any arbitrary superimposition of any preconceived architectural facade. The decision to express the structure by cladding the main structural members with black anodyzed aluminum and slightly receeding the remaining surface to be filled in with a glass curtain wall was a deliberate act to highlight its visual strength. The clear expression of the structure indeed helped to give the building a character and an architectural quality that an a-priori facade would have never achieved. But to achieve structural aesthetics the design of the structure itself had to recognize at every step its potential visual statement. Such an awareness makes the engineers more conscious of the need to design the structure as efficiently, elegantly and articulately as possible. The John Hancock Center in Chicago is a structural expression of strength and vitality that gives it a distinct architectural presence in its urban setting.

Structural aesthetics goes beyond the visual expression of the structure from outside the building. The visual and physical environment it creates within the building for the occupants is of great importance. The John Hancock Center diagonal truss tube while producing a sense of strength and physical elegance of the building from outside also contributes to the sculptural elegance of the spaces within. The juxtaposition of the diagonal members in its fenestration gives it an unusual sculptural effect. The two intersecting diagonals looked at from inside the second floor lobby as well as the lobby of the apartment on the forty-sixth floor (Fig. 3) are particular examples of the structural aesthetics of this frame as perceived from within. In the apartments located above the forty-sixth floor which had diagonals going through their exterior fenestration were of high demand because of an additional sculptural impact (Fig. 4) Structural aesthetics in its more comprehensive aspect therefore, must consider the external view and perception of the structure and its proportions as well as the internal perception of the structure by the occupant creating a sense of elegance, sculpture and comfort. The triangular window spaces in the John Hancock Center, particularly in the apartments are indeed perceived as extremely desirable, comfortable and sculptural in character.

3. John Hancock Center, lobby on forty-sixth floor



4. John Hancock Center, model apartment

Steel trusses have their own natural proportions and when set at intermediate levels on the exterior of the building create an aesthetic form worthy of full expression. The belt truss concept in steel construction for intermediate height buildings, within 40 and 60 stories, has the inherent structural aesthetic quality which deserves full architectural expression. The First Wisconsin Bank Building in Milwaukee (Fig. 5) is an excellent example of the structural aesthetics of trusses in a building.

AESTHETICS OF CONCRETE STRUCTURES

The aesthetic of concrete structures in bridges by engineers like Maillart and in shell structures by engineers like Nervi is well established. But in buildings until the early 1960's, the exterior of concrete buildings were mostly given the curtain wall or masonry bearing wall expression. In as much as the concrete beam-column frame for earlier tall buildings was considered inadequate for more than ten stories, the frame expression of concrete buildings could seldom be justified. But their expression even in low rise buildings, except in shell structures, was not exploited by the architects, perhaps because of a lack of understanding and appreciation of their structural forms. In the early sixties the use of prestressed concrete made it possible to create long span floor systems and with it great opportunities to express the elegance of such structures became available. An excellent example of such a building was the United Air Lines Headquarters Building near Chicago (Fig. 6) which was designed as a two-way post tensioned grid with column spacing at 66 feet (20 m.) in one direction and 60 feet (18 m.) in the other direction. A clear expression of that structure and its elegance was architecturally highlighted by moving the window glass line about six feet (1.8 m.) behind the exterior so that the structure and its proportions could be clearly expressed. Structural aesthetics is once again enhanced by the slender elegance of the thin slab spanning 66 feet (20 m.) integrated in scale with the slender columns in the same plane. The particular case of the United Air Lines Building brings out an interesting aspect of structural aesthetics; that is, the structural aesthetic appreciation of any period in history is intimately related to its contemporary technology of structural materials and methods of construction. For example, if a masterbuilder in the Nineteenth Century had proposed and drawn up an elevation of the building showing 30 inch (75 cm.) deep edge beams spanning 66 feet (20 m.) without any intermediate support, he would certainly have been seriously questioned, not only for his lack of knowledge of construction but even more for his lack of structural aesthetics. With today's technology of prestressed concrete, these slender proportions are feasible and buildable and therefore can be visually accepted and enjoyed as an expression of the beauty of structure.

In taller reinforced concrete buildings, the visual expression of structures has been integrated in the overall architectural facade only very recently. If we look at the flat plate construction in tall buildings we find that it is used mostly in conjunction with a shear wall. Even in such a structure an effective expression of the structure can be made by moving the glass line inside from the perimeter thereby exposing the slab and exterior columns in their true proportions. An excellent example of such an aesthetic expression of structure is the Hartford Insurance Building in Chicago (Fig. 7). The visual effect of the structure is heightened by the gentle tapering of the slab at the columns. The occupants of this building enjoy the aesthetic value of the structure further because of the added comfort created by the shading effect of the overhang.

