Zeitschrift: IABSE journal = Journal AIPC = IVBH Journal

Band: 6 (1982)

Heft: J-15: Interaction between architect and structural engineer

Artikel: Interaction between architect and structural engineer

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DOI: https://doi.org/10.5169/seals-26291

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Interaction between Architect and Structural Engineer

Collaboration entre l'architecte et l'ingénieur civil

Zusammenarbeit zwischen Architekt und Bauingenieur

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SUMMARY

The architect sees his ancestors among the Greek, Roman and Renaissance sculptors. The engineers claim the Roman civil engineers. Yet both groups have developed their skills, the architect as achievor of human satisfaction, the engineer as manipulator of physics as well as his knowledge of construction practice. Their education and training processes are now highly developed yet quite different and their attitudes are products of their processes. Yet personality profiles show similarity within the two disciplines. Perhaps this is why conflicts arise. More awareness of each other's contribution has developed; yet more is needed.
The following two papers reflect some results of the discussion about design and aesthetics of civil engineering structures that took place within IABSE Working Commission V at its meeting in London in September 1981. The two authors explain their personal view of the design problem and the advantages of an early and close collaboration between structural engineer and architect. It is foreseen to continue the discussion of this problem in the near future.

RÉSUMÉ

L'architecte considère que ses ancêtres sont les sculpteurs grecs, romains et de la Renaissance. L'ingénieur croit avoir ses racines dans l'époque des constructeurs romains. Les deux professions se sont beaucoup développées: l'architecte cherche à répondre aux besoins de l'homme en matière d'habitat et d'espaces construits, tandis que l'ingénieur cherche à maîtriser et à appliquer les lois physiques dans ses constructions. Leur éducation et leur formation sont aujourd'hui très développées, quoique assez différentes, et leurs comportements en sont le résultat. Le profil de personnalité montre cependant une certaine similarité entre les deux disciplines, ce qui est peut-être à l'origine des conflits bien connus dans la construction. Une meilleure prise de conscience de la contribution et de l'attitude intellectuelle de l'autre partenaire reste nécessaire.
Les deux exposés sont le résultat des discussions sur la conception et l'esthétique des constructions de génie civil, que la Commission de Travail V de l'AIPC a eues lors de sa séance à Londres en septembre 1981. Ils reproduisent les idées personnelles des auteurs sur le problème de la collaboration entre ingénieur et architecte. Cette discussion devrait se poursuivre à l'avenir.

ZUSAMMENFASSUNG

Die Architekten sehen die Bildhauer der griechischen und römischen Kultur sowie der Renaissance als ihre Vorgänger. Die Bauingenieure leiten ihre Herkunft von den römischen Baumeistern ab. Beide haben ihre Fähigkeiten und Berufsbilder stark entwickelt: Die Architekten in erster Linie, um die menschlichen Bedürfnisse nach Wohnraum und Bauten zu befriedigen, während sich die Ingenieure hauptsächlich in der Beherrschung der physikalischen Gesetzmässigkeiten und der Bauverfahren übten. Ihre Ausbildung und Verfahren sind heute weit entwickelt und trotzdem noch sehr verschieden, obwohl die beiden Berufsbilder gewisse Ähnlichkeit aufweisen. Vielleicht ist dies mit ein Grund für die zahlreichen Konflikte im Bauprozess. Mehr Kenntnis von der Tätigkeit und der Denkart des Partners ist dringend notwendig.
Diese zwei Beiträge sind entstanden als Folge der Diskussion über den Entwurf und die Ästhetik von Ingenieurbauten, welche in der Arbeitskommission V der IVBH anlässlich der Sitzung in London im September 1981 geführt wurde. Sie geben die persönlichen Ansichten der Verfasser über die Probleme des Entwerfens von Bauwerken und der Zusammenarbeit zwischen Ingenieur und Architekt wieder. Es ist vorgesehen, die Diskussion dieser Fragestellung fortzusetzen.

