THE EIA PROCESS: A CHALLENGE TO DECISION MAKING ENGINEERS

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1. Introduction

George F. Sowers was a very wel known geotechnical engineer, who in the course of a 50-year professional career investigated the technical causes of several hundred failures and became increasingly aware of the purely professional value of failures, showing how our scientific understanding and technical experience sometimes are distorted or thwarted by our attitudes, habits, and procedures. He evaluated how these human attributes were involved in almost 500 cases of technical failure and published his findings a decade ago.

This paper is intended mainly for engineers who are at the upper levels of decision making as managers or leaders of infrastructure and industrial projects. It starts with an abstract of Sowers' findings as a reference framework, Sowers (1993). Afterwards, a short description of the participation of the engineer as a decision maker in the development of projects is presented. Finally, a thesis is put forward about the incidence of human factors in the environmental and social impacts of projects.

2. Sower's findings in engineering failures

Sowers paper's purpose was to examine the reasons behind the technical causes of selected failures and near failures. He defined failure as the rupture or collapse of significant parts or all of the project or where operation of the project had caused significant damage or injury to others.

As shown in fig 1, he found out that 58% of the problems or failures originate in design and 38% arise during construction. Of those originating in design, one third develop during construction and two thirds during operation; and of those arising during construction, about half originate during design and the other half during construction itself.

Based on the almost 500 case histories analised by Sowers, he found that the causes of serious problems can be separated into three categories:

- absence of contemporary appropriate technology (12%)*,
- ignorance of contemporary technology (33%), and
- rejection of contemporary technology (55%)

Absence of contemporary knowledge or technology

* Number in parenthesis is the contribution to the total cases of failure

In geotechnical engineering and in some other civil engineering specialties, abscence of knowledge has two dimensions: a) absence of data; and b) absence of theoretical knowledge or experience. Sowers figures are referred only to this second dimension.

Stage of project	*Problem origin (%)*	*Problem occurrence (%)*
Planning	**1**	**<1**
Design	**58**	**<1**
Construction	**38**	**41**
Operation	**4**	**57**

Fig 1 Problem origin and occurrences in civil engineering

Ignorance of prevailing practice

According to Sowers, ignorance of prevailing practice has three dimensions:

- "Failure arises because of faulty decisions made by persons who do not have the proper knowledge or understanding to make the decision. This lack of knowledge has two dimensions. One is the depth of knowledge, where an engineer skilled in overall decision making lacks the specialized knowledge for a particular task. A second dimension of ignorance failure involves making interdisciplinary decisions without the necessary breadth of knowledge."

  "[...] our complex problems require team effort involving both specialists and generalists who work in tandem. [...] When both generalists and specialists recognize their own limitations as well as the essential value of the other's knowledge, sound engineering results. [...] a substantial proportion of the failures from ignorance were related to arrogance ("I know it all") or intolerance of other viewpoints."

- "Another cause of ignorance is failing to keep up with new developments. Some engineers learn little after their formal education is finished."

- "Blind reliance on analytical systems is a third dimension of ignorance. [...] Too often the results appear to be credible because the raw data have been ground up and reconstructed in a new attractive form, and expressed in a way that implies great accuracy, without understanding how or why."

Rejecting of current technology

Sowers states that "[...] rejecting current technology is applied to situations where the engineer understood current technology, but failed to apply that knowledge to the situation that led to failure. Although rejections is often a malicious or negligent action, it sometimes is not. Instead, chains of circumstances, sometimes hidden in custom, the decrees of management or society, personal inadequacies, and intense pressures are largely responsible."

Sowers separates the rejection also in three categories: faulty communication, lack of liaison (no communication), and overresponse to pressures (malicious communication):

- "The best examples of poor communication are some engineering specifications. They are often written so as to protect the communicator by legal language or by limitations of responsibility. However, the protection and limitation objectives partially mask the communication. [...] Clear communication is not only good sense: it has become a legal necessity."

- "[...] Liaison involves two-way communication and coordinating action between different disciplines and project stages. It is often guided by custom or formalized by organizational structures that define responsibilities or impose rules that control communication. Sometimes these rules are designed to preserve jurisdiction, turf, and organization pride."

  "Large multiple discipline projects and those involving different political entities or large public agencies appear to suffer more from inadequate liaison than do small projects. It is the professional responsibility of the engineers to develop the necessary liaison for any project, overcoming the objection of those who thwart liaison for their personal benefit or to satisfy bureaucratic structures. This requires courage and perseverance, but the result is better, safer engineering."

