Considerations About the Integration of Geological and Geotechnical Studies Applied to Engineering Projects and to Environmental Impact Assessment in São Paulo State, Brazil

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Bitar Omar Yazbek, Sofia Julia A.M. Campos, Amarilis Lucia C.F. Gallardo, Braga Tania de Oliveira, and Caio Pompeu Cavalhieri

Abstract

This paper brings to discussion the quality of the integration of geological and geotechnical studies that is achieved for the purpose of engineering projects and for environmental impact assessment. The integration of these studies in different phases of a development is analyzed, in order to aid, both at the same time and importance, the building of suitable constructions under the engineering and environmental sustainability points of view. We expect to contribute to a better understanding of the form and the current stage of this integration, especially in relation to the effective improvement from the geological and geotechnical knowledge acquired in both application fronts. Observations accomplished in infrastructure constructions were taken as reference, featuring roads, railways, pipelines, mines, development lands and landfills, accomplished in the last years in the state of São Paulo, Brazil, and submitted to the Environmental Impact Assessment (EIA) process, a tool that has helped enhance the integration of geological and geotechnical studies generated in both fronts. The results show that signs of integration exist but there still is a certain separation. Some technological and management challenges have been shown in a way to better improve the integration of the geological and geotechnical knowledge in new developments.

Keywords

Geological and geotechnical knowledge • Environmental impact assessment • Infrastructure constructions

194.1 Introduction

Studies involving geological and geotechnical knowledge are usually distinguished based on two application fronts: one aims at certifying the technical viability of engineering projects and at subsidizing construction and operation; and the other, a way of dealing with the environmental impacts and demonstrating the environmental viability.

In relation to engineering projects (which include a conceptual project, basic project and executive project), the required geological and geotechnical studies are linked to the challenge of predicting the interaction construction-physical environment behavior in order to ensure the execution of a safe, operational and technically suitable construction. Under the environmental viability point of view, and also trying to predict the interaction construction-physical

B.O. Yazbek · S.J.A.M. Campos (✉) · A.L.C.F. Gallardo · B.T. de Oliveira · C.P. Cavalhieri
Institute for Technological Research of São Paulo State, Sao Paulo, SP, Brazil
e-mail: scampos@ipt.br; labgeo@ipt.br

B.O. Yazbek
e-mail: omar@ipt.br

A.L.C.F. Gallardo
e-mail: amarilisgallardo@usp.br

A.L.C.F. Gallardo
Uninove, EPUSP, Sao Paulo, SP, Brazil

G. Lollino et al. (eds.), *Engineering Geology for Society and Territory – Volume 6*,
DOI: 10.1007/978-3-319-09060-3_194,

environment, the highest concern is to evaluate the adverse future consequences in relation to the environment.

Therefore, although there are different focuses, approaches and tools, the geological and geotechnical studies required in both application fronts include essentially the same object of analyses (the interaction construction-physical environment), a fact that highlights the importance of the integration accomplished in both fronts. Among the aspects that could be analyzed in relation to these studies, the technical cooperation between the involved teams in their preparation in each front and the effective integration of the geological and geotechnical knowledge developed in both applications are discussed. This is not only in favor of having a larger team and rationalization of resources, but also in the way of offering a refined and major comprehension about the construction-physical environment interaction.

194.2 Objectives, Materials and Methods

This paper aims at analyzing the relation established between geological and geotechnical studies elaborated for an engineering project and for environmental impact assessment and management, starting with the environmental impact assessment (EIA) concerning the same projects.

In order to reach the expected objectives, a bibliographic review was carried out about the issue. Studies performed for same project that approach geological and geotechnical knowledge in both application fronts were considered, as well as observations about the accomplished studies for engineering projects, and environmental studies related to cases in which the authors of the current work had some interaction, either supporting the environmental entity or the developer, in different stages of the development. Infrastructure construction cases were submitted to EIA procedures and the environmental license in the state of São Paulo (southeastern Brazil).

