Incentives and obstacles to creative design

René WALTHER
Prof. Dr. Ing.
Dr. Ing E.h.

1. Introductory remarks

The generation of novel engineering works is certainly one of the most challenging and rewarding endeavours any creative mind can wish to accomplish. One can only admire the creative prowess of the Roman master builders who among other conceived and realized the beautiful Pont du Gard (fig. 1) some 2000 years ago. Fortunately they had then not to fight against restrictive overregulations as we have nowadays to do, yet this impressive structure obviously met the most severe criteria of durability since it is still solidery standing up.

fig. 1: Pont du Gard

After the fall of Roman empire its grandiose art of bridge building was all but lost for about one millennium. Charlemagne tried to have a bridge built over the Rhine River on ancient Roman foundations, but this endeavour failed lamentably. Throughout the Middle Ages the art of bridge building was mainly based on artisanal tradition, where the attainable spans were limited by the then feasible strength of stone arches or by the length of the available timber beams. Leonardo da Vinci, one of the most prodigious genius of mankind, proposed to the sultan of Byzanz to build a stone arch bridge over the Golden Horn with a span over 200 m, but his idea was well ahead of the time and could not have been realized, among other due to the poor foundation conditions.

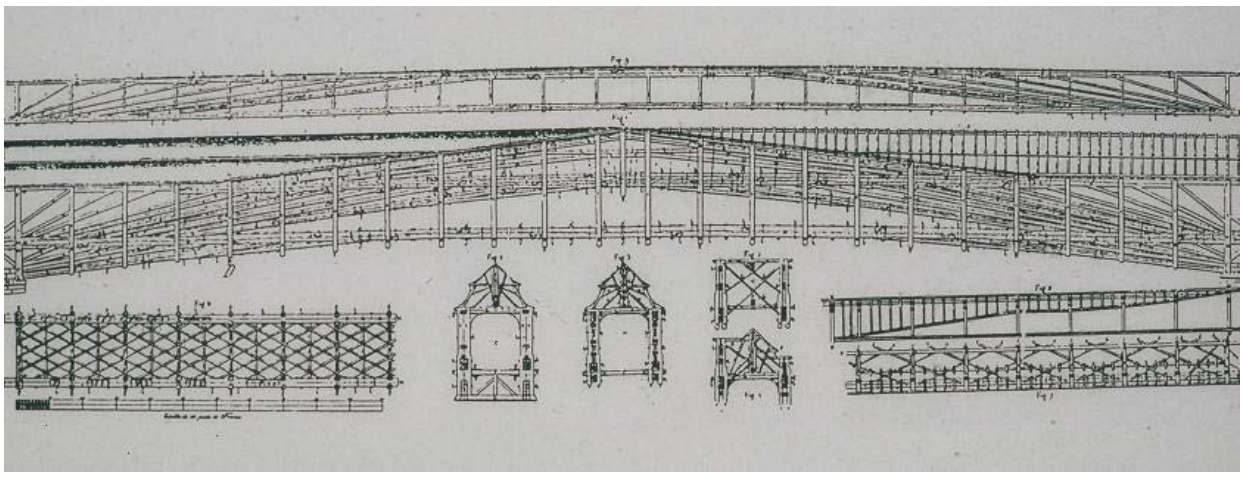

fig. 2: Grubenmann's proposal of a bridge over the Rhine River at Schaffhausen

In 1775 a very creative craftsman, by the name of Hans-Ulrich Grubenmann, submitted a daring design of a bridge over the Rhine River with the then unheared of span of 110 m (fig. 2). But this project met the fate not quite uncommon even nowadays: the technically incompetent but politically powerful authorities of the city of Schafhausen raised a lot of objections and forced Grubenmann to add an intermediate pier.