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Certainly the relationship between architects and engineers is different in different countries. In some countries even difference in title does not exist and there is only one word for both professions. Even more certainly it is extremely difficult to generalise about such inter-relationships - they probably cover the full gamut from Z to A.

The title architect is an old one, according to Liddell and Scott[1] from the Greek word αρχιτεκτων meaning 'a chief artificer, master builder ... director of works, architect, engineer ...' and certainly for a long time the architect and the engineer were the same person - who else designed the Parthenon, Salisbury Cathedral and so on. In some countries to this day the titles and institutions have never separated and, though there is diversity in education, they are still one profession.

We each claim however different ancestors. The architectural profession claims the Greek, Roman and Renaissance sculptors; men like Pheidias, Appollodorus and Michelangelo who beautified their cities with public buildings. The engineers claim the Roman civil engineers who developed the infrastructure of their great empire. Vitruvius[2] is a historical text to engineer as well as architect. Yet for all of the Romans' successes in bridge, road, water and building engineering, in spite of their founding technical schools for engineers, it was construction engineering they carried out, restrained by what they could do with their materials, rather than the application of scientific knowledge.

Through mediaeval times the professions were the same. They were designing before they built but there is no evidence of any strength calculations. But they achieved great buildings. The vault of St Peters at Beauvais rose to 50m and this height was only exceeded with the advent of steel.

The use of theory in designing structures probably dates from the rebuilding of St Paul's Cathedral. The theory was evolved by Robert Hooke and its quality is that it not only defined the structural behaviour of the dome but also provided a design tool which is still used today.

A free translation of his solution is 'as hangs a flexible cable, so inverted, stands the touching pieces of the arch.'[3] What was so fundamental was not the catenary line under the self weight but the suspending of weights from different parts of the chain. Hooke was a friend of Wren, no mean mathematician himself, whose dome of St Paul's was the result of many discussions between himself and Hooke as they walked in the Park. So Hooke records in his diary on 5 June 1675 that Sir Christopher Wren 'was making up of my principle about arches and alter'd his module by it.' So chains were placed around the dome and it has not given trouble. Probably Hooke was the first consulting structural engineer.

By the middle of the 18th century the principles of statics were known, the working and breaking strengths of many materials were tabulated and the Principle of Least Work, the energy equation, known to many technicians. Yet the change from a craft routine to a prediction of behaviour based on measurement was very slow. In France the famous 'Corps des ingenieurs des Ponts et Chausées' was created in 1720. They tried to use exact methods of mathematics, geometry and statistics to determine structural sizes and evolved strength tests. It led to the domination of engineers in France, elitists trained to control great enterprises.

The early British civil engineers in the 18th century, were more in the Roman tradition. They came from modest backgrounds, were extremely practical, good surveyors and observers, constructors, interested in how things worked rather than why.

It was the advances in iron and steel production, which led to great innovation in construction. Within two years of the Ironbridge at Coalbrookdale (1779) a considerable use of iron in industrial structures had developed. Yet it was not for a quarter of a century that an architect used it for a 'designed' building when Nash used cast iron for a roof at Attingham Hall near Shrewsbury. It is generally true that technical developments have been applied considerably later in architect designed buildings than in industrial structures.

19th Century engineering was heroic and its achievements of span, space and height are admired to this day. Yet the architects with their lack of historical precedent for handling the spaces, design and detailing in those materials were largely not interested. Their chance of fame lay in reviving historical styles. The two professions worked uneasily together.

Yet the very success of the civil engineering profession produced conservatism - and at the same time civil engineering education was developing within the universities. University chairs were founded, first at London in 1841 and so on. In the universities there was an increased pull to see engineering as an applied science. A considerable amount of work developed on methods of structural analysis.

It is interesting that the most fascinating structures of the interwar years were developed by a group of academic engineers for structures for airships. But it is probably true to say that the failure of the British incursion into airship design was because they, like many engineers worldwide, saw the problem as one of analysis rather than the possibility of design.

Between the wars architecture started to be seen more as a creative craft and started to emulate the structures of the engineers. The two professions started to work together more closely. But we are all defined by how we are educated and trained; defined by our methods of working.

