

Engineering and Modern Society – A tight mediation

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Summary

Today's engineers' activities are changing. From purely technical tasks at the beginning, engineers now have to face a lot of parallel administrative work. These activities are time and money consuming, restraining engineers from expressing their real art in technical developments and creativity. Evolution of modern society, a difficult economic situation and a competitive market have changed the social position and the role of engineers. It's a big challenge now to push forward the engineering community towards some evolution, in order to recover its place in society, by regaining lost credibility and confidence. The goal is to rebuild an attractive profession able to inspire and enthusiasm young generation for the future.

Keywords: Engineers, engineering art, society, profession, young generation, call for tenders, competitive market, fees, administrative work, technical services, engineers and their environment.

1. Introduction

He creates, designs, develops, plans, imagines, combines, adapts, lays out, redraws and redefines space and the way of life. Serving society, he makes transportation, moving, and communications possible while at the same time organizing them, thus bringing people closer together. You named the Civil Engineer.

He has been a source of admiration for many decades through audacious works and forged man's perception, giving him bridges, dams, large halls, railroad stations, airports, skyscrapers and offshore platforms as aesthetic references. Each one of his works generated strong new feelings, adding more references. Construction challenge, lightness, adequacy of means, invention and technical performance turned engineers into main actors of the architectural creation since the industrial revolution.

From the start of the contemporary engineering era – at the turn of the 18th century – the engineer has been admired as much for the spectacular aspect of his works as for his approach that prefigure creativity characterizing industry's new times. Unwillingly, he was brought to shape the visible world because all great projects were built thanks to his science and intuition to find at the same time, solutions for structural stability and building processes, thus strongly shaping his works.

The evolution and diversification of materials and construction elements over the last two centuries have been tightly linked to the development of structures. From cast iron to iron and to steel, reinforced concrete, prestressed concrete and metal alloys, together with the industrialization of more traditional materials such as brick and glass, new structural types have been invented. Truss beams, large exhibition halls, steel arches, concrete frameworks, thin shells, tensile, suspended and inflatable structures are just examples of the formidable development that characterizes this period. Constant search for structural efficiency and lightness has guided engineers in their thrust for innovation.



Fig 1: Engineering art – bringing the shape of modern world and the man's references

The dark side of this evolution was the emergence of a spirit of conquest attached to civil engineering and construction as the result of the close ties that grew between engineering and economy during the industrial revolution.

Serving a society based on capitalism and permanent growth, relying constantly more on the planet's resources, engineers have built, laid out and organized lands that had been uninhabited or considered as totally wasted before. He has created railways, roads, tunnels, pipelines of all kinds, without always caring for the long-term consequences of his acts. Convinced of bringing progress to mankind with his infrastructures, he has turned engineering into an act of violence against nature. And so, suspicion started to emerge in parallel with the admiration that had been aroused by great and symbolic works. Engineers have slowly become considered as responsible for an outrageous urbanization that has led to the chaos of entangled elevated roadways and other elements of modern infrastructure.

Current evolution of society and the population's new interests redefine the engineer's place and activity. Disregarding momentarily the above mentioned negative points, it is clear that the history of engineering stresses the aura of a profession not afraid of responsibilities, playing an important social role and aware of the services given to society. But this analysis is generally based on the study of great works and developments and therefore relates to only a very limited number of engineers dealing with this type of large projects. It is therefore not representative of the profession as a whole that vastly increased during the last century. Nevertheless, the image remains good and attractive and prestige lingers on in the memory of people who experienced the major developments of the past 60 years.