5. First Wisconsin Bank Building in Milwaukee, Wisconsin

6. United Air Lines Headquarters Building inElk Grove Village, Il

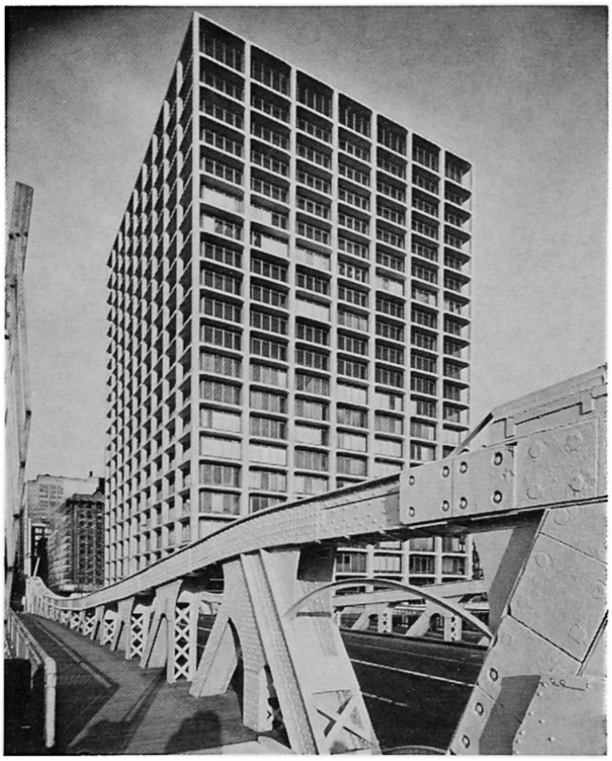
AESTHETIC EXPRESSION OF LOAD PATHS

In the framed tube concept the exterior elevations of the building are indeed bearing walls in contemporary materials which have been punched through at intervals to create windows. Once this is understood it is easy to look at the larger openings which may be necessary at the ground floor more in the concept of the bearing walls rather than the concept of a very rigid transfer girder. In the 38-story Brunswick Building in Chicago the large opening at the ground floor was created by a 24 foot (7.5 m.) deep reinforced concrete girder, 8 feet wide all around the perimeter to support the framed bearing wall above that level. This was a monumental solution and its clear expression of structure had indeed a strong structural architectural impact. But in a later building a more transitional transfer was achieved in a classical bearing wall approach. In the Marine-Midland Bank Building in Rochester, New York (Fig. 8) the large opening on the ground floor was achieved through a gradual transition of load paths from the upper floors to the far spaced ground floor columns. The structural shapes and sizes of intermediate floor columns and spandrel beams were proportioned according to the actual load flow. The result was indeed a visual impression of the classical arch in a traditional stone-masonry bearing wall construction. The structural aesthetics here was the result of the honest expression of the load flow pattern.

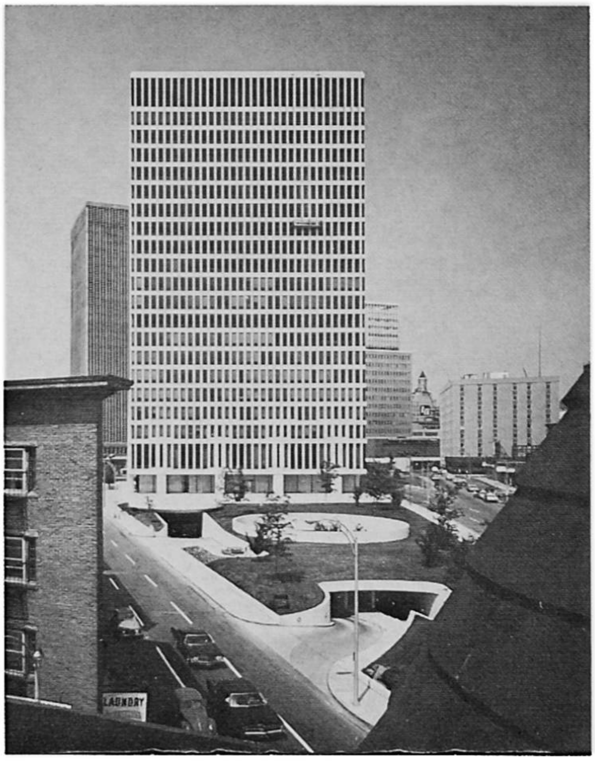
For concrete tall buildings the original concept of bundled tubes, first used in the Sears Tower, is now being explored in a more organic shape in a number of new buildings. Each of these buildings are being studied for the proportions and forms through a totally integrated structural architectural expression. The author hopes to discuss the findings of some of these studies at the time of the Congress.

AESTHETICS OF CABLE STRUCTURES

Cable suspension bridges have been in use for almost 75 years. These bridges all derived their aesthetic value from the natural form created by the structure. In buildings, the use of cables has not yet been fully explored and experimented. There does exist the possibility of creating large clear spans for special unobstructed space needs by hanging the roof structure from cables projecting out of masts. A very recent example of it is the Baxter Lab Cafeteria Building near Chicago (Fig. 9) which has a 300 foot by 150 foot (90 m. by 45 m.) roof. The need for an inside column free space was social as well as functional; social in the sense that it was desirable to create an inner environment with a spirit of celebration and relaxation which would be enhanced by a clean structural grid on the roof and a feeling of unobstructed extension of inner space into the outer landscaped area; and functional in the sense that the gathering of large numbers of people throughout the day indicated elimination of inner supporting columns, if possible. In designing this building every effort was made to express the unusual slenderness and



