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Innovation in Engineering and Management

Innovation en ingénierie et en gestion de projets

Innovation im Ingenieurwesen und Management

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Angelo Pozzi, born 1932, graduated at the ETH in Zurich. He was active in several large projects at home and abroad; complex management problems of all kinds are a special challenge for him. Since 1971 he has been Professor for Engineering Management at the ETH in Zurich. Today he is the Chief Executive Officer of the internationally active Motor-Columbus Corporation.

SUMMARY

We dispose of an enormous innovation potential, enabling us to organize projects in a more effective way, to realize them more efficiently and to use them more economically. Why do we hardly make use of this potential? could it be that the numerous regulations and codes have become a barrier for new developments? Why do we plan and construct, mostly uncritically, simply following the requirements of others, even though we are aware that we will be held responsible for the result? We have to consider increasingly the project concepts, the project targets, the project economy, the project organization and the project management, promoting innovation effectively, and let it develop more freely. We need a climate favourable to innovation; how do we achieve this? The problems are demonstrated by practical examples, and possible solutions discussed.

RÉSUMÉ

Nous disposons d'un important potentiel d'innovation permettant d'élaborer des projets de façon profitable, de les réaliser de manière efficace et de les exploiter économiquement. Pourquoi ce potentiel est-il si peu utilisé? les nombreuses prescriptions et normes sont-elles un handicap aux nouveaux développements? Pourquoi établissons-nous des projets et construisons-nous sans critique ce que les clients exigent, bien qu'après coup la société nous rende responsables du résultat? Nous devons nous préoccuper davantage de la conception des projets, de leur but, de leur économie, de leur élaboration et de leur gestion, favorisant efficacement l'innovation et lui laissant plus de liberté d'action. Nous avons besoin d'un climat qui encourage l'innovation; comment y parviendrons-nous? Les problèmes sont illustrés sur la base d'exemples pratiques et des éléments de solution discutés.

ZUSAMMENFASSUNG

Wir verfügen über ein gewaltiges Innovationspotential, damit Projekte nutzbringender gestaltet, effizienter realisiert und ökologischer genutzt werden können. Warum nutzen wir dieses Potential kaum? sind allenfalls die vielen Vorschriften und Normen zum Hindernis für neue Entwicklungen geworden? Warum planen und bauen wir kritiklos oft einfach das, was von Dritten gefordert wird? für das Resultat werden wir normalerweise verantwortlich gemacht. Wir müssen uns vermehrt mit den Projektkonzepten, den Projektzielen, der Projektökonomie und dem Projektmanagement befassen, die Innovation nachhaltig fördern und ihr mehr freien Lauf lassen. Wir brauchen ein günstiges Innovationsklima; wie schaffen wir das? An praktischen Beispielen sollen die Probleme dargestellt und die Lösungsansätze diskutiert werden.

1. Introduction

Civil engineering is getting into a cul-de-sac,we have become *captives of our own successful past.* We have at our disposal an enormous knowledge and ability in the design and construction of individual facilities, especially their load-bearing structures. Structural engineering has captured our imagination and trough the possibility of computer support it has become even more fascinating. Through regulations, codes and standards our projects and the problem-solving processes have tended to become overregulated, we know a great deal about very many special problems. However we are contributing too little towards the solution of problems which will decide the future. Perhaps many of us, due to the success in solving special problems, are no longer in a position to differentiate between the really important problems and those that are interesting, but less important. *Project management* and *project engineering* must become more innovative if we want to be equipped for the *new tasks* which lie before us. Our concern must be directed towards using our innovative skills and potential for the really important problems of the coming decades.

2. Successfull Past

We look back on a very successful development in the planning and construction of civil works. It was the *power of innovation* in our profession which made possible the enormous progress of civil engineering in the developed countries; *advances in materials* was to a large extent responsible for the decisive changes which occured. These were followed by new, time and cost saving *construction methods;* and in parallel a continuously improved understanding of the relationship between load and the behaviour of structures was developed. This led to even better model concepts and correspondingly to more refined *design methods.* This process is still in full swing, the benefit, however, has become smaller in relation to the cost and effort involved. The main problems no longer lie only in structural engineering as has been recognized for some time.