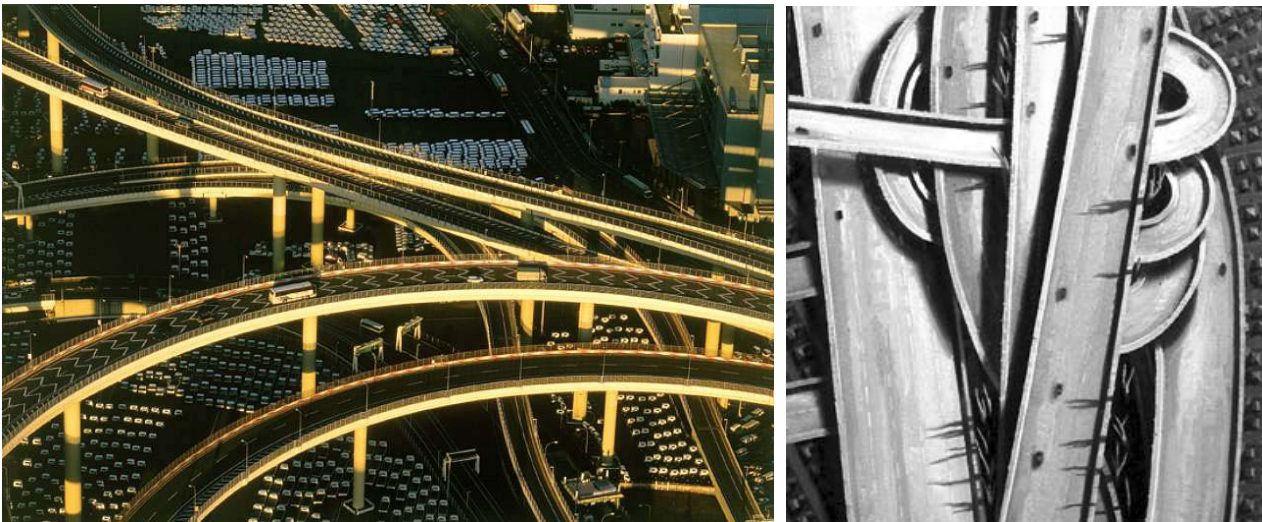


Fig 2: Outrageous urbanization deserves the image of the profession

What about today's generations? A poll conducted in industrialized countries among teenagers of 10 to 16 shows that two thirds of them don't know precisely what civil engineers are doing or, worse, that they even exist. So what about the former shining image? Civil engineering has definitely evolved, but has it properly adapted to the modern world with all its requirements, its advantages and drawbacks? How to escape an aging image that prevents young people to be attracted by this activity?

There is no easy answer to these important questions, but they reflect a serious and deep problem that jeopardizes the profession's future. Far from being able to express fully his creativity, the engineer is faced today with a difficult economic situation and a deep change in his activities necessitating a new approach of the problems due to the fact that he has become a service provider like many others.

2. The Engineers Community

There is no reliable statistic of the number of engineers as a function of time, but it is sure that the profession is very old and took an active part in the development of society. Due to favourable circumstances, the number of engineers greatly increased between 1940 and 1970 before stabilizing itself about 1980 and finally decreasing nowadays. It generally followed the evolution of the construction market, although with a small time lag due to a progressive reorientation of his activities and the development of more specialized niches. The number of engineers today is very high, if not too high considering the potential of the construction sector and the investment policies of states and private businessmen who turn towards fields more profitable in the short term.

In this community, about 25% of the private sector engineers work in large firms employing more than 200 persons, while the remaining 75% is working in small firms employing 1 to 200 persons, with a majority of them in the 1 to 50 person range. This distribution has a great importance for the following developments.

3. Has the Civil Engineer Reached the Peak of his Art?

The concept of engineer is today being totally redefined, his place in society is re-evaluated and the scope of his services in the strict field of construction is decreasing. Used to be a generalist, he becomes a specialist and his works – which used to be proudly displayed – become less and less visible when it is reduced to construction optimisation or energy consumption during materials fabrication and building operation. The old construction know-how is replaced by new demands in connection with the multiple networks found in buildings today. Networks, thermal and acoustical comfort, sunshine exposure control, layout flexibility, operation parameters, all are becoming today more important than structural stability. Construction and civil engineering have currently been pushed in the background of higher technologies dealing much more with telecommunications and information control than with forms and materials assembly. At the forefront of engineering in the past, construction is today just one of the many fields of engineering. The civil engineer deals with

the design of the envelope, but his mission often ends there and, unlike the architect's, his role is seldom noticed by the owner. Roads, waterways, bridges and buildings still dominate our environment, but the user's eye is more attracted by equipment, signs, advertisements and all the urban furniture that fill daily life.

Over the last 30 years, computer developments have made the static and dynamic analysis and design of ever more complex structures possible. Any shape can today be calculated and internal forces in the structure no longer need to follow the shortest or most logical way. Form is not anymore necessarily the consequence of a natural flow forces or the result of the engineer's know-how.