7. Hartford Insurance Building in Chicago, Illinois

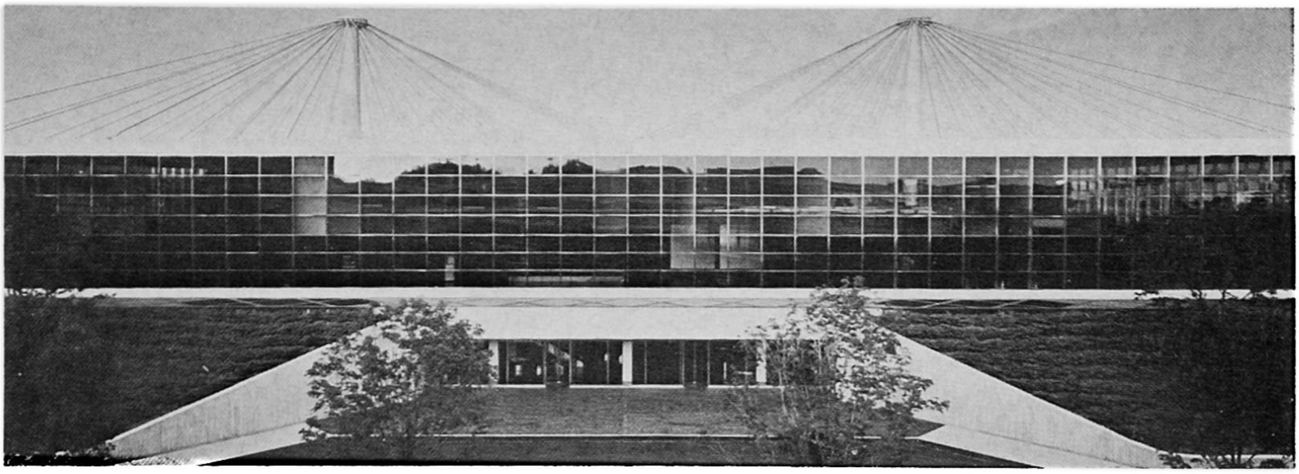


8. Marine-Midland Bank Building in Rochester, New York

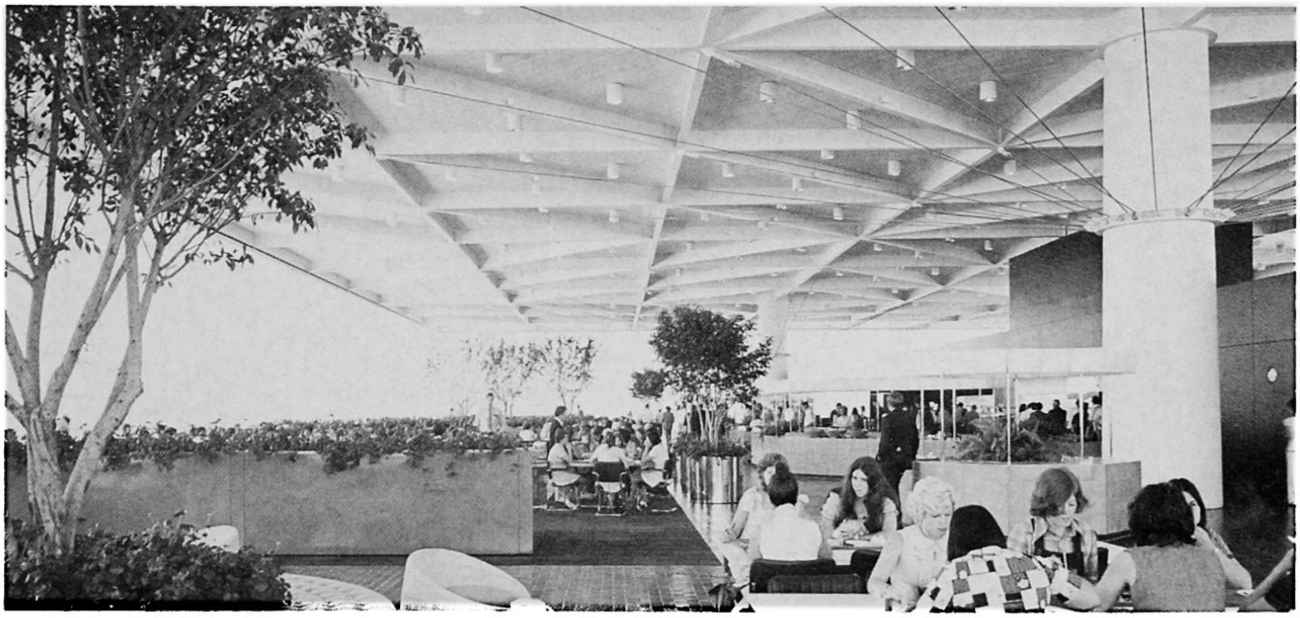
floating character of the roof line and to visually create the honest impression that the entire roof is indeed supported by the radiating cables from the two central masts. From inside, stabilizing cables radiating from the mast up to the roof beams, give the inner space a convincing and distinct structural aesthetic character generating a sense of amazement on the first visit into the space (Fig. 10). Structural aesthetics, once again, was achieved by making the structure efficient and achieving simplicity in slender proportions while satisfying the social and functional needs.

AESTHETICS OF FABRIC TENSION STRUCTURES

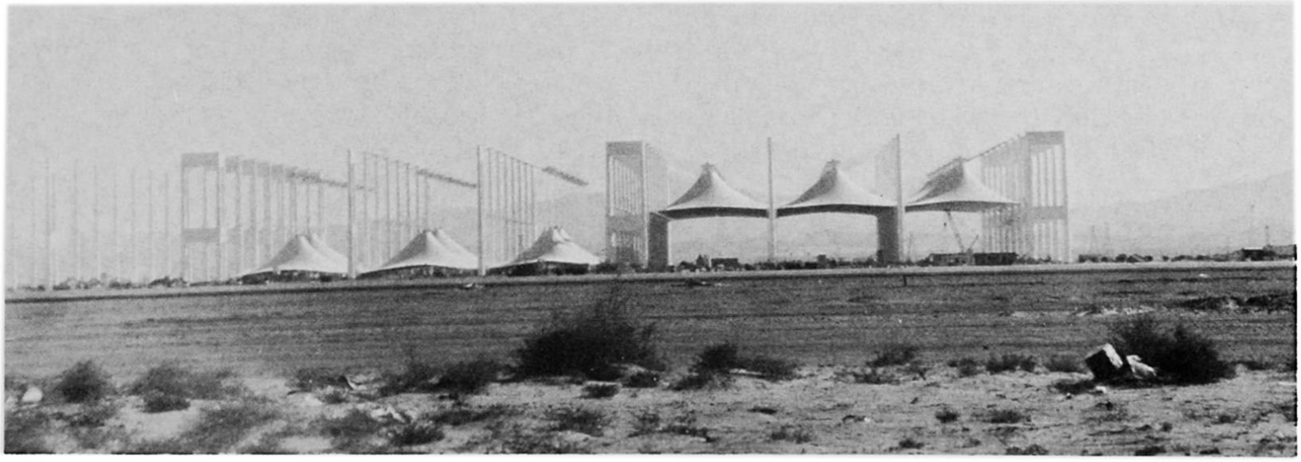
Cable network tension structures have been used successfully for a number of years and the structural simplicity and elegance have always been the essense of the overall architectural expression of these buildings. The pioneering work done for the German Pavillion in the Montreal Expo, 1967 and the Munich Stadium for the Olympics in 1976 are two excellent examples of this kind of structure. Unlike the rigid structures discussed earlier, the tent forms created by the two-way cable network had an added impact on the environment and thereby also made a cultural statement by the engineer/architect. A logical extension of such a structural system has been tried by the author in the Haj Terminal in Jeddah (Fig. 11) requiring a roof surface of almost five million square feet (470,000^{2}m.). The need for such a terminal for the pilgrims coming to Jeddah for their final destination to Mecca indicated the creation of an environment and not an enclosed building.