Unfortunately this marvelous structure (fig. 3) was set on tire by Napoleon's army.

fig. 3: Model of the realized bridge

If we turn now from the past to the present, we must regretfully recognize, that creative engineering becomes more and more difficult, among other due to a never ending flood of restrictive codes and bureaucratic obstacles. It is indeed difficult, to imagine how a creative mind like Eugene Freyssinet, could nowadays successfully realize his fertile ideas such as his invention of prestressing which revolutionized the whole construction industry. One damaging consequence of the actual tendency of overregutalion is, that the important role of the civil engineers in the field of construction and their public recognition is steadily diminishing. One sign of this fact is, that even in the authentic engineering domain of bridge construction invitations to participate in design competition go today often in the first place to architects, who may then assign the unthankful task to imagine how their

sometimes chimerical ideas could be realized to engineers. The collaboration between engineers and architects can indeed be very fruitful and deserves to be encouraged, but the leading role must be assumed by competent bridge – engineers.

Since bridge design competitions are in principle an excellent incentive to enhance creativity, the merits and shortcomings of some of them recently carried out shall be discussed.

2. Bridge competitions

The Diepoldsau Bridge over the Rhine River

Because the old steel truss bridge was heavily corroded, the state authority decided to replace it by a very conventional concrete girder bridge. However this unspectacular but albeit economical project met a stiff opposition of the population, who suggested to have a more modern and showy structure being built, such as for example a cable-stayed bridge. The authorities reluctantly agreed to organize a design competition, but with the condition that the costs of innovative alternatives may not exceed the ones of the official standard project.

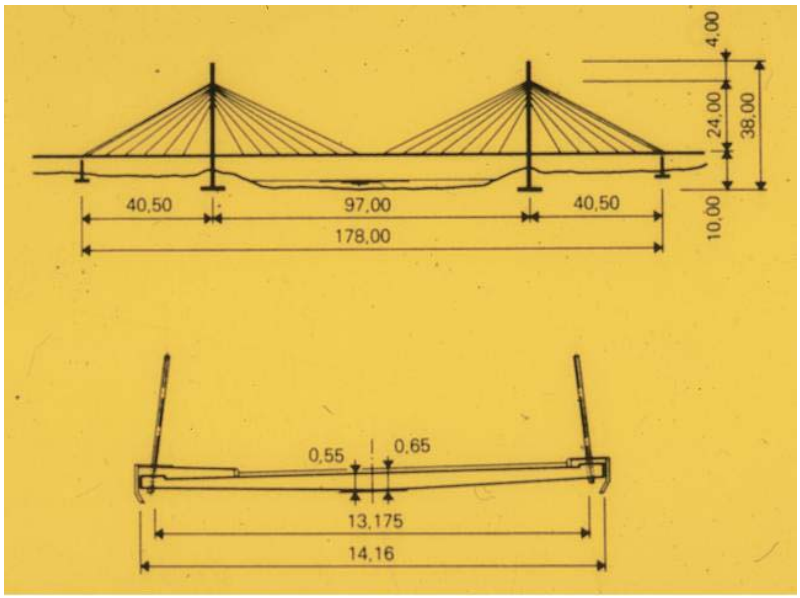

fig. 4: First cable-stayed bridge with slender concrete deck at Diepoldsau

This economical pressure lead to the idea of substantially reducing the costs of a cable-stayed bridge by providing it only with a simple slender concrete deck (fig. 4). However it was not quite easy to convince the authorities and experts, that the stability of such structures depends primarily on the layout of the stays but much less on the stiffness of the deck. In order to prove that fact, theoretical and experimental investigations were carried out at the Swiss Federal Institute of Technology in Lausanne (fig. 5). This concept proved to be very propitious and has since been applied to many modern bridges, such as the Evripos Bridge in Greece, the Zaltbommel Bridge in the Netherlands and last not least the very innovative Ting Kau Bridge in Hong Kong.

fig. 5: Tests on cable-stayed bridge with slender concrete deck

The Charles de Gaulles Bridge in Paris

Even at the risk of being impolite and criticized, it may be worth to cite an example of how bridge design competitions should not be conducted. For the new bridge over the Seine River in Paris, then called Austerlitz Amont, ten renown architects were invited to submit their proposals, who could then, if they wished, seek the collaboration with one of the preselected engineering firms.

