Education of the risk in Civil engineering

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ABSTRACT: This paper presents the principle of the risks assessment in Civil engineering, a pedagogical program in INSA LYON and the example of the LYON' City : ground movement risk management.

1 INTRODUCTION.

The engineer of Civil engineering has to face risks of multiple natures in the exercise of his profession: geologic risks, design risks, construction risks, financial risks, starting risks, risks of management of the works (life time).

Thus, in the programs of education, it is advisable to bring into the consciousness of the students the notions of vocabulary, perception and estimation of the risk, in order to allow them to estimate the risks with a full knowledge of the facts so they would prevent and reduce them at most.

In this regard the teaching has to present as much the grasp methods of the danger problem as well as the hazards typology and the methods of prevention and protection to systematically face up to these multiple risks. The multidisciplinary and complex features of the study and the management of the risks in Civil engineering need to be underlined.

Risk teaching in Civil engineering distinguishes various discrimination's levels:

- Definition of the studied system;
- Identification of the unwanted events;
- Identification of the causes of dangers;
- Estimation and evaluation of the risk;
- Definition of the criteria of acceptability

We will base on the presentation of the educational program developed in the INSA of LYON by taking examples from those described above in the management of the risk of ground movements in the City of Lyon.

2 THE TRAINING ON THE NATURAL AND TECHNOLOGICAL RISKS IN THE INSA:

This pedagogical choice is intending for the 5th year students, at the end of their engineering formation.

It is called "transversal" because it is aimed at the students of all departments: Civil Engineering, but also Mechanic, Energetic, Informatic... Ms. Irini DJERAN-MAIGRE, Civil and Urbanism Engineering Professor, coordinate this class.

In the group of 25 students, 60% are from Civil and Urbanism Department and 35% are from Environment Department.

This optional course emphasizes the difficulties of hazard risk and safety measures distinguishing in the natural and technological field.

Specifics problems of Civil Engineering are treated: landslides, avalanche, flood, earthquake…For these natural hazards, the Civil Engineer intervene to identify and define the territorial presence of risks or to build adjusted and efficient protections and/or constructions. He can also work at an administrative level in the risk assessment.

The student has to prepare himself to act as a social participant and to intervene in the politic field. Indeed the engineer's position may be variable: it could be a technical and scientific assistance in political decisions, but sometime, it could act as a technical justification of the political decisions made in the risk assessment.

2.1 *Pedagogical organisation.*

This course presents

- analytical and methodological ideas concerning the risk discrimination, care and prevention.
- hazard typology and safety techniques in different fields.

The students have to choose a concrete project for a two or tree person team workshop session.

Teachers are from INSA for the general pedagogic set. It could also be people who work in the field, and who bring their valuation in the risk knowledge, safety technique settings, accident management and thinking about sociological impact of risks and prevention policy.

2.2 *Methodology: example of avalanche*

A specialist in the field communicates to the students the current knowledge on the triggered mechanism of avalanches, the typology of their geographical distribution, the dangers for people and human installations. The natural chance is translated into terms of energy, trajectography and power of destruction. Considerations of local policy concerning land organization are approached.

Then, a specialist of Civil engineering comes to describe the types of constructive parades: nets, walls or relief modifications. He gives the elements of sizing in terms of materials and structure which could be opposed to the power of avalanches, to prevent them or to change their way.

The professors and the professionals then propose study cases to the interested students: places where the chance exists, where the vulnerability is identified and where it is necessary to conceive a prevention plan. The students inform themselves on all the constituents of the problem. They possibly go on the spot. At the end of their study, they propose the solution which has been possibly operated, made a critical discussion and propose better alternative ideas.

They determine new protection settings, land policy modifications, creation of protective structure of which they insume the conception, the justifications and the sizing calculations.

This work serves to write a 20 to 30 page report that is then exposed during 20 minutes in front of teachers and experts for a contradictory evaluation.

3 THE CITY OF LYON IN FRONT OF GEOTECHNICAL RISK: AN EXAMPLE WHICH CAN BE DECLINED ON AN EDUCATIONAL MODE.

One of the subjects which are presented by professionals is the prevention of the risks of ground movements in the City of Lyon. This example contains all the elements which allow to illustrate the method evoked in the first part of this article.

During the training, a conference is held by municipal civil servants, and a visit in the field allows the students to well know the dangers and the principle of the protective actions developed by the municipality.

3.1 *Definition of the studied system ...*

The territory of Lyon is marked by a damaged topography, unconsolidated detritical geology and the effects of a multiyear urbanization. The result is a risk situation that sometimes causes very deadly accidents (1930, 1932, 1977), which could be very penalizing for the social life and public or private finances.

The city of Lyon is built in the confluence of the Rhône, one of the main rivers of France, and the Saône, its big tributary from North-East. The height of the city varies between 170 m on banks to 250 m for the hill of North, Croix-Rousse, or to 300 m for the South hill, Fourvière. Hillsides are sometimes vertical on 30 or 40m of height. In this context, the urbanization exists since the Roman period. Modern works go alongside to very ancient buildings on a geology very reshaped by all these successive interventions. The relief itself was modified to allow road or building constructions at the feet of reliefs. Numerous works of retaining structures or veneering result from this reshaping of various historical periods. Subterranean galleries were dug to get the water of hills. The most ancient are Roman.