9. Baxter Laboratories Cafeteria Building in Deerfield, Illinois



10. Interior Baxter Laboratories Cafeteria Building



11. Haj Terminal, New Jeddah International Airport in Jeddah, Saudi Arabia

In search of the most appropriate forms of roof in the desert environment of Saudi Arabia, the fabric tent form appeared to be the most natural and attractive for the region and evoked the cultural heritage of the land. Furthermore, in the perspective of the thousands and thousands of tents which are used for the Haj in the Mecca area, it was even more relevant to devise a tent form that evokes the spirit of the Haj. In recognition of these factors, a structural tent form was developed using teflon coated fiberglass fabric 1 mm. thick which interacts with radiating cables. These tent units are hung from piers spaced at 150 feet (45 m.) on centers and soar from 65 feet (20 m.) above ground reaching to a height of 118 feet (35 m.). These tent units are arranged in modules of twenty-one such units (3 x 7 units). Ten such modules (210 units) provide the Hajiis an environment of transition from the air-conditioned spaces inside the airplanes to the generally open environment of the Haj process. The structure of the tent repeating itself 210 times, helped in making the structure more economical compared to possible alternate steel or concrete roof systems. What is more, through the expression of the simplicity and naturalness of the structure form, it provided an aesthetic ambience and a cultural identification which will undoubtedly evoke the spirit of Haj to the millions of Hajiis who pass through it.

CONCLUSIONS

In describing the examples of steel, concrete, bearing wall, cable and fabric tension structures in building, an attempt was made to underline and bring to focus the essense of structural aesthetics in buildings. Structure is based on reason which has its own inherent aesthetics. Well detailed efficient structures always possess the elegance of slenderness and reason and has the possibility of a higher transcendental value than the whims of an a-priori aesthetics imposed by some architects who do not work closely with the engineers and do not have an inner feeling of the natural forms of structures. The a-priori concept of building expressions and forms are indeed the result of the dichotomy created in the last century by the splitting of the classical masterbuilder into architects and engineers working separately from each other. The simplicity and honesty of structure with its implicit strength and stiffness, its elegance through optimum slender proportions, can indeed provide an architectural expression that has its own vitality and aesthetics. It is hoped that the clear understanding of structural behavior and the resulting forms will help the future teams of architects and engineers to design buildings in which the aesthetic quality of structure and technology can merge with the social and architectural values to create buildings that will eloquently speak of our time.

Leere Seite
Blank page
Page vide

I

Structural Beauty of Shells

Beauté structurale de voûtes minces

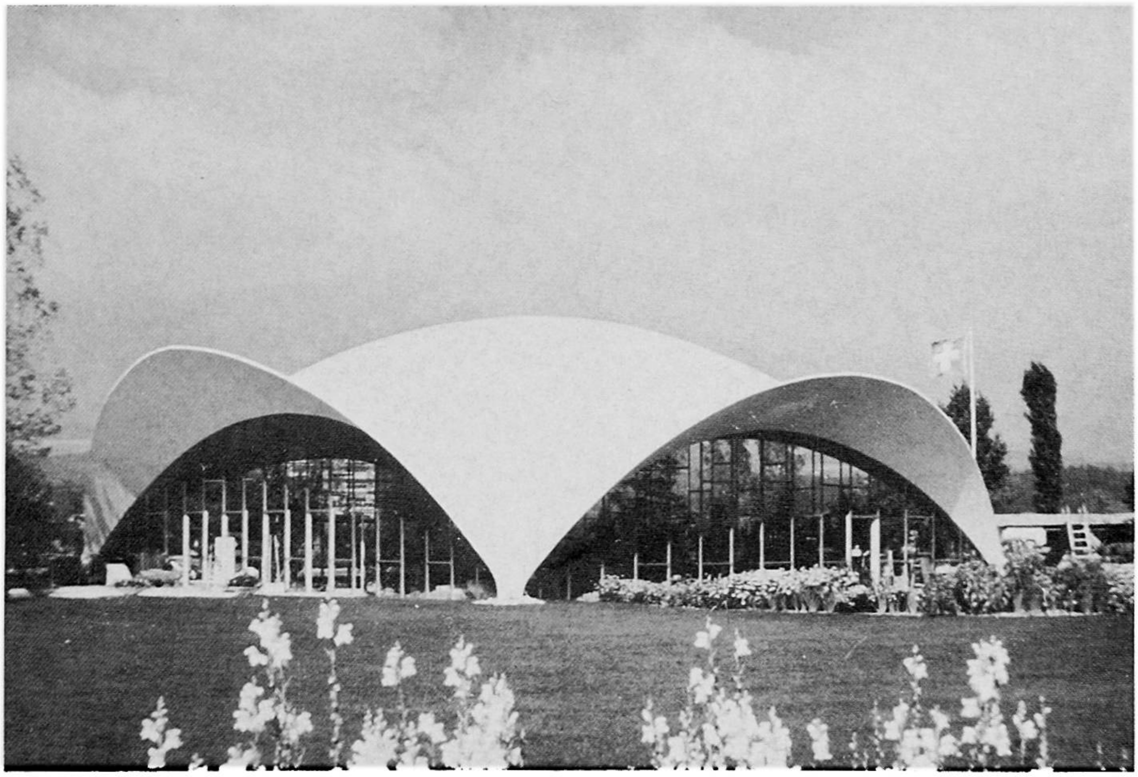
Aesthetik der Schalen

HEINZ ISLER
Dipl. Ing.
Ingenieur- und Studienbüro
Burgdorf, Schweiz

SUMMARY
Freeshaped shellstructures following natural laws express by their lightness, simplicity and efficacy natural beauty.

RESUME
Les formes libres de voûtes minces expriment la beauté de lois naturelles.