The jury was composed by about 20 members of the local political and administra-tive bodies, supplemented by only two engineers, who were grandly called “personnages qualifiés”, which might suggest that this attribute did not apply to the other members.

The result of this somewhat queer competition was rather disappointing:

Some proposals were Utopian and asymmetrical solutions - even good ones – were excluded with the dubious argument that all Seine bridges in Paris are symmetrical. However this is not true – there already exist assymetrical crossings – and if this would have been a valid criterion, it should have been stated beforehand.

The jury could finally only agree to chose the least spectacular albeit quite decent solution (fig. 6), which could certainly have been obtained by directly mandating a competent bridge designer without an ambitions competition, which caused considerable unwarranted costs and disappointments.

fig. 6: Charles De Gaulle Bridge over the Seine in Paris

Competitions without issue

It is even more distressing when design competitions are launched without the chance or even the intent that the project in question will ever be realized.

This was for example the case for the "Thames Water Habitable Bridge Competition" in London, for which only architects were invited. The fact that there was no follow-up might not seem surprising or deplorable, since most projects were quite Utopian.

Of more objectionable consequences was the competition for the replacement of the heavily corroded Williamsburg-Bridge in New York, where a great number of renown engineering firms participated, who together spent several million dollars for their very elaborate projects, only to learn afterwards, that the authorities decided to have the old bridge repaired. And this in spite of the fact, that the winning proposal (fig. 7) of Professor Schlaich and the author would have been considerably cheaper than the finally executed rehabilitation, which did not improve the critical traffic conditions.

fig. 7: Project of a new Williamsburg Bridge, New York

A similar fate experienced the many participants of the Pool Harbor Bridge competition: it seems that the organizers just wanted to obtain some gratis informations, what could in principle be envisaged at this site, without having the means or maybe the intention for a subsequent realization. This lead to an inexcusable waste of expenditures to be shouldered mainly by the participants.

The Stone Cutter Bridge Competition, Honkong

A scandalous case of arbitrariness occurred recently at the competition for the bridge mentioned above. In the submission condition a clause was inserted that the winning projects would become the property of the convener, who could then use it, as he pleased. In spite of this basically illegal provision a great number of designers participated at this competition, unfortunately also the author of this paper. However the biggest deception had to be suffer by the winner, since the detailed elaboration of this project was awarded to another engineering firm.

It is really a shame, that our profession silently accepted such an unfair procedure. One could only wish that professional engineering organizations would be bestowed with more authority to effectively intervene against such flagrant abuses.

The Millau Competition

Since the grandiose Millau Viaduct is extensively treated at this symposium, it might be recalled, that there had also been a competition, albeit a special one, called "étude de definition". The first project, very similar to the one now realized, was initially worked out by the engineers of the SETRA under the then leadership of Michel Virlogeux.

However it was felt that for such an important endeavour renown architects should also be involved. Thus five teams lead by architects were commissioned and decently paid to elaborate one of the bridge types preliminarily assigned to them by the organizers. This was indeed quite an unconventional procedure, because the first thing a competent bridge designer normally does, is to sketch and analyse several feasible solutions and on account of this to select the one, which he deems most promising. But the restricted approach chosen in this case resulted not so much in a competition between the designers, but rather between bridge systems, since only one of each type was allowed to be submitted. This was somewhat unfortunate, because besides several worth-while projects (fig. 8) the concept which in principal could have had real potentials of winning, that is a continuous girder with a lower external tension cord (fig. 9), was architecturally treated in too utopian a way to be seriously considered.

fig. 8: Proposal of an arch-bridge for the „Grand Viaduc de Millau"