- "Pressures on engineers, individually and as groups cause many of the rejections of technology that lead to serious problems and failures. [...] Time, money [...] are constraints that excite the pressures brought by individuals and organizations. They often are the ultimate forces that cause the engineer to reject current available technology. The engineer is nearly always squeezed by money and time; i.e., to a point these pressures are legitimate. The essence of good engineering is solving a problem in a timely manner, with a favorable benefit-cost ratio and with an appropriate margin of safety. However, if limited time and money jeopardize project performance and safety, that is bad engineering."

3. Human factors in environmental and social impacts of engineering projects

The core theme of the IAIA'02 Conference was "Assessing the impact of impact assessment". One of the main conclusions of the Conference was that the DAD 'old', but still currently worldwide spread, method of project management has to be disregarded in favor of the 'new' DDD one. Both methods are suscintly expressed in table 1.

Table 1. DAD vs. DDD engineering projects management methods

Project stage	DAD Method	DDD Method
1	Project design with deep engineering and economic considerations but without timely and serious environ-mental and social studies. →Decide ***(D)*** to undertake the project	Project design with equivalent considerations regarding engineering, economic, environmental and social aspects. In depth discussion ***(D)*** of the project all kinds of implications.
2	Preparation of the resulting EIS. The project is announced ***(A)*** to the environment authority and to the public.	Decide ***(D)*** to undertake the project and present the EIS to the authority for approval.
3	Defend ***(D)*** the decision taken against any observation or objection by the authority or the public.	Deliver ***(D)*** the project (construction, operation & maintenance) making sure that the design considerations are fulfilled and monitoring the environ-mental and social impacts.

Evidently, the systematic application of the 'old' DAD method has produced all kinds of environmental and social impacts, locally and regionally, with global reverberation by cumulative effects. The impacts before the 1970s can be almost fairly attributed to ignorance by the decision makers. But not anymore since that decade.

We can use Sower's extremely valuable information in order to visualize the human influence on current and future environmental and social impacts of engineering projects. It can be said straightforwardly that the human influence can be divided into the same three Sowers' categories:

absence of contemporary appropriate technology ignorance of contemporary technology rejection of contemporary technology

And that the reasons he found as the main causes of failures in civil engineering works are the same behind the inadequate or absent consideration of environmental and social factors during planning, design, construction and operation of development projects:

a) Persons without the appropiate background and/or understanding to make decisions take them and they turn out wrong

- A person well prepared for taking decisions in a particular field lacks the specialized capacity needed in another field

- People take multidisciplinary decisions without the appropriate breath of knowledge

b) Lack of continuing education

c) Blind faith in computational results

d) Communication failures

Taking into account the academic curriculum of most engineering careers, it's easy to see that those engineers with status or power to decide over planning, site selection, construction and/or operation of development projects, need the contribution of specialists on other fields in order to make their job properly and assign equivalent weights to economic development, environmental protection, and public participation and social development.

This implies the need for reinforcing the engineer capabilities to interact with professionals and specialists in other 'distant' disciplines like: biology, ecology, archeology, anthropology, sociology and others. As Sowers pointed out, we must leave apart our characteristic arrogance and intolerance when a project is built; otherwise, it is possible that we might be solving the wrong problem. "A good engineer has a feel for the appropriateness of his solution from the narrowest technical details to the broadest concepts of planning", Peck (1969). And a good engineer cannot trust blindly the words of consultants on other fields; he or she must be knowledgeable and have enough engineering judgement so as to ponder others' opinions, maintainig always an integral perspective of the project.

The typical communication problems among engineers –they can understand other engineers quite easily but not other people- must be overcome as soon as possible. Good communication is particularly very important in environmental impact assessment, since an EIS is both the environmental calculus sheet and the document that states the engineering, environmental and social feasibility of a project; it also serves simultaneous technical and legal objectives. So, depending on the terminology, precision, depth and clarity of an EIS, a project may be approved, refused or face opposition, and in extreme cases the person responsible for the EIS may be found guilty of putting forward false information.

There are more and more cases where the project developers must interact with the public in order to explain the project, answer questions and make clear its benefits but also its environmental and social impacts, i.e., to explain what must be written in the EIS. Currently the Mexican environmental legislation is rather ambiguous about public participation but, without any doubt, the community weight on project decisions will grow in the future. In countries like the USA, Canada and the EU members, for instance, public involvement starts at the project planning level (scoping); this will occur sooner than later in Mexico and other countries with less environmental protection experience. Thus, engineers must be well prepared to put forward the scientific underpinning of a project; this means that they will have to broaden not only their written and oral communication skills but also their dialogue capacity.

Certainly money and time pressures take their toll of the quantity and quality of environmental and social studies that are done for a specific project. It is the duty of the engineer in charge of the project to procure the needed economic and human resources in time to undertake those studies. The engineer has to consider that, for big projects in enviromentally sensitive areas, the environmental studies require at least one year to be done in order to observe the seasonal variations of living organisms behaviour. An engineer that doesn't agree with this statement, would design a dam spillway with less than ten years of hydrological data of the river catchment history, not to say with less than one year of information?