The bridging of rivers, valleys and bays was from the beginning a challenge to civil engineering. The changing requirements for living, work and communication have caused enormous developments in buildings and structures. The reliable supply of large regions with water, the production and distribution of sufficient quantities of energy, the waste disposal of highly populated regions, etc. has led to exacting demands on civil works of all types. Civil engineering today is at a level at which the existing technical problems can be solved with more than sufficient quality. Do we also sufficiently well understand the overall systems of which civil works are part?

We have available today in the industrialized nations a large capacity for the planning and construction of civil works. In the last few decades we have carried out an immense volume of civil work. In a few industrialized regions the volume measured in real terms over the last 30 to 40 years has practically doubled (Fig. 1). As they age these civil works will have to be more and more intensively maintained and continually modernized. The need for civil works in these countries is to a sufficient extent covered, the demand for additional works will sink accordingly.

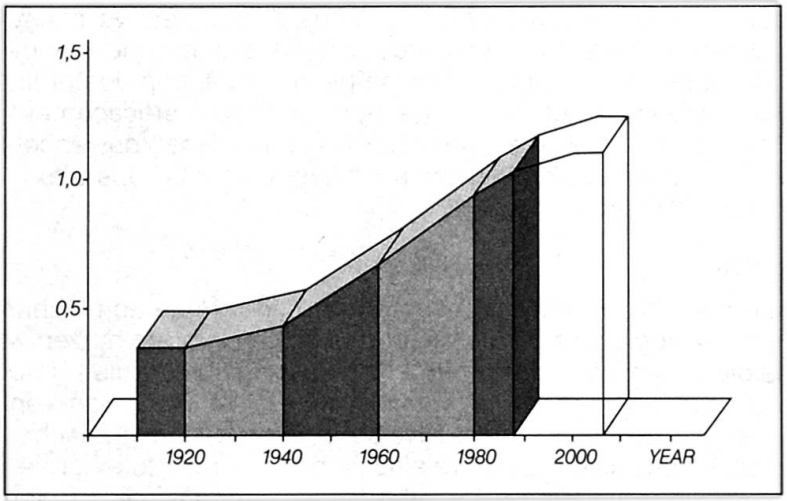

Fig. 1 **RELATIVE INCREASE IN VOLUME OF CIVIL WORKS**

In this boom phase over the last 30 to 40 years we have intensively developed civil engineering technology and brought it up to a high standard. And this in spite of serious mistakes being made time and again, time and cost schedules not being maintained, the quality and functional efficiency not corresponding to the planned objectives. This reflects the fact that *project management abilities have lagged behind the level of technical ability.*

3. Challenges of the Future

We face a challenging time in which novel, complex and decisive problems will have to be solved under time pressure. Our power of innovation will increasingly have to be turned towards the following problem areas "*management* of large projects", "understanding and improving the functional efficiency of *complex systems*" and "the optimal use of *available resources*". Civil, urban and rural engineering will have to make the most important contribution towards solving the problems which will arise through the increase and concentration of the world's population.

What actually will happen in the next 20 to 30 years? In the developed regions the population will stabilize at a level of approcimative 1.3 billion (billion $=10^9$), this means that it will not significantly increase as compared with the present level of 1.1 billion. In the developing regions it will be a different story. In 1950 the population was 1.6 billion, in 1980 already 3.2 billion; the population is expected to again double in the period 1980 to 2020 and will then stand at some 6.5 billion (Fig. 2). This enormous development is accompanied by an increasing concentration of the population in urban areas (Fig. 3).