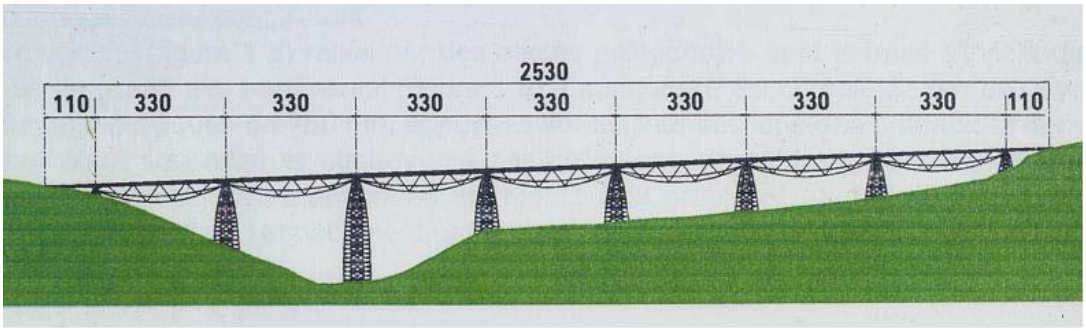

fig. 9: Proposal of a bridge with lower tension cord for the „Grand Viaduc de Millau“

In contrast to this, the original structurally sound initial project of the SETRA was later favourably refined by the architects (fig. 10).

fig. 10: Pylon of the „Grand Viaduc de Millau“

Notwithstanding these sometimes critical remarks design competitions remain an excellent means to enhance creativity, but in order to obtain a successful outcome, some basic principles should be observed, the paramount being, that the leading role must be assigned to experienced bridge engineers. This pertains not only to the competitions but also to the jury. The latter should not only be called upon to render a final judgment, but should also be involved in formulating the tender conditions and for the detailed checking of the submitted projects.

For important projects it is often advisable to proceed in stages. In a first stage the interested participants are only requested to submit the basic ideas of their envisaged solution, thus limiting their expenditures to a reasonable level. Furthermore it permits the organizers to make a far more valid selection than on the basis of the voluminous prequalification forms the applicants are now requested to submit.

In a second stage a restricted number of selected engineering-firms would be mandated to work out their proposed project in sufficient detail to eventually put it up for tender. It seems only fair to remunerate the chosen firms decently for their important work.

In the final stage one or in certain cases two promising engineering projects would be open for tender by contractors, who may or may not be allowed to submit alternatives, in particular as far as construction methods are concerned.

3. Obstacles to creativity

As already mentioned in the introduction, the freedom of creative design is today severely hindered by an never ending flow of ever more voluminous official regulations. This is all the more annoying, since this sorry state is to a large extent brought about by the engineers them-selves, who do not seem to realize that their urge for excessive code-making contributes to the steady decline of the standing and public recognition of the whole profession, one outward sign of this is the drastic decrease of students in this field at many Universities. Creative design is often thought to be the exclusive domain of architects, whereas engineers are often only seen as performers of statical calculations and as interpreters of codes.

This last task has become very frustrating, since the whole set of regulations to be observed has not only been drastically increased, but they are often full of contradictions and formulated in an complicated and sometimes incomprehensible way. The laudable goal of unifying the codes in Europe by the introduction of the euro-codes has unfortunately rather contributed to the confusion, since many countries have specified their own rules of application in addition to the national codes.

That this must not be necessarily be so, may be demonstrated by considering the special field of shell constructions: there exist next to no provisions in the codes for such structures, probably because this subject is too complex for code-comissions. When Professor Zerna, an expert in this field, was asked what he would recommend, he jockingly remarked: “in shell constructions the stresses should be kept in reasonable limits”.