Fig 3: Extensive use of Computer technology open the way to any structural form (Bilbao museum and Gateshead Millenium bridge)

For usual buildings, owners are much more interested in the exploitation, modularity, networks, domotics rather than in the performance of the construction system, which is of secondary importance, when not even considered as restraining the development potential and the flexibility of the building's future operation.

The picture looks brighter in the field of large constructions and bridges of all kinds where the technical challenge of spanning long distances remains attached to the final structure, so long as the architectural design doesn't wipe out the cohesion and logic of the engineer's work as it happens too often nowadays.

Has the engineer's science reached a peak or a halt in its evolution? No revolution comparable to the discovery of reinforced concrete or prestressing is in sight. Nothing suggests fast developments in the construction field, even though new materials such as high performance concretes and composite materials are a breakthrough in construction engineering: they seem reserved to a very narrow range of structures.

Applications of these materials in day to day construction is far from obvious. As a matter of fact, these materials find many more uses in fields of high technologies such as space research or even naval construction where their contribution is determinant.

So what about "traditional" engineering? It evolves, adapts to changing markets, opens up new and larger fields because rebounding and reformulating problems is an important part of the engineer's science. Thus a new orientation towards lighter and more translucent structures that should become almost invisible and immaterial by mixing for instance glass and cables, or using inflatable and short-lived structures. A better control and adequacy of the structural design with respect to its real life expectancy in the related economic context is also a part of this evolution. Let's not forget that a tent is a far better performing structure than any other building type when rated with respect to its lifespan.

The increased concern for environment and ecology is another reason for redefining the engineer's activities. If such changes appear somewhat late, it is all the more essential to replace the former aggressive image of civil engineering by a new involvement in the protection of the environment. As he selects materials for a new construction, the engineer will now have to take into account the various ecological aspects of their production such as energy consumption (including the one

necessary for their future elimination), renewability of resources, toxicity, etc. Some design choices will be made to prevent potential problems at the time of demolition and recycling of the construction. Water treatment, elimination of jobsite wastes, materials toxicity, optimum shipment of supplies: all these aspects should be integrated in the design process.

This emerging philosophy generates new specifications for the engineering profession. Trained to exercising analysis and synthesis, and given the economic and ecological situation, the engineer may find himself in the position of having to advise against a project that would not comply with the rules of sustainable and social development. This is a totally new approach for most engineers and owners: knowing to give up and to convince others to reformulate a project that otherwise doesn't fit in its global environment be it for social, financial or technical reasons. But there is yet a long way to wisdom.

The strong gap existing today between industrialized and emerging countries is in part responsible for the slowness of this evolution. So long as engineers from industrialized nations will be able to satisfy remorselessly their taste for domination in countries demanding fast expansion and equipment, mutation will take place with difficulty.

By accepting this mutation though, the civil engineer will be again at the centre of society's development and preservation of its environment.

Has the engineer reached the peak of his art? The answer is yes if we only refer to his current knowledge, but certainly not with respect to his overall capabilities: by using his multidisciplinary, his analytical and open mind, his creativity, he is ready for the challenges of the near future.

This could be a happy end for a profession that suffers from an aging image and a lack of recognition. But there is a long and steep way to go in an unfavourable economic and social situation that tends to restrain more and more the fields of activities and competences of engineers. Important obstacles currently stand across the way, confronting the profession with the mediocrity of bureaucracy that limits his means and considerably refrains the enthusiasm and creativity necessary to reach this promising goal.

4. Multiplication of the Documents

Gone is the time when all the documents Maillard needed for one of his arch bridges could hold in one or two A4-size archive boxes. The archives of a similar structure nowadays take up 10 to 15 times more volume. If the engineer's plan used to show all his assumptions, calculations and schematics of the forces' flow through the structure, today a large number of drawings comprising numerous details, lots of meetings, expertise, fabrication and control reports, quality insurance programs, material testing certificates and what not are required. Quality and control of the final structure has undoubtedly improved. Some of the requested documents require the set up of a stringent construction process that benefits the resulting construction. But because of the complexity of the future construction's environment and the growing importance of technical equipment, a very large number of actors and specialists have been added to the operation flowchart, hence a multiplication of the meetings number and corresponding reports. Depending on his function in the project, the engineer is responsible for the writing of a large number of these reports and for transmission of information.