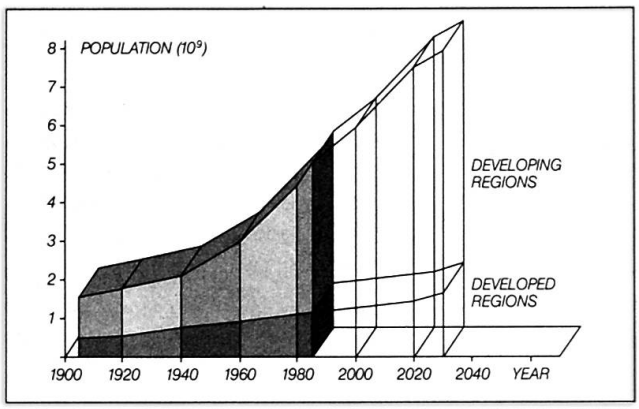

Fig. 2 **GROWTH OF POPULATION IN DEVELOPED AND DEVELOPING REGIONS**

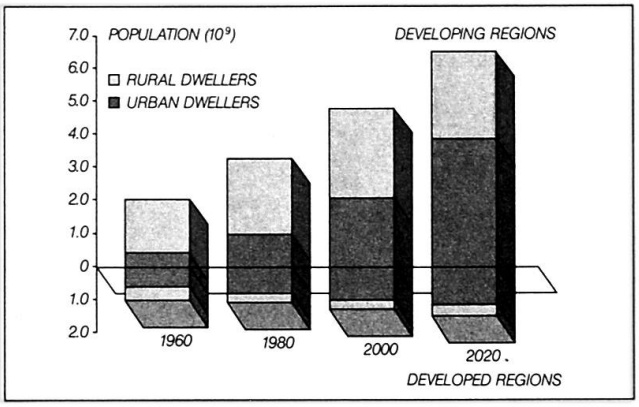

Fig. 3 **GROWTH OF POPULATION IN RURAL AND URBAN AREAS**

Although we had to some extent a grasp on this development in the last few decades, one can hardly say that for the future. On the basis of present forecasts the absolute increase in population in almost all parts of the world will be concentrated in towns. There will be an enormous influx of people from rural to urban areas incident to this increase in population (Fig 4).

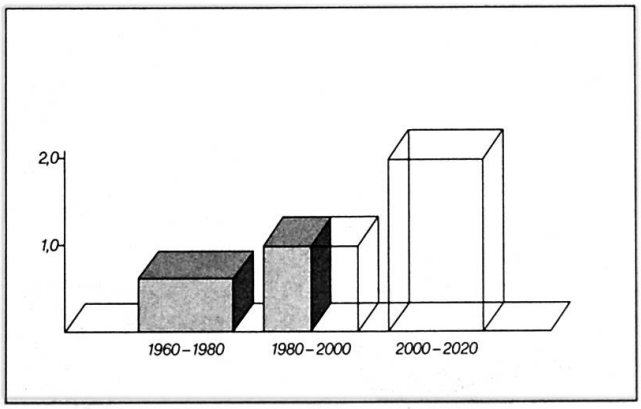

Fig. 4 **RELATIVE INCREASE OF MIGRATING PEOPLE INTO URBAN AREAS IN DEVELOPING REGIONS**

Expressed in another way, relatively fewer people must manage rural areas so that the rapidly increasing urban population can be supplied with sufficient food. For simplicity we can reduce this forecasted development to one single parameter, namely the number of new urban areas (Fig. 5). The new large urban areas with over five million inhabitants will practically all exist in the developing regions. That means: 200 to 300 new urban areas with over one million inhabitants will develop in the current 20-year-period of which about 20 urban areas will exceed-five million inhabitants (Fig. 6).