The architect probably seems himself as 'an ideal, a de Vinci amongst lesser mortals; artist, technologist, humanist, scientist, a capitalist in business, a marxist in deference to the public good.' The public probably does not see him as broadly as this but undoubtedly sees him as the 'creator' of a building and even of the environment, in that they see the visual characteristics of a building as being the 'art' in it. In this they see the creation as being the product of one man and are rarely aware that architects offices can be quite large and that most of those architects who become known as successful are the leaders of groups. An American, McKinnon,[4] led a team who attempted to test architects' personalities. They selected three categories; the first being 40 architects who were world famous and these they subjected to the broadest range of personality tests. Then there was a category 2 of forty three architects who had worked in well-known practices and each one of whom had worked for some time for a member of category 1. Finally there was category 3 - thirty-one ordinary architects. From these tests they determined that the members of all categories had a high capacity for status, great interest in and responsiveness to minor needs, motives and experiences of others. Category 1 were noticeably higher in social presence, self-acceptance and flexibility and lower in sense of responsibility, socialisation, self-control, tolerance, sense of conformity and unconformity. This corresponds to a description in Blake's book, The Master Builders[5], of Frank Lloyd-Wright as 'arrogant, strident and full of conceit' and Le Corbusier as 'cold, suspicious, pugnacious and arrogant'. But at the other end of the scale, and the impression which the group 3 profile conveys, is of men who were good citizens, responsible, productive, sensitive and effective. The span of personality is such as to make one accept that there is a wide spectrum of extroverts and introverts who produce good architecture.

Certainly in McKinnon's determination of the measure of desire to exert control over others, creative architects scored higher than any other professional group tested and they also rated highly on femininity.

In most countries the majority of an architect's training is by project work in which the student is set a design problem which he starts to solve, being given periodical advice and criticism by members of staff. This method of teaching, on a one to one basis, is obviously a theoretical idea but it is heavy in staff requirements. This often means that in reality it is not well done and yet still requires an amount of time and resources which engineering educators are often deeply jealous of. Architects teach architects and see design as the most important part of what they do. There are no sub-disciplines in architecture: technology, they are often described as 'supportive studies' and designed to skirt the peripheries of a subject rather than the core. Because of this architects are often technically unsure. Many architects, though far from all, see themselves as determining the design of the building and their engineers as making that design stand up or providing the services for it. Brought up in an era where form followed function most architects start with planning, the building form derives from that plan. There are recent moves in architectural fashion which are bringing back more historical style into the facades and into the planning of their projects. There are exceptions, some architects see their role as providing visual/cultural continuity and are aware that some of this comes from a knowledge and ability to handle the environment around the site. They recognise that an engineer, with his knowledge of physics, can creatively join him in determining the form of this answer. Certainly most architecture is carried out by analogy - by looking for historical precedent to prove or disprove a solution.

Where the architect will see design as 'the performing of a very complicated act of faith'[6] the engineer will see it as 'the optimum selection and prescription of components and elements in order that they satisfy the true needs for a set of circumstances'.[7] This perhaps expresses the difference between the architect's and engineer's values. Primarily the engineer sees himself as a constructor, engaged in the art of the possible. He has been taught the physics of the environment and materials and these he can use to design - though he is more likely to use them to test whether a design will work in practice - more as an analyst than a creator. The public generally supports this view and does not see the engineer as creative but carrying out the task of making something work and stand up. In this role the public views the engineers as extremely responsible members of society. I am aware of no such study on engineers as McKinnon's though there are several papers on attitudes engineers hold - many that seem quite incompatible. Southey[8] described Telford as 'simple, friendly, nomadic, fantastically hard working and very proud'. From Rolt's books[9] Brunel was 'proud, desired glory, ruthlessly logical, could be both gay and witty and then acutely melancholy, deep, violent and passionately striving', George Stephenson was a 'proud, jealous and intolerant man' whilst Robert, his son, was 'humble, cautious, conservative, sought advice and always acknowledged help.'