ZUSAMMENFASSUNG
Freigeformte Schalenbauten, leicht, einfach und wirkungsvoll zeigen die Schönheit natürlicher Gesetzmässigkeit.



Garten Center Wyss Solothurn

Ausstellungshalle Kilcher in Recherswil

TWENTY-FIVE YEARS ATTEMPT FOR STRUCTURAL BEAUTY

Shell structures have an inherent capacity to express structural beauty. We all know the unsurpassed masterpieces of Felix Candela, where he for the first time expressed the lightness and elegance of shape with ribless shells.

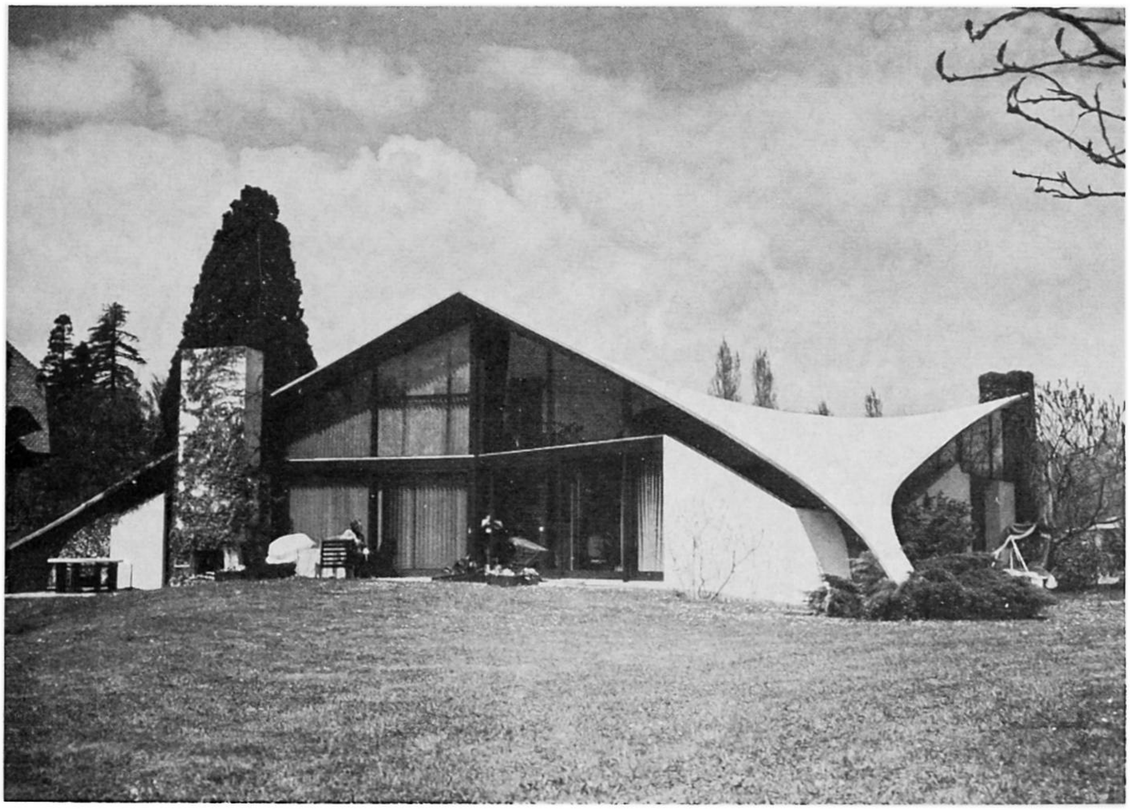
The author, in 1954, discovered the virtually unlimited potential of non-geometric shell-shapes, which especially pleased him because of their high aesthetic value.

He had the opportunity to realize quite a number of new shell-shapes for all sorts of buildings: representative buildings, garden centers, churches, theatres, stations, markets, restaurants, even industrial buildings. The enclosed pictures give some examples.

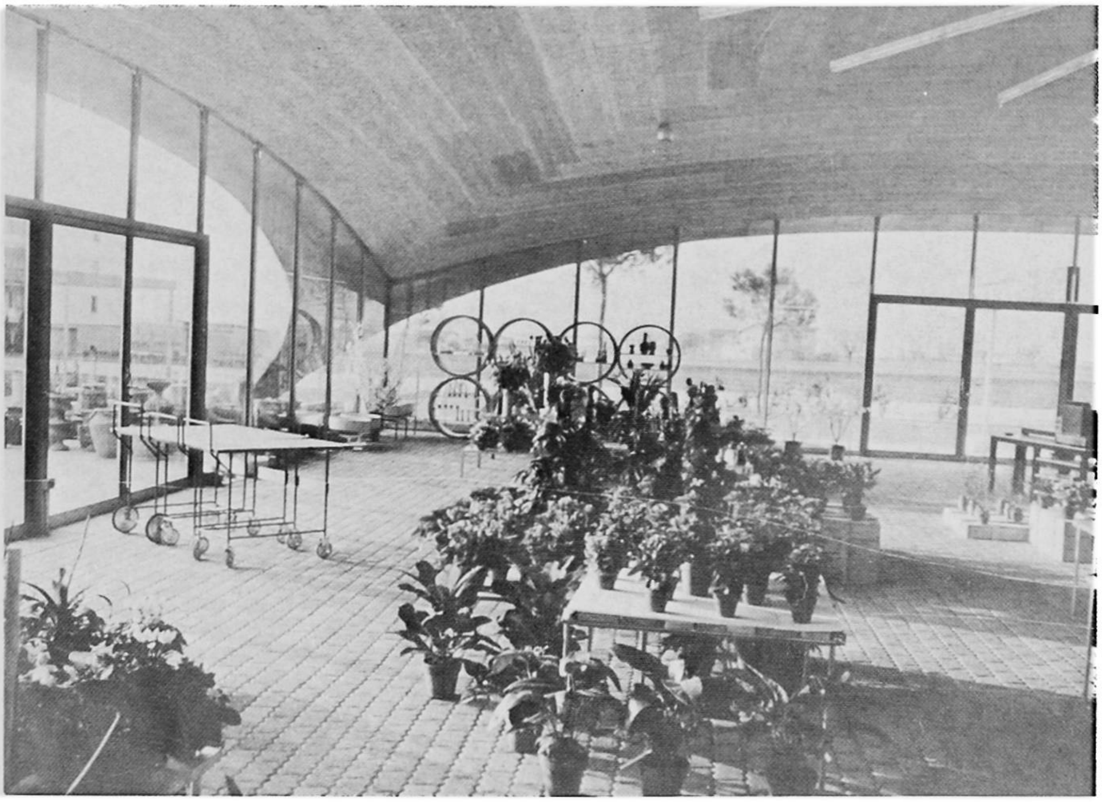
As Prof. Leonhard in his general report states, in the design of a building, some rules have to be observed: for instance, good proportion, simplicity, honesty, etc. The same rules are valid when designing a building with shells.