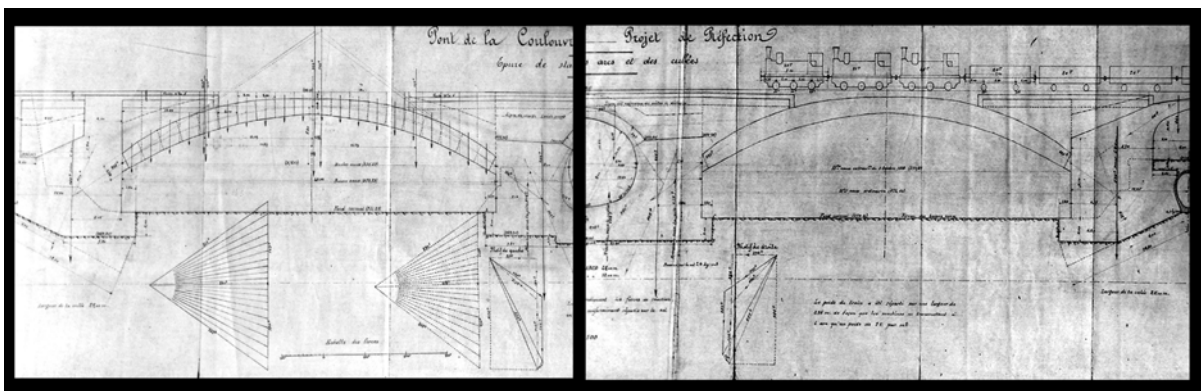


Fig 4: Stability design of the “Coulouvrenière” bridge 1895 - ing. Vautier

At the same time the design tools have greatly eased his technical work regardless of its complexity. From 80% that used to be required for the project development and analysis, only 30 to 40% are now dedicated to this task and the rest is used for meetings and administrative work. In other words less creativity and more paperwork, but still in the technical framework of the project. This might be considered as a normal trend in the current society characterized by the multiplication of standards and regulations of all kinds supposed to insure the proper integration of a structure in its environment.

But there is a much more perverse obstacle limiting significantly the development and evolution capabilities of engineers: free competition, public markets regulations and especially the way to enforce them constitutes a brake, when not a brutal halt to the engineers' activities and their creativity.

With some examples and references to precise points, we want to stress certain aspects that threaten the future of the civil engineering profession development.

5. References and Prequalification Documents

Call for tenders represent the actual way of awarding contracts to engineers for design services. Most procedures are done in two rounds: a round of prequalification for a first selection followed by a round of detailed evaluation of the remaining candidates with their bid. Given legal deadlines to advertise the call for tenders, time required for the procedure, deadlines for appeal and negotiation phases, the project start is delayed by six to eight months. During this time the potential candidates all produce an important amount of administrative work that adds up to a social cost that often exceeds the design cost of the future structure.

Preparation of a prequalification file requires much time, is a tedious and uninteresting work that cannot be entirely accomplished by administrative personnel. Appropriate references will need to be collected, forms to be filled, nice flowcharts to be drawn that are most of the time useless for the future of the project. Presentations speaking highly of the bidder's organisation will be written along with striking arguments to try to influence the owner's choice. In other words: an impressive volume of paper with very poor contents with respect to the energy required for its preparation.

But even more perverse and dangerous are the selection criteria that are applied. It becomes very difficult for the owner to decide between the candidates because most of the time all of them are more than qualify for the job. One of the methods is to formulate very restrictive requirements with respect to the requested references. As an example, a recent call for tender for a relatively simple bridge in Holland requested to mention "four references of bridges with spans in excess of 150 m completed over the last five years". In another case it was "three references of high speed railway bridges with spans larger than 70 m completed over the last five years". Who can meet such stringent requirements but large firms collecting their references worldwide? Even if requirements are not that restrictive and that evaluation is based only on the number of appropriate references or the yearly turnover in the corresponding field, this eliminates from the start all small- to medium-size firms and consequently the younger ones. As time goes by, the number of potential companies for interesting jobs decreases constantly. If a firm doesn't acquire large contracts during one or two years, or if its size doesn't allow it to handle enough work, its source of usable references quickly dries out. And never mind if the references of large firms have been managed by persons scattered around the world who will never be in touch with the project: the file is complete, period.