So it appears we can say that though their values are different the personalities of famous leaders of architectural or engineering design teams can come from anywhere within the range of normality. Since McKinnon proves from his tests that there is a direct relationship between the amount of publicity an architect gets and the judged creativeness of his work, the only personality trait you can be certain of is that the leader must be motivated to succeed, be self-satisfied and be good at advertising. It must be the mix of the design group which is important and would suspect that this is as true of engineers as of architects.

An engineer's education is in line with those of scientists. Usually there is a heavy lecture programme, starting with pure science and mathematics and gradually embracing more and more application. There are laboratories in order to teach how to measure and so to learn how to relate theory from practice. There is usually limited project work. This usually calls for highly imitative design and concentrates more on the detailed analysis of the behaviour of elements or joints. True application and the learning of design is usually left to the training period in design offices after university graduation. A knowledge of construction the engineer is deemed to need is covered by a period working on site for a contractor or site engineer before professional qualification is allowed.

There are still some conflicts and resentments between architects and engineers. The architect tends to resent the engineers who have moved into his territory of building and resents even more the outspoken criticism of the architect's performance. Architects tend to think that engineers can only design what they have done before, that they over-design their structures and that if they are not kept in their place they could affect the scale of fees that architects get.

The engineer believes that the architect is airy-fairy and basically incompetent on technical matters. He really feels that engineering is objective and exact and cannot understand why architecture is not also. He tends to despise the architect for his lack of relationship with the contractor. He resents architects copying engineering solutions and subsequently claiming them as architecture (such as the Crystal Palace and the London railway terminals of Victorian times). Most of all the engineer resents bitterly the architect trying to act simultaneously as both designer and administrator of the whole design and construction group because it seems to him those two functions should be separated if judgements made are to be fair for those engaged in such a complex process.

Mostly the conflicts are about threats to each groups values - values largely defined by their system of education. There is justification in both professions' views of each other but conflict has reduced. Certainly the two groups now work together much more closely. But more understanding for what each other does and more respect for this contribution is needed if we are to have a better industry. After all both bring different sensibilities as well as methods to the design process. Architecture is at core based on historical scholarship since it is engaged in providing visual, spatial and cultural continuity. The core of an engineer's knowledge comes from thought based on research; the measurement of the behaviour of the physical environment related to practice. Obviously the two groups overlap each other and have some of each other's knowledge. Yet all engineers accept that architects put values into buildings which they cannot conceive of until they experience them and surely engineers' methods of thought can extend the possibilities and provide new qualities.

Engineers are now becoming more aware of the creative contributions they can make. There are patterns of solution in any building and that while those patterns may be derived from studying similar buildings there are also certain patterns which can only come from a knowledge of physics. It is those which the engineer should realise and be able to bring into the design process.

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INTRODUCTION

The title should be seen in relation to the cooperation between the engineer and architect on bridge projects, large and small.

These projects have the engineer as the superior, whereas the architect is the subordinate assistant, contrary to the normal order of proceeding in housebuilding. Working under such circumstances the architect acts as advisor and a critic implementing relevant aesthetic argumentation, who can recommend but not demand. This does not mean that the architect is without responsibility.

The authorities have considered it necessary in todays democratic society to engage both landscaping and structural architects in the road and bridge projects already from sketching.

Through the recent years the public has shown an increased interest in the scenic values, the way the landscape is treated and the consequences of the technical development's influence on nature and environment.
Such public activities, often exercised by local associations, are promising with regard to the preservation of scenic and environmental qualities and should be encouraged, however, it might be difficult to find a mutual solution of f. inst. a construction of a bridge in a landscape. The structure must submit to the scenic and environmental situation and not dominate. The contrast between manmade structures and the virgin landscape might even add to both of them new exciting qualities.
The architect has the opinion that it is relatively simple in principle to integrate the engineering and environmental design processes and produce a better total design, but it requires a multi-disciplinary approach based on professionals who can think in therms of expertise other than their own.