The foremost task lies, in the opinion of the author, in leaving off everything that is not necessary. A well-shaped shell is such a dominant structure, that it needs no addition of other dominant elements. On the contrary it forbids them. The shell is the supporting structure and the space enclosure at the same time. So it cannot be but honest. It fits very well in natural environments, as demonstrated for instance by garden centers. If placed in a reasonable distance from cubic buildings, it can also fit into urban or other manmade surroundings. It sometimes gives a desirable contrast.

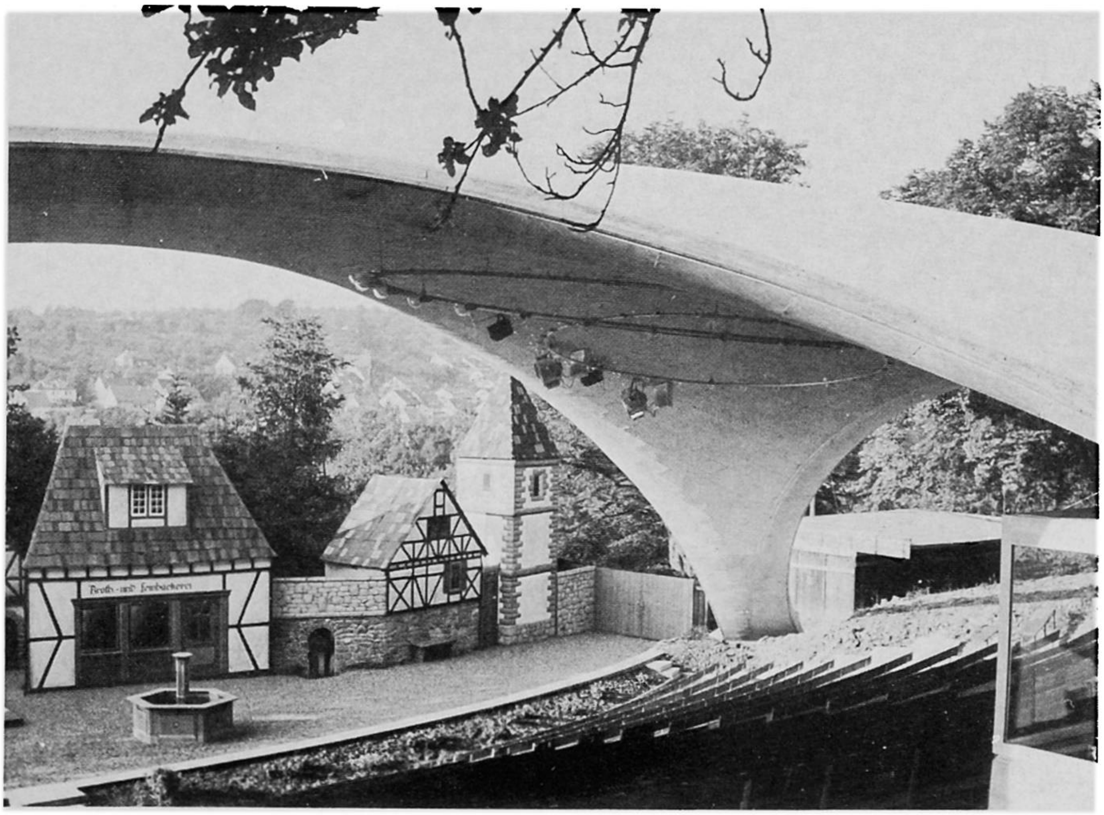
The shell technique of modern shapes offers very light structures of utmost simplicity. It will, because of its economy and beauty, have its place in future architecture, as the dome and arch structures of the past.