The owners' headaches are just as bad since they run out of arguments to eliminate candidates whose application files are very precise and complete.

As a result, only a closed group of firms are eligible for certain market types, keeping out the vast majority of engineers whose only fault is to work for small offices. Young enterprising and independent engineers are no longer given the opportunity to bring their dynamism and enthusiasm to serve the technical field. Keeping out young generations is a fundamental mistake for the profession's future.

And let us not speak of the bid preparation that consists more of taking advantage of the slimmest gaps in the specifications than developing an appropriate methodology and technical approach to the project generally totally unknown at that time. In the present times of stiff competition, this results in an offer that is usually far below all recognized recommendations for fees calculation.

Such procedures require outrageous investments that are more easily absorbed by large firms than by small and young ones which don't have a large enough base – be it financial or in terms of personnel – to afford to participate to several large offers during the year. This has the same consequences of restricting the candidates to a narrow slice of the profession as already shown above.

This trend unfortunately tends to generalize even to more traditional building design markets, when they don't even turn to general contracting. In such cases competition is so hard that contracts are acquired on a pure cost price basis, without any profit margin.

We are very far from technical development, from the image of an engineer deeply motivated by his work and the search for the most efficient structure. Were energy and time spent in these procedures affected to the project design and construction, then quality of the services would be remarkable.

The situation is not any better on the owners' side whose task is also getting more and more difficult.

The situation looks better in the case of design competitions where the technical expression remains a governing factor in the selection of the project and the team. But this is reserved to exceptional structures and also requires a prequalification stage with the same drawbacks as before.

6. What about Service?

Given a very competitive market, offers are calculated tightly and time assigned to each project phase is very limited. As a consequence, the engineer is no longer at the entire disposal of the owner to defend his interests to the last. This modifies significantly the relationship with the owner. The engineer no longer has an open mandate but a tightly negotiated contract with a very narrow margin. Services will be provided within the agreed financial framework. The resulting situation isn't satisfactory for anybody: used to the total dedication of his engineer, the owner is frustrated by his new lack of availability and has the feeling of being pushed into the background, whereas the engineer will have to constantly monitor the scope of his services and warn the owner of any work that wasn't planned in the contract. Hence sometimes a mistrust between owner and engineer. Dedication is no longer what it used to be.

*The bitterness of poor quality services remains long
after the short sweet taste of low price !!*

7. Some new practices

Buildings – whether residential, administrative or industrial – are often constructed by a general contractor. If it doesn't have its own engineering office, the general contractor signs up with an outside firm. This opens widely the door to many abuses. Because there are no rules and since any savings made at the subcontractors' expense will profit the main contractor, the latter will press his subcontractors with a very stiff competition and use questionable motivation methods that will aggress the profession's ethics. The following example shows a bad practice that unfortunately tends to develop in the construction of simple and repetitive buildings.

A major contractor calls for bids by engineers for the design of a vast residential complex near Geneva. Following a first evaluation two engineering firms are selected, that made an offer approximately 60% lower than the fees recommended by the profession (SIA recommendations). The firm that gets the contract in the end is the one offering the largest savings in reinforcement steel. As a counterpart, the engineering firm receives 10% of the savings in reinforcement costs. As a result, the interior walls are built without any reinforcement except ties at top and bottom. Because the general contractor is also the property developer and is quickly selling the apartments, long term behaviour and durability of the structures are the least of his concerns.



Fig 5: Extensive repetitive buildings are often the theater of many abuses

Where are the engineer's ethics and reputation? Market difficulties and survival push him to accept such condemnable practices. The legal and hierarchical project framework doesn't allow him to oppose such decisions. It is march or die.

This situation stresses the decreasing importance of the engineer in the traditional construction market. He becomes one actor among others, his technology – being not hi-tech - is not appreciated and property developers or investors are simply not interested in his action: it generates expenses, not profit.