Only observations on large development cases and from different sectors were taken as reference, as well as the relatively recent ones back to the last 10 years, reaching a number of 41 developments (17 roads, 1 railway, 1 conveyor, 1 pipeline, 6 mines, 1 estuarine drainage channel, 4 development lands and 10 landfills).

In order to do the analyses on the basis of observations during each development and also by reviewing data and information, the AIA/EIR was considered in each case and the Basic Environmental Plan (BEP), as well as the denominated Construction Environmental Plan (CEP), the latter formalized only in some developments. Regarding the engineering projects, differences according to each case and casual checking of the conceptual project, basic project and executive project are pointed out in relation to specific features available.

We expect to identify elements that characterize the integration of the geological and geotechnical studies performed in both application fronts. One characteristic to be investigated is the context in which the integration occurs; in other words, the different stages of the development. Another characteristic is the various moments throughout the duration of a development in which the integration of the knowledge obtained in both application fronts tends to happen. Thus, it is essential to verify the relationship between the frequent stages in the preparation and execution of engineering projects and in EIA. A third characteristic is about the way which the cooperation and/or contribution between the technical teams occur, as well as a possible integration between the geological and geotechnical studies applied in both fronts.

Considering these characteristics, the level of integration reached between the geological and geotechnical studies for engineering projects and for environmental impact assessment and management were analyzed for each case. To have the result and the level, individual analyses were done, ranking the developments according to three levels (low, medium and high). The results were compiled in a chart, beginning with the predominant analyses. After making the observations for each case, the results are discussed and a summary of the most important conclusions is presented, expecting to cooperate to a first reflection about the theme.

194.3 Overview on the Integration of Geological and Geotechnical Studies

Although geological and geotechnical studies are found in the national and international literature, the integration of such studies in both application fronts is a topic that is hardly ever considered, especially when it comes to the analysis of the same development undergoing an EIA process.

Some works deal with the theme, which can be distinguished by physical environmental characteristics in engineering projects and in the environmental studies. Both are usually treated separately, the characteristics referring to geological and geotechnical studies performed on both fronts. Anderson (2006) states that many of the products that come from detailed geological and integrated mappings have been used as primary database to the future environmental planning of the North American state of North Dakota. Many unfavorable geological conditions are found, as clay deformation in soils of lacustrine origin, inappropriate supportability and presence of mass movements, which are among the most important causes of geological, geotechnical

and environmental problems. There is also the difficulty in defining the railroad grade and the fact of recent and repeated seasonal floods in urban areas. The importance of the relationship between environmental geology and the geological processes in the physical environmental understanding, as well as the influence of geology in the engineering processes, especially regarding infrastructure constructions, are scenarios that must be taken into account together (Bell 2008). The author examines the probability of geological risk aspects, the importance of water and soil resources, environmental impact from mining, waste disposal and pollution in the environment, as well as many other aspects that result in environmental problems.

Concerning the integrating methods used, it is believed that the complex project elaboration implies the participation of several specialists, with different degrees and viewpoints. Therefore, the relationship among these specialists may become problematic in practice. Aiming at contributing to the effectiveness in the conception of large projects, Grebici (2007) developed a model that integrates different methods of cooperation, of organizing the process and of conception of other intermediate products and their adequacy to the development purposes, stressing out the importance of developing proper methods of cooperation. Indeed, many negative environmental impacts may be prevented or at least have its magnitude dramatically reduced by having effective cooperation between designers and environmental teams (Sánchez 2006). Sánchez and Hacking (2002) also emphasize the importance of linking the EIA to the Environmental Management System (EMS) of a development, using the studies conducted in order to elaborate the EIA/EIR for the construction management, operation and deactivation of developments, which in practice does not happen.

194.4 The Necessary Integration

The geological and geotechnical knowledge acquired or generated in engineering projects is also relevant in order to assess and manage environmental impacts and vice versa. However, it is possible to notice that physical field studies conducted in both application fronts are developed separately, commonly with distinct professionals and technical teams.