		YEARS 1960	1980	2000	2020
>1 MIO	WORLDWIDE	100	200	450	1100
>5 MIO	DEVELOPED REGIONS	7	11	12	13
	DEVELOPING REGIONS	3	19	38	77
	WORLDWIDE	10	30	50	80

Fig. 5 **NUMBER OF URBAN AREAS**

	YEARS 1960–1980	1980–2000	2000–2020
NEW URBAN AREAS >1 MIO PEOPLE	100	200–300	500–800
NEW URBAN AREAS IN DEVELOPING REGIONS >5 MIO PEOPLE	15	15–25	30–50

Fig. 6 **NUMBER OF NEW URBAN AREAS**

The future brings a real *challenge,* because what happens in the developing regions in the next decades, is not without influence on the developed regions and vice versa; the interdependence will become increasingly greater. The main problems of the future will lie in the development of *well-functioning urban areas,* in the increase in the production capacity of *rural areas* and in the setting up of suitable *transport and communication systems.* The centre-of-gravity of the problems to be solved clearly lies in the developing regions.

4. Civil Engineering and Future Problems

What is actually new about the problems of the future? At first sight apparently little; we shall as before construct facilities so that sufficient water and energy is available in urban and rural areas; plan and construct so that *suitable space* for living accomodation, work and recreation is available; we shall plan and construct *facilities for traffic,* supply, waste disposal and communications, so that the required mobility, an acceptable *environmental impact* and the necessary flow of information is ensured. However, when we take the previously described developments into account then the requirements on these projects will really have to change.

In the developed regions the demand for new civil works as a result of the stabilizing population will decrease, the existing facilities will increasingly be modified through modernization requirements, the optimal utilization of the existing facilities will in the future still be a difficult task for civil engineering.

In the developing regions there will be an entirely different set of problems. The requirement for new facilities has already greatly increased and will further increase with the enormous increasing population and its concentration in metropolitan areas. In many urban areas current projects for new facilities cannot cover the demand by far, and this situation will get worse. Simple, suitable, practical solutions which can quickly be put into practice are called for.

We have at our disposal good methods and a high standard of civil engineering technology, when dealing with planning and construction of individual facilities. The deficiencies are noticed when the *overall systems and concepts,* the *masterplans,* are examined. Here we shall be challenged again, here we must apply our innovative potential; project management and project engineering will be the most important tools (Fig. 7).

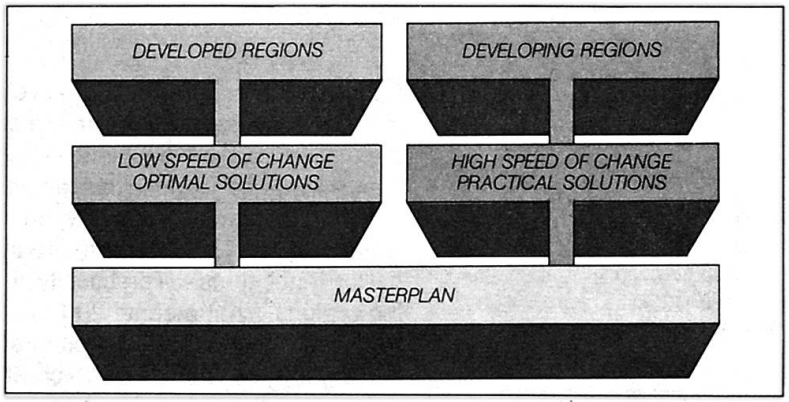

Fig. 7 **MASTERPLAN**

5. Project Management

Project management encompasses the systematic search, working out and realizing solutions for known and accepted problem situations; basically the project can arise from any particular problem area. With *project management* we guide a very complex *optimization process* between project, end-user, environment, project team and technology (Fig. 8). Certain rules are peculiar to each element, they determine the behaviour of the element. The rules of technology are well known to us, as far as planning and construction are concerned; we feel somewhat less certain about the laws which dictate the behaviour of the environment.