In this context, the stake for the municipal people is the inhabitant's security: to protect them from the appearance of a large-scale disaster, to protect the users of the public space against any consequence of badly executed public or private works, to check that construction sites take place without damage for the workers nor for the neighbours.

3.2 *Identification of the unwanted events.*

From the observation of the past accidents, a list of the chances can be established: landslides, rocky collapses, in-rushes of water, fall of breast walls or veneer, muddy castings, ground collapses, subsidence, disorders on adjoining...

The most dramatic events are fortunately rare, but numerous events occur periodically. The pluviometric crises reveal all the potential weak points of the urban territory. In 1983 for example, 20 collapses of diverse nature and importance had taken place in the same night after a rainy period (350 mm of water in one and a half month) and at the end of a day of intense haste of 50mm. The result was a typology of "superficial" geotechnical accidents, involving layers of elevations or colluvions, dilapidated or badly sized works or still unconsolidated subterranean cavities. Other accidents originate from the ageing of the system of drinkable water pipings: leaks can cause real muddy flows or knock down walls in the slopes. Generally, the large-scale geologic accidents with deep surfaces of gliding are not observed.

3.3 *Identification of the causes of danger …*

From the study of the causes of the chances, the mapping of the zones where the structural factors that could be responsible for accidents are present was able to be realized, using a multicriterion methodology. The concern is to anticipate the accidents by determining to best the places where they could occur and the circumstances which would activate them.

The City of Lyon made several decisions:

- Establishment of a municipal department dedicated to the accident management and to the risk prevention.
- Forming of an advisory committee represented by external experts (geologists, geotechnicians, territorial agents)
- Cartography of the strong or attenuated risk on the communal land.

The setting of this municipal structure obeys to the will to discern the causes of accidents and to act on these causes.

The cartography was the object of several methodological stages. First the statement on the ground of all the risk indications: dilapidated or unsuitable constructions, badly drained wet zones, underground passages in poor condition, badly led works …

Then the conceptualization of these sector-based observations to generalize them to the whole territory from similar conditions: 1st manual cartography of the city of Lyon in 1982. In 1994, an automatic multicriterion cartography (topography, geology, retaining structures, galleries) is realized and refined in 2002 thanks to a more sophisticated ground digital model.

Thanks to these documents, the municipal department has a legitimacy at its disposal for its intervention.

3.4 *Estimation and evaluation of the risk …*

The preventive practice of the City of Lyon is notably based on the examination of the documents of urban development like planning permission in risk zones. A first estimation is realized: it leads to measure the risk induced by a project on the territory where it establishes, or the risk to which it exposes itself due to the conditions of its environment (geotechnical perimeter).

The monthly meeting of the experts and the technical department also allows clarify the nature and the reality of these risks.

Their role is to understand the consequences of an operation of town planning regarding to the stability conditions of a site, grounds and constructions. They have to pronounce on the means announced in the study, on the survey of the ground already realized to say if the knowledge of the place is sufficient and if the techniques of retaining structure, excavation and construction will guarantee safety.

3.5 *Definition of the criteria of acceptability …*

Once the stakes defined, the community has to explain its degree of requirement for the guarantee of safety. This one is modulated according to the importance of the project, stakes and predictable risks. It always happens that events surprise the experts, that construction sites do not take place in best: and nevertheless the conditions of admissibility of the town planning operations are clearly shown. As for the natural events bound to the climate or connected to weakness of the basement, they keep their part of unavoidable events.

The conditions of acceptability are collectively established during the meetings of Committee that pronounces itself on the adequacy of the answer proposed by the petitioner of a project, through the study of ground, the project of foundation, retaining structure, drainage, etc., to satisfy the insertion in a site.

In the facts, the City of Lyon imposes on the private individuals to develop all the average possible by carrying to their knowledge, by orders, the points to which they have to conform, both at the level of the maintenance and at the level of the constructions or the developments.

These requirements are restricting and expensive. The role of the administration is to present technical requirements that have to be adapted, justified and nevertheless acceptable by the citizens.

This example shows the complex relations that exist between administrative and political actors, scientific and technical actors and finally the owners and the authors of projects. In Lyon, the consensus exists so that the means of prevention are applied.

4 CONCLUSION.

The education of the risk in Civil engineering such as approached here helps the students to learn several levels of analysis and decision:

The clear identification of the threats and the stakes domain by domain

The knowledge of the phenomena that could drive to risks, the knowledge of the techniques to face up to the dangers and to protect the persons and the possessions.

The proportionality between the means and the stakes.

Other aspects can also be approached, in a more mathematical education. They concern the quantification of risk in the constructive operations of the Civil engineering. This approach where intervenes the probability theory applied to the sizing of the

structures or to the calculations of stability is less descriptive, more predictive, and rather reserved for the conception of the works and for the risks they incurred than at the notion of the risks incurred at the level of the law and order because of fortuitous events concerning the public safety.

The teaching of the management of the risk also has to explain to the students the possible evolution of management policies, in France at least, to a more liberal conception where the risk management is sent back to the private actors.