The engagement of aesthetic advisors in such projects has already no doubt contributed to avoid controversy over environmental questions and the authorities have disposed of a responsibility, which they consider beyond their capability and are not prepared to take.

THE BACKGROUND OF THE ARCHITECT

In ancient time in Europe the sovereigns usually engaged, as a member of the court, a master builder, just as it was customary to include in the court a musician, a composer and a director of the musical activities within the court. Some of them have attained eternal life both on account of their remarkable talent within their profession but also on account of their prominent employer, materialized in compositions which are repeatedly played all over the world in front of enthusiastic audiences or in buildings which still attract the public because of their aesthetic prominence or sometimes their daring constructions related to the time of their erection.

The master builder was the responsible person and the dominant person in charge of the design and the erection of the building. He was both the engineer and architect in one person and his name was connected with the building.
It is fair to assume that the master builder has confered with many other people involved in the process of erection, persons who had experience concerning the structural and constructional problems and who were familiar with the properties of the material within their profession. There has already by that time

been a collaboration between people with technical knowledge, though by experience, and the person who was responsible for the completed structure with its aesthetic qualities and technical requirements.

The design was influenced by the contemporary currents in the society, as well as the understanding of the client's wishes, how to comply with them and how to satisfy sometimes a vain and ambitious person. Some of the employers, royalties and noblemen were well informed and knowing with regard to aesthetical qualities, not only within architecture but also in music, sculpture and painting.

The aesthetic ideal is closely related to the social order in society, the level of technology and the leading class and their way of living, which form the synthesis and the basis of the creation of the ideal.
Changes within the social order, the technical possibilities and the way of living are gradually communicated and influence the concept of beauty.
Social revolutions have no immediate influence, because the class in the society which take over as the new leading class in its way of living imitated the class just above. Gradually the new leading class finds its conditions for living and thereby a new aesthetical ideal materializes.
This is not related to architecture only, but to all other branches of art, music, painting and sculpture. The correlation between arts is a fact. The retrospective view clearly discloses the various style epoches where the branches of art form a synthesis.

Aesthetical rules and theories and traditons are valid within limited periods until the concept of beauty becomes boring, until it comes out of step with the way of living, the social order and the technical level, leading to abrupt, sometimes provoking breaks with the "good taste".

The capitalistic order of society which replaced the feudal society in France in 1789 had about a hundred years to elaborate and develop its ideal of beauty before a more radical change of the concept took place.
Some say the French impressionists and their contemporary composer Claude Debussy were preparatory and lead to cubism in the beginning of our century and to a radical change of musical ideals. The late romantic era came to an end.

The cubistic painters inspired the avant-garde architects and new styles, futurism and functionalism developed.
The structural form without decorations was the only essential. "Form follows Function" became the leading slogan. Le Corbusier formed another thesis: "The house is a dwelling-machine". An expression which not only in its terminology is "industrial and technological" but in its point of view sees the technologic, democratic society reflected in a new style of architecture and also in all the products we make use of in our daily life.

"Form follows Function" may easily be misunderstood, if it is litterally perceived. It cannot be true that any form deriving from a more or less well defined function should be satisfactory. Unless the function is well defined and refined the slogan is not acceptable. The works of the late Pier Luigi Nervi are remarkable because the structural function of these works is refined and in relationship with nature's organic structures.
Lately some trend of oppositional attitude manifests itself in what is named post-modernism. "The house as a picture".

DESIGN OF BRIDGES

The design of bridges have through time been related to the architectural style of buildings. The introduction of new basic structural materials has contrary to the change in society caused a radical change in the design of bridges. The industrial production of steel profiles for constructional use has enabled the engineers to design new type of bridges with larger spans, either as cantilevered structures like the Firth of Forth bridge or as ordinary steel girder or steel arch bridges.
The fortuitous invention of reinforcing the concrete with steel made by Monier, the gardener, utilized in tubs for the exhibition of flowers and plants nearly a hundred years ago and later Hennebique, the contractor, who began the more professional analysis of this material and its application for constructional use and the following years of intense scientific and technological research, introducing relevant calculations combined with materialistic creativity f.inst. Freyssinet's invention of prestressing of the reinforcement, has given us today a structural material which we can give almost any shape we like.