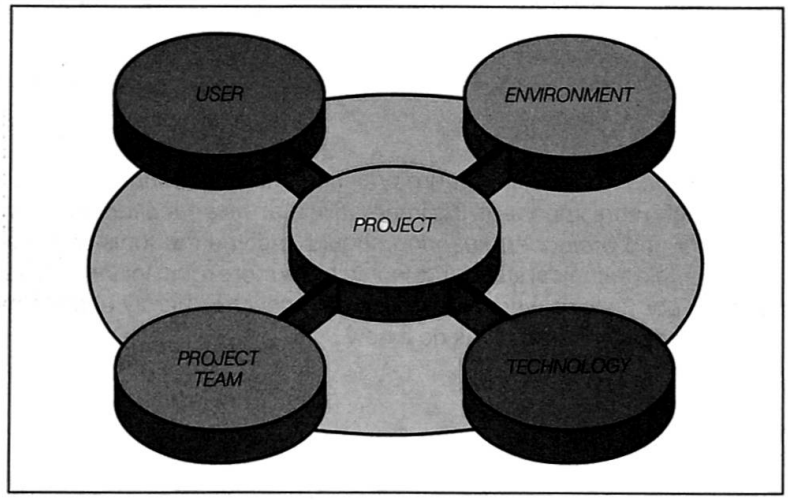

Fig. 8 ***JOINT OPTIMIZATION PROCESS***

People take up an important position in this optimization process, they are involved as end-users as well as members of the project teams. They do not behave according to the rules of technology but according to the rules of psychology and sociology.

Each group of rules has its own peculiarities, limitations and possibilities, and it requires a high level of ability on the part of the project manager to control this optimization process taking into account the various rules of behaviour of the individual elements to achieve the required objective. It is not sufficient to design only one part of a system very carefully and then to expect that another part, which includes *people,* will adjust accordingly. Here the real problems are hidden, which always leads to difficulties. As examples one can refer to the increasing criticism by society of large technically sound projects, or as can be seen time and time again the failure of a project team to complete a project on time and within budget.

We must more intensively deal with the rules of all elements in the optimization process, in order that our projects are more well balanced. We must devote *more innovation towards project management* and not to keep it at arms length, only because technical problems are easier to solve.

6. Project Engineering

Project engineering is the art of working out a project comprehensively, taking into account *aesthetics, function, technology* and *economics* and to solve the related problems. Good project engineering ensures that a project as a whole, as well as in its individual parts, fulfils the applicable criteria.

Our projects are very much influenced by technical conditions; this is specially illustrated by the large number of codes and standards that have to be applied in a project. In addition, these codes and standards exhibit a high level of detail reflecting the very high standard of present technology.

In the education of engineers this dominance of technolgy is not without its drawbacks. Our engineers are extremely well educated from a technical point of view, and exactly for that reason the understanding and interest in creative, economic and operational problems is less well developed. This situation has various effects in practice. Most projects fulfil the technical requirements very well, the deficiencies are to be found in the non-technical requirements. Our innovative capacity is involved above all in the direction of technology so that as a logical consequence the development of project engineering goes the same way. This unbalance should be

continually corrected. In education, project engineering including its fundamentals must be accorded a significantly higher priority than is the case at present. Project engineering must be intensively further developed, above all projects must be integrated into an overall concept or *masterplan.*

The development in micro-electronics, computer and simulation technology have opened new avenues for project engineering. One of the main problems of modern project engineering can be increasingly better solved, namely, to have for each project an objective-orientated and well functioning *project information system* available at the right time. With such a system the treatment of new, more complex projects can in time benefit much more from the groundwork and experience gained from previous successful projects. *Computer aided project engineering* allows a comprehensive treatment of projects, the quality of the projects will correspondingly increase.

7. New Tasks

We must re-adjust to the *changing character* of future projects. The *non-technical aspects* in the treatment of projects will become increasingly more important. It is imperative that the *education* of civil engineers is expanded and that *project management* and *project engineering* should become the tools of the engineer as much as mechanics. A relaxation of the rigid technical standards would allow more room for innovative solutions, *computer support* will create enormous possibilities whose potential up to now has hardly been tapped. Let us apply our *innovative capacity* in the right direction and let us do it now.