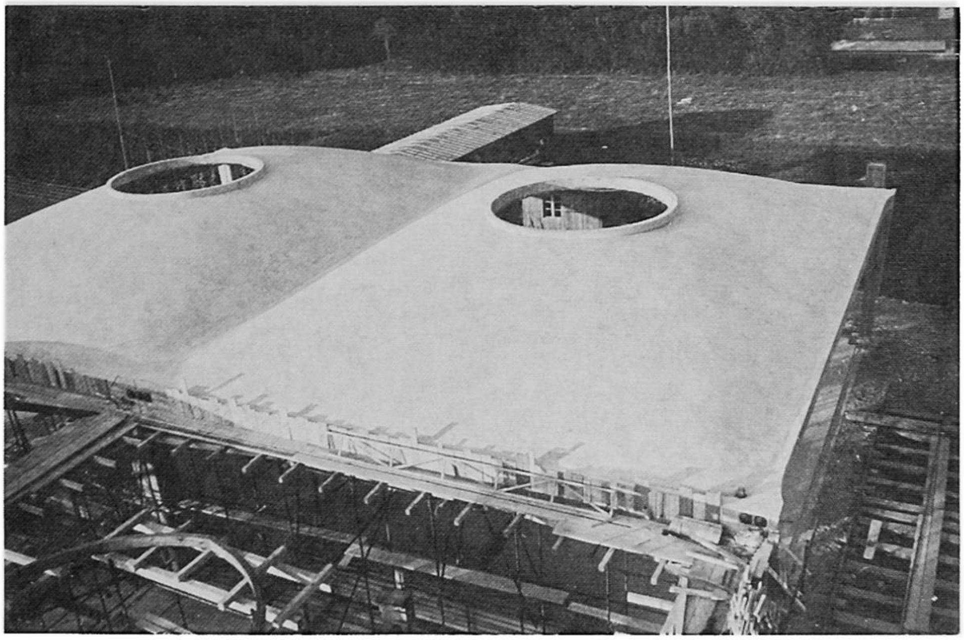
Wohnhaus Camoletti in Collonge Genf



Garten Center Bürgi, Camorino

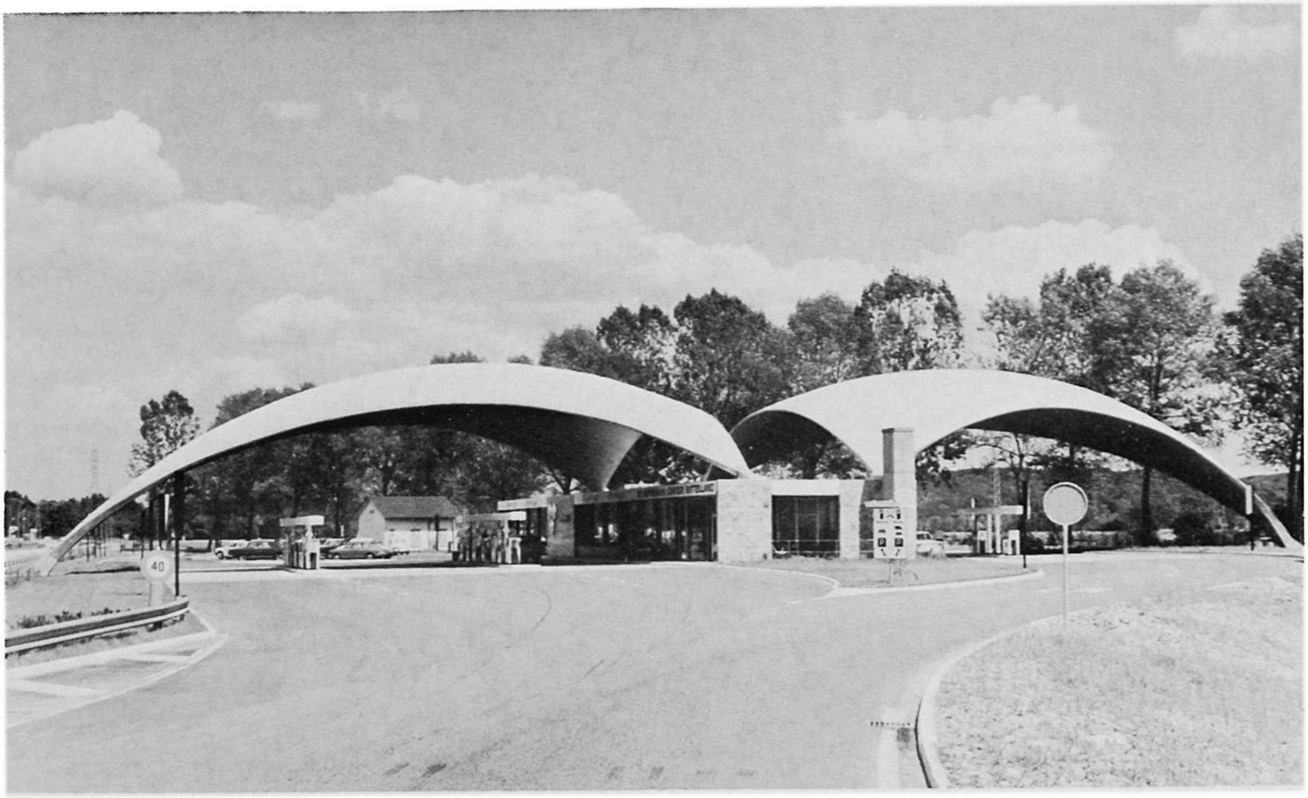


Freilichtbühne Naturtheater Grötzingen



Buckelschalen Blaser Hasle-Rüegsau

Töpferei Artisans Clause in Ponthierry Paris



BP Tankstelle Deitingen

Garten Center Clause St Appoline Paris

F. LEONHARDT
Prof. Dr. Ing.
Stuttgart, Bundesrepublik Deutschland

SCHLUSSFOLGERUNG

Wir sahen: Ingenieurbauwerke können schön gestaltet werden. Viele schöne Brücken finden die Zustimmung der Mehrheit der Menschen. Islers Schalen können begeistern. Die meisten Autoren fanden die formulierten Richtlinien für schönheitliche Gestaltung berechtigt. Wir haben aber auch unterschiedliche Meinungen über Ästhetik im Ingenieurbau gehört. Mein Wunsch ist, daß wir darüber nachdenken, daß wir durch das Analysieren schönheitlicher Qualitäten verschiedenster Bauwerke mit der Zeit zu Erkenntnissen kommen, die uns die schönheitliche Gestaltung der Ingenieurbauwerke mit etwas mehr Sicherheit erlauben, als dies bisher der Fall ist.

Eine mündliche Diskussion in so großem Kreis ist in der Regel wenig fruchtbar. Die Arbeitsgruppe wäre jedoch dankbar, ausgereifte Stellungnahmen und Anregungen zu diesem Thema schriftlich zu erhalten. Die Arbeitsgruppe wird in jedem Fall an dieser Aufgabe weiterarbeiten und zu gegebener Zeit Ergebnisse vorlegen.

Die schönheitliche Gestaltung unserer Bauwerke muß in Zukunft so ernst genommen werden wie die Statik zur Erzielung der Sicherheit. Es muß mehr getan werden, um dieses Ziel zu erreichen, damit die Menschen unserer Generation und unsere Kinder mehr Freude an schön gestalteten Bauwerken haben können. Wir dürfen die Wirkung schönheitlicher Qualitäten auf unsere Mitmenschen nicht unterschätzen. Die heute weit verbreitete Abneigung und Verurteilung der Technik beruht zum Teil auf der Häßlichkeit vieler baulicher Anlagen der letzten Jahrzehnte. Wir müssen begreifen, daß es falsch war, vorwiegend nach den billigsten Lösungen zu fragen, und daß es sich in sozialer Hinsicht lohnt, Mehrkosten für gute Gestaltung, für Einpassung und für harmonische Farbgebung aufzuwenden.