8. The Engineer: a Necessary Evil?

Another striking example shows how investors regard the engineers' activities in the case of a large industrial and administrative operation. Following a very stringent and selective call for bids for design of the production center of a large company, the owner signed a contract with a multidisciplinary pool of civil, mechanical (heating and ventilation), plumbing and electrical engineers that had to set up their office at the job site. In order to prevent any future claim from contractors and service providers in contact with the pool, the owner set up a legal office adjacent to the engineering one to evaluate, check and approve all outgoing and incoming documents. While the engineers are paid an average of 70€ an hour after hard negotiations, the legal advisers obtained 300€ an hour without any discussion. The advisors are considered to bring a favourable return on investment while engineers are seen as only generating costs.

In addition to its downgrading aspect, this example also shows the apparent suspicion and lack of confidence of the owner in his representatives. Relationship between partners is consequently strained and the notion of consultant serving his client partly disappears.

9. About Fees

The difficult economic situation has created an environment encouraging all sorts of abuses in the negotiation of design fees. The first responsible ones are the engineers who accepted to work below profitability. Like any other profession, engineering needs to yield a profitable margin to insure its development, continuing education and to allow investments to improve its services. But the very limited profits – if any – are nowadays used to finance bids preparation. Here too the unbalance between large and small firms shows clearly. If major firms, thanks to profits brought by the number and diversity of their contracts, can still afford to express themselves technically in design competitions, it has become a luxury for small and young firms.

Everybody knows that a 30% saving in design fees amounts to less than 2% of the construction cost and that a bad design can easily generate important increases of the final construction costs. But the message is seldom heard. If on one hand correct fees are not a sufficient condition to ensure adequate services because these ones depend on the actors' qualifications, on the other hand saving on the design necessarily limits the time and means available to the engineer to fulfil his mission.

10. Conclusion

The examples given previously show that the profession is currently in the middle of a dangerous storm for its development. In order to move towards a brighter and more peaceful future, it is absolutely necessary to restore confidence and to give all the engineers the possibility of expressing their creativity. The currently followed direction is simply opposite.

This starts with universities and technical high-schools that reduce their efforts and investments in the basic fields of engineering to turn to so-called high-tech or more fashionable fields such as biotechnology, robotics, telecommunications, computer sciences, etc. Basic engineering is regarded as an aging discipline and young people consider it as a harsh profession that is restricted by many standards and lowly paid. It looks simply less “fun” than the currently fashionable fields.

It is most important to promote the profession and attract young people to bring fresh blood and prevent sclerosis. But a favourable economic environment is necessary to allow them to express their sense of innovation and enterprise, and this not always under the tutorship of senior engineers.

It is absolutely required to restore this environment for all actors of the profession, regardless of firms sizes. It is a question of putting everybody’s creativity and imagination to work for technical and technological advances. It is the only way to progress towards healthier engineering.

Competition is to be encouraged at the technical level, and not at the financial level alone. Design competitions are fabulous stimulants of creativity and innovation. But the specifications and requested documents for such competitions should be tailored to limit the competitor’s investments, allowing them to express fully their technical ideas rather than wasting their time on the preparation of voluminous files.

This requires that fees for regular design work generate reasonable profit margins to finance such activities. Defining the right price, defending it, applying it and making other ones apply it too is also the engineers’ responsibility. But it is impossible to establish universal basis for fees calculation, the economic environment and the different approaches in various regions and countries influence it. It is a very difficult problem that only adequate information of the owners in order to make them fully aware of the value of provided services, will be able to resolve progressively. And there is certainly a very long way to go.

The same approach should apply to procedures of selection of the engineers. Application regulations and evaluation criteria should fully allow the market access to all types of firms and especially to young people. This difficult and complicated problem that is not going to find a quick solution and that might split the profession in two categories in the short term: the chosen ones and the excluded ones. Unfortunately, this splitting is not conditioned by technical qualifications of the persons involved and this is a considerable restraint to technical and economical development. There is no miracle solution to this problem. Some professional associations try to establish recommendations for the application and judgement of such procedures in order to bring some order, but discussions are hot because interests diverge.

Given the amount of unanswered questions, it is difficult to end this presentation on a totally optimistic note. Potential certainly exists and it is obvious that major changes will take place in the activities of, and services provided by engineers. The road is long and difficult but it is necessary to bring the profession back to its original vocation, i.e. a technical one. Let us not become submerged and suffocated by a growing bureaucracy that is a sickness of today’s society.

Imagination, creativity, counselling, development and construction are the keywords of the engineer’s activities and his motivations. Let us respect and force respect of these values.