In Denmark bridges are usually designed and constructed as reinforced concrete structures in order to use the home produced cement and other materials and save the imported and more expensive steel. Only a few larger bridges up to now have a superstructure of steel, being competitive as a consequence of their construction as suspension or cable stayed structures.

It is the engineer who decides which type of bridge is adequate in the present case. The alignment and the location of the bridge is determined in cooperation between the Road Department and the environmental authorities with the assistance of both landscape and structural architects. When these basic questions are settled the cooperation between the consulting engineer and the architect commences.

THE DIFFERENT APPROACH

The engineer's study emphazises on realism and rationalism. His education shall enable him to take responsibility for the stability and safety of structures. The static calculations to ascertain and prove these qualities are complicated and imply the knowledge of mathematics, a mathematic mind, often with a scientific approach. He must be familiar with the behaviour of structural materials under different conditions and attain a comprehensive knowledge of the properties of the materials introduced in the design.
The technologic research of the basic materials, the difference in the properties of reinforced concrete and steel demands that the engineer specializes, if he wish to prosper. He must devote all his efforts to and concentrate on a materialistic, realistic and rationalistic approach to constructional and structural problems. It is only fair under such conditions, that evaluation of aesthetic qualities may be subdued and offered less consideration.

This may be the cause of the engineer's inclination to concentrate on structural details of a project offering less consideration of the unified whole, the environmental and the scenic situation as integral and important parts of a project. The tendency to concentrate on details leads to a procedure in the design process, where the completed structure depends on a combination of the various, though perfectly well designed technical details by which, however, the transition of the component elements turns out to be the obstacle.

The architect gives first priority to the unified whole appearance and consequently the details become subordinate and must be designed accordingly, in conformity with the intentions and the aesthetical philosophy of the design. The appearance of a completed structure should never reveal constructional difficulties.

There are different ways to solve the architectural design and there are also different ways to solve the statics of a structure. The various possibilities must be analysed and evaluated from an aesthetical point of view, because the statical principle of a structure implies the embryo for the artistic elaboration of the final design.

THE COOPERATION

The commitment is to make a design, which in a responsible way is related to the prevailing level of the technical possibilities.
The more the two parties are able to approach the task without preconceived ideas the better. No two projects are identical. The conditions are different and the technical and aesthetic elaboration should be unprejudiced and thoroughly analysed. The cooperation shall be a challenge without loosing sight of technology and aesthetics in unison. The product of our cooperation is exposed to other peoples judgement, we expose our technical and aesthetic commitment.

It cannot be avoided that certain problems in a design of a structure are crucial and might lead to heated arguments. The excitement in such moments is, however, only a token of the serious and responsible engagement by both parties in the project. The excitement is caused by the feeling of being on the verge on ones capability to solve the problem. Such moments might be useful for the creative mind both in technical and aesthetic sense and thus maybe achieving a better solution.

The engineer's force in the argumentation is the ability to produce facts concerning technical questions and their solution subordinated by figures and curves. If he is in favour of a better technical solution, which may cost more, he is able logically to prove such additional costs and why they are recommendable. If the architect is in favour of a better aesthetic solution, which costs more, it is the experience that the economic consequences get first priority and not the aesthetic quality, though it is just as logical that a better aesthetic solution may cost more as may a better technical one.
Unless a better aesthetic design of a structure can be combined with also a better technical solution the chance of the architect's point of view being adopted is dubious.
The client is usually inclined to be sympathetic to a more expensive technical solution, because a rejection may bring about a responsibility, which at a later date could have its effect, whereas a rejection of a better aesthetic solution does not involve actual responsibility.

According to a book in honour of the late Pier Luigi Nervi, a master builder in our time, the engineer and architect in one person, world famous for his artistic and technical design of buildings, made the following pronouncement: "The commitment of the engineer, constructor or designer should never be judged - first and foremost - on a techno-economical level but should be judged on a techno-aesthetic level. An engineer and an architect should never ignore aesthetic demands, even within the technical heart of a structure".