The demands associated with requirements that are specific to each context, such as the object and the scale of the generated cartographic products, contribute to such separation. While engineering project studies tend to focus on the knowledge of the underground physical environment and on scale detail, environmental geological and geotechnical studies aim at the whole understanding of the geodynamic surface, where possible negative consequences of a certain development tend to be highlighted by an environmental viewpoint. It is worth mentioning that it is regarded just as an aspect that is commonly observed rather than a rule. There are some studies that reveal exactly the opposite, as a result of specific demands. The scale is presented as a differential in some cases only. Also there are some situations where the impact is distinguished in details, as it happens in the cases of interferences in the groundwater related to mining, landfills and allotments. The situation where the connection between the studies conducted in both application fronts is noticeable refers to cases involving underground projects such as road or rail tunnels, in which the knowledge developed in each one is often useful to the other one. It is understood that the subsurface knowledge is as important as the surface one in projects with relevant interventions either on the ground or in the groundwater.

Table 194.1 Relative degree of integration of geological and geotechnical studies conducted for the purpose of engineering projects and assessment and management of environmental impacts, as overall prevalence observed in relation to all cases, according to the project phases proposed in IBAMA (2009)

Studies aimed at engineering projects		Studies aimed at assessment and management of environmental impacts			
		Environmental planning tools		Environmental management tools	
Project level	Engineering studies and projects	AIA/EIR	BEP construction	CEP or EEP	EMP, EMS or BEP construction
Viability or pre-project	Conceptual project and feasibility studies	H	M	NA	NA
Project development	Basic project	M	M	L	L
	Executive project	L	L	M	L
Installing, building nd/or assembling	Executive project updated	L	L	M	L
Operating	Functional plan or operational project	L	NA	NA	M

Note EIS/EIR—Environmental Impact Study/Environmental Impact Report; BEP—Basic Environmental Plan; CEP—Construction Environmental Plan; EEP—Environmental Executive Project; EMP—Environmental Management Plan; EMS—Environmental Management System. L—Low; M—Medium H-High; NA—Not Applied

Table 194.1 was obtained using the cases discussed and the analysis of each one of them concerning one of the three ranking levels (High, Medium and Low), related to the integration of geological and geotechnical studies conducted with engineering projects, and assessment and environmental management purposes.

194.5 Conclusions

The results obtained with the completion of this study suggest the following conclusions: (**a**) although with different approaches and tools, both geological and geotechnical engineering projects as environmental studies include essentially the same object of analysis. This suggests the importance of the integration between geological and geotechnical studies carried out in both fronts of application; (**b**) geological and geotechnical studies conducted for the purpose of an engineering project, also when used in EIA, tend to facilitate the identification of significant environmental aspects and impacts. Likewise, geological and geotechnical knowledge acquired or generated during the EIA process, including environmental management to be carried out in phases of installation and operation of projects, has also been proven as useful to engineering projects. However, in view of the potential for integration, it is observed that much can proceed. There are signs of cooperation between the technical teams as well as integration between studies applied to engineering projects and the assessment and management of environmental impacts, but a certain separation still predominates, which is a possible situation influenced by the specific demands required in isolation by developers in each front; (**c**) the integration provided by the temporal and content matching in the achievement of engineering and geoenvironmental studies required for a project, due to the linking of EIA to environmental licensing, has been observed, but it is still well below the potential level. The fact that some new developments in the degree of integration shown indicate relatively higher situations can be better obtained with a larger number of cases; (**d**) both geological and geotechnical knowledge acquired during the feasibility stage and development of a large-scale engineering construction often fail to be fully used during the phases of installation and operation of such projects, a fact highlighted by the frequency degree of integration considered low and average these stages, which undermines the effectiveness of systematic planning of works and environmental impact assessment.

Finally, not only a greater synchronization among the activities of each context is required, but also actions and attitudes that facilitate the proximity of technological contents. It often seems that it depends more on the perception of professionals who lead the engineering projects, in order to foster the effective integration with environmental teams. The current challenge is to encourage cooperation of different perspectives on the same object and increase the exchange of knowledge acquired and generated in the stage of feasibility, development, installation and operation of a development, and these results could be achieved by approaching geologists and engineers involved in both fields.

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