In summary, the 'solutions' to the four deficiencies marked as *a)* to *d)* mentioned above have already been put forward by Sowers (1993):

- Engineers must abandon their arrogance and intolerance regarding other points of view.

- Both generalists and specialists should recognize their own limitations as well as the essential value of the other's knowledge.

- Engineers have a professional responsibility to engage only in tasks for which they are properly qualified.

- Precise communication is essential for the work of engineers. Communication is a skill, so it can be learned either at the professional school or by attending continuing education courses. The same can be said about integral project appraisal, environmental management and EIA methods.

- Formal and infromal rules that interfere with sound management of projects, designed to preserve jurisdiction, turf, and organization pride, have to be turned down.

There are clear differences between environmental problems, social problems and civil engineering failures. Environmental problems can be originated in any project phase but are usually concentrated in the planning and design stages; and they usually show up only when the project begins operation, although in some cases they can be detected during construction. This statement is made visible by the broad arrows in fig 2: environmental impacts show up during operation but their origins can be placed in the planning and design phases of projects.

On the other hand, social problems may turn up at the planning phase itself, fig 3; this happens when a project matures very slowly and faces opposition by at least a certain sector of the public, as has been the case in Mexico with some development and tourist projects well publicized in the country and abroad. This is consistent with the Interorganizational Committee on Principles and Guidilines for Social Impact Assessment (2003) appointment: “The social environment is different than the biophysical environment because it reacts in anticipation to change ...”.

A bad site selection from the geotechnical point of view, for example, can be solved by changing the type of foundation or reinforcing it during construction. But a wrong site selection decision from the environmental perspective doesn’t show up until the project is operating. Then it is impossible to remedy the environmental impacts; at best they can be reduced but at a very high cost.

Finally, by comparing figs 1, 2 and 3 it becomes evident how differently a decision making engineer has to look at a development project nowadays compared to only a few years ago: in the first figure there are only four arrows, the number grows to seven in the second one, and to ten in fig 3.

4. Conclusion

Engineers must realize that a well designed project in terms of its functionality is not a good project unless it fits into the environmental and social surroundings of the site where it is to be developed.

5. References

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6. Acknowledgements

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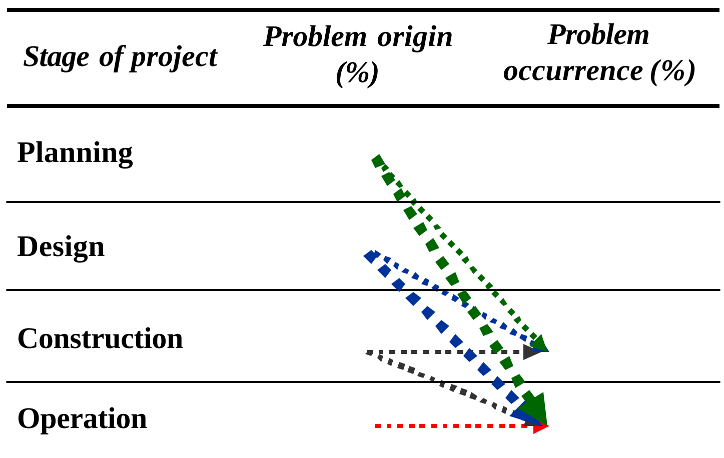

Fig 2 Origin and occurrences of environmental impacts

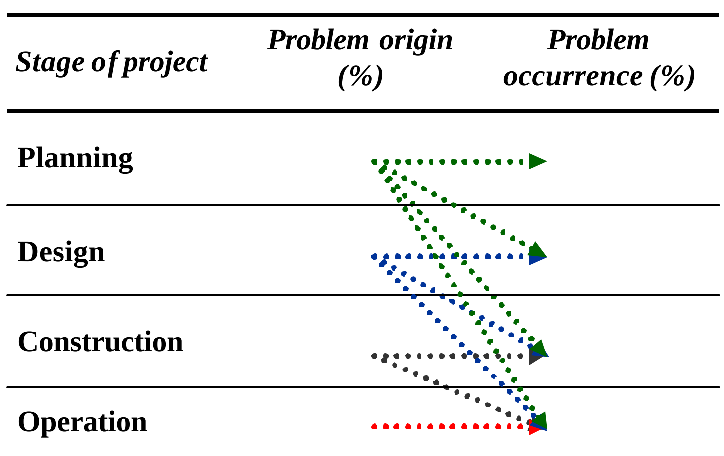

Fig 3 Origin and occurrences of social impacts