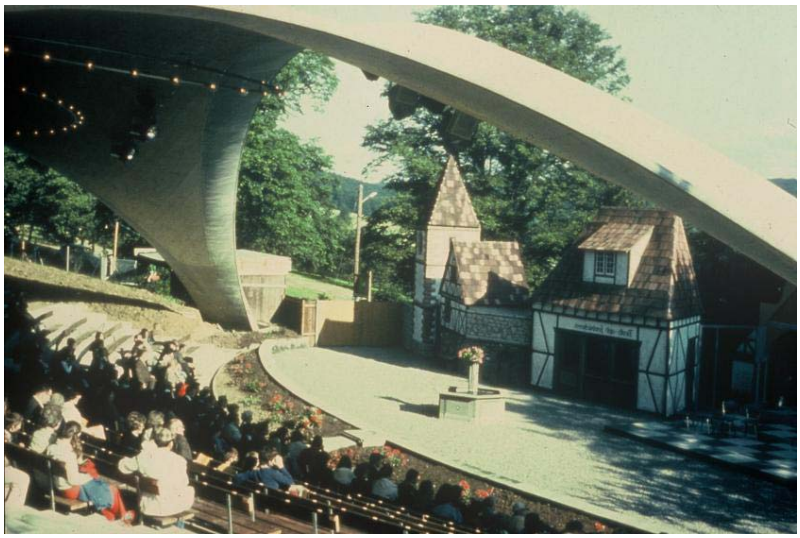

fig. 11: Shell for an open air theatre in Grötzingen, Germany

fig. 12: Glass-grid dome of the Neckarsulm indoor swimming pool ➤

Thus in spite or rather because of this lack of official directives, creative engineers, such as for example Candela, Heinz Isler, Jörg Schlaich and others have always been able to conceive and realize most beautiful and daring shell structures (fig. 11 and 12). To this end they have set up their own methods of analysis and criteria for safety and serviceability.

As just one example the degree of prestressing as specified in the French Codes may be cited. They foresee three degrees of prestress, that is classes I, II and III, which correspond roughly to the termes of full, limited and partial prestressing. There is a certain risk that administrations or owners blindly request the supposed superior class I, even if this is neither structurally nor economically warranted. For flat concrete slabs the said code permits in principle the partial prestressing, but in a later clause it is specified, that under permanent loads no concrete tension stresses may occur in the vicinity of the cables. This has the detrimental consequence that the very favorable concept of flat slabs with concentrated prestressing of the column strips (précontrainte par bandes d’appui, Gurtstreifenspannung) becomes practically impossible, and is therefore hardly ever used in France.

Creativity is sometimes also prevented by pure bureaucrativ whims. The method of incremental launching of concrete bridge girders, developed by Prof. Leonhardt (fig. 13) was for a long time not accepted by German authorities, who changes their hostile attitude only belatedly, when the technical and economical advantages of this procedure demonstrated by applications in other countries could no longer be overlooked.

fig. 13: Incremental launching of a highway bridge

However the obviously logic idea to supplement the internal centric prestress needed for launching by subsequently added external prestress required for the completed structure was barred, since the latter was deemed to be unsafe. Then about ten years ago the external prestressing was all of the sudden imposed for all federal highway bridges, with the argument that this method permits an easy inspection. It is surprising that the construction industry swallowed such repeated turn-abouts, probably fearing that it would otherwise loose contracts.

All these examples show – and many others could be cited – that rigid overregulation is a serious handicap for inventive designers, and that it would be much more reasonable to leave such matters to competent engineers, who are fully capable to make the right decisions and willing to assume the ensuing responsibility.

4. Conclusions

In the foregoing critical appraisal of the present situation with regard to creative design, several proposal for improvement were made. But the question remains, who should bring it about.

It the first place prominent engineers should individually fight for the public recognition of their important rôle they play in the built environment, as for example architects successfully do.

This task should also vigorously be pursued by professional institutions, among other by our own “fib”.

Since there are unfortunately too many national and international engineering organizations with similar and overlaping objectives, the author proposed in 1988 the merger of FIP and CEB, an idea, which was first met with a lot of resistance. After long and difficult negotiations, the merger came finally true by the creation of the now flourishing fib. However it is felt, that the already existing collaboration between the major engineering organizations in the so called “liaison committee” should be strengthened. Its objective should not be restricted to the coordination of the too numerous congresses and symposias, but be widened to enhance the role and public recognition of our profession. Among other it would be rewarding to create a joint commission with the sole objective to propose and enforce a drastic reduction of codes and administrative regulations to a digestible minimum.