These words meet exactly with the attitude of the architect. It implies, however, that the architect is accused of neglect of economic consequences. That is not true.In the architect's aesthetic considerations and recommendations of a solution the economical factor is evaluated on line with the engineer's technical demands.
The actual costs in such cases are not the obstacle but the philosophy of minimum costs, a primitive form of accounting when compared with the value for money criteria, which is rather more difficult and time consuming to apply.
The architect must persistently try to convince a client or an engineer that value for money includes things other than engineering standards and maximum time savings.
The architect, who usually is a lonely person, arguing his points of view in a forum of engineers, may permit himself to ask if this always can be considered a competent jury to make the final decision?

THE ARCHITECT'S COMMITMENT

Aesthetics do exist also in a calculation of statics, in figures and equations. The evaluation of beauty, the aesthetic perception of an equation, a curve or a calculation of pure technical origin imply the knowledge of mathematics and the tangible substances, which are involved, i.e. an identification with the development of the subjects in question by an emotional mind.
It might be quite difficult for the engineer in some way or the other to express in plain words to an audience, why it is beautiful. It might of course have to do with the simplicity of the equation or the calculation or the linear progress of the curve, however, this cannot be an adequate answer only, some abstract qualities are involved.
In a working committee the engineer often expects that the architect in plain words is able to explain why one form has more beauty than another. We must realize that it is not possible.

In the book "Architecture and its Interpretation" by J.P. Bonta the author says: "There is no support of the undoubtedly widespread opinion that architecture speaks for itself. Nor that the architect himself knows what the public response will be. The process of interpretation is an indispensable basis for communication on architecture, as the interpretation transcribes the non-verbal expression of architecture into a "language"".
This means that architecture comes into existance through the process of interpretation and in this very way becomes alive in what is written and what is said. Through interpretation some structures become more important than others, and if they withstand repeatedly being re-interpreted they will enter into eternal life in the history of architecture.

Sometimes the engineer may get the impression that the architect is airy-fairy. This is not correct. In his design the architect must incorporate the structural elements, the static principle, the combination of different materials in the structure, the environmental conditions, the practical function of the structure etc. They are all very real and tangible components that must be considered in the design. None of them must be neglected if the architect's suggestions shall have a chance to be accepted.In order to attain proper knowledge of the technical components it is useful if the architect is present when technical questions are discussed among the engineers.
For the architect to listen to the arguments on technical problems is stimulating and often his apparent, inactive and passive presence is just the inspiration needed in the creative process.

Creativity is irrational. Ideas, fantasy, visions and faith are offsprings of the irrational mind. The emotional life and feelings do not follow rational courses. When the idea is conceived it shall be taken up for logical and rational consideration and elaboration.
It is paradoxical that the more liberty i.e. less conditions and restrictions in working out a design the more difficult it is to arrive at a definite conclusion. The more restrictions and conditions to abide by the easier it seems for the designer to follow a line towards a result.

The possible trend of the replacement of one style with another can be explained quite obviously in the retrospective view. If we look into the future there is no obvious trend to follow. This has also been the situation in the past.

Today there are three prominent buildings each with their very different concept of architectural design. The Sidney Opera by Jørn Utzon, the Pompidou Centre in Paris by Piano and Roges and the Philip Johnson skyscraper in Chicago. They do not indicate a trend to follow but they will no doubt influence future architectural designs in some way or other.

We must realize that it is the individual with the creative and the artistic approach, which indicates the path to follow.
The creative process is personal and not a democratic process. This is true with reference to composers, painters and sculptors. From where and when these artists get their inspiration is almost impossible to verify.
Can a group which is democratic also be creative? What is said above seems to exclude this possiblility.

The design group has a complex task, to unite in the design technology and aesthetics, to unite realistic and materialistic qualities with abstract qualities. The creativity of the group is a possibility, if the hypothesis for the interaction between structural engineers and architects is a mutual challenge and inspiration.