Das wachsende Umweltbewußtsein wird eines Tages zur Folge haben, daß wir manches Häßliche der Vergangenheit wieder abbrechen und durch Schöneres ersetzen werden. Ich bin sogar der Überzeugung, daß wir hierzu häufig öffentliche Mittel aufwenden werden, so wie zur Zeit die Nostalgiewelle manche Steuergelder für die Sanierung schöner, alter Bauwerke, besonders in alten Stadtteilen, freimacht. Wenn wir gar erst einmal aufhören werden, Milliardenbeträge für Verteidigung und Rüstung auszugeben, dann stehen genügend Geldmittel zur Verschönerung unserer Umwelt zur Verfügung.

Was sind Reiz und Charme dieser Stadt Wien? Es sind die schönen alten Bauwerke in Verbindung mit gepflegten Grünanlagen.

Ich wünsche, daß wir schönheitsbewußt werden und bei unserer beruflichen Arbeit der Notwendigkeit schönheitlicher Gestaltung Nachdruck verleihen.

CLOSING REMARK

We saw that engineering structures can be beautifully shaped. Many good looking bridges find the approval of the majority of our fellow-men. The shells of Isler can fill us with enthusiasm. The majority of the authors agreed that the formulated guidelines have some validity.

However, we have heard also different opinions about aesthetics. I wish now that we reflect on these opinions, that we come to findings by analysing aesthetic qualities of structures, to findings which allow us to design our engineering structures with regard to aesthetics with more security than it is the case at present.

An oral discussion in such a large audience is usually not fruitful. The Task Group will, however, be grateful to receive written comments and suggestions to this subject. The Task Group intends to continue its work for this subject and to present at a later occasion.

The aesthetic aspects for the design of our structures must be taken as serious as the static analysis to secure the safety of our structures. More must be done in order to reach this aim, so that the fellow-men of our generation and especially our children can have more joy by well shaped structures and buildings. We should not underestimate the effect of aesthetic qualities of the built environment on our fellow-men. The wide-spread aversion and condemnation of technical achievements are partially based on the ugliness of many buildings or structures of the last decades. We must get aware that it was wrong to look primarily for the cheapest solutions and that in social respect it pays to spend some extra money for pleasing designs, for integration and for harmonic colouring.

The growing consciousness for environmental qualities will some day make us dismantle ugly buildings of the past and replace them by beautiful ones. I am even convinced that public money will be used for such work, similar to the tax money which presently is spent for saving and restauring beautiful old buildings, especially in historic city centers, as it was caused by a wave of nostalgia. If we should stop spending billions for defence and armament, then there would be sufficient tax money available for the embellishment of our environment.

What makes the attraction and charme of this City of Vienna? It are its beautiful old buildings in connection with well kept gardens and parks.

I wish that we become beauty-conscious in our profession and that we give emphasis and energy to the necessity of aesthetic design.

CONCLUSIONS

Nous venons de voir que les ouvrages de génie civil peuvent être conçus de manière esthétique. Beaucoup de beaux ponts reçoivent un accueil favorable auprès de la plupart des gens. Les voiles minces de Monsieur Isler peuvent nous enthousiasmer.

D'autre part, nous avons eu le récit d'opinions divergentes sur l'esthétique en génie civil. Je souhaite que nous y réfléchissions et que, en analysant les qualités esthétiques de différents ouvrages, nous arrivions avec le temps à des connaissances nous permettant une conception esthétique des ouvrages de génie civil avec plus de sûreté que ce n'était le cas jusqu'à présent. Au sein d'un tel auditoire, une discussion n'est généralement pas très fructueuse. Cependant, le groupe de travail serait vraiment reconnaissant s'il recevait des prises de position mûrement réfléchies et des suggestion sous forme écrite. En tout cas, le groupe se propose de continuer dans cette tâche et de présenter, le moment venu, les résultats de ce travail.

Dans l'avenir, il faudrait que la conception esthétique de nos ouvrages soit traitée avec autant d'attention que le calcul et le dimensionnement effectués en vue de la sécurité structurale. On doit oeuvrer davantage dans ce but, afin que les hommes de notre génération, ainsi que nos enfants puissent éprouver davantage de joie avec des ouvrages beaux et bien conçus. Nous ne devons pas souestimer l'effet des qualités esthétique sur nos contemporains. L'aversion actuellement très répandue et la condamnation de la technique sont en partie basées sur la laideur de beaucoup d'installations construites au cours des dernières décennies. Il faut que nous comprenions que c'était une grande erreur d'exiger généralement des solutions le meilleur marché, et qu'il vaut la peine, du point de vue social, d'accepter des frais supplémentaires pour obtenir une bonne conception esthétique, une adaption à l'environnement et une coloration harmonieuse.

L'intensification de la conscience pour l'environnement nous conduira un jour à la conclusion que nous devons démolir maintes laides choses du passé pour les remplacer par des ouvrages plus beaux. Je suis même convaincu qu'on utilisera souvent à cet effet des fonds publics, comme on le fait déjà actuellement pour la restauration d'anciens ouvrages, en particulier dans certains anciens quartiers d'habitation. Si nous arrivons même une fois à stopper les dépenses se chiffrant en milliards pour la défense et l'armement, nous aurons alors assez de moyens pour financer l'embellissement de notre environnement.

Qu'est-ce qui fait l'attrait et le charme de cette ville de Vienne? Ce sont les anciens beaux ouvrages parmi les îlots de verdure bien soignés.

Je souhaite que nous prenions conscience de la beauté et que nous accordions davantage d'attention à la nécessité d'une conception esthétique dans le cadre de notre activité professionnelle.

Leere Seite
Blank page
Page vide