ANALYSIS OF THE RISKS GENERATED BY CONCEALED WORKS IN THE FIELD OF CONSTRUCTION

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Abstract: *This paper refers to construction works that become concealed, as well as to the dangers and risks they generate; it also focuses on the potentially negative consequences of concealed construction works on the quality and safety of buildings. This is a constant, critical issue which requires prevention methods, thorough research for the risks identification and monitoring by all stakeholders directly involved in the construction stages. This article describes and proposes an original method of qualitative and quantitative risk analysis for concealed construction works we define as the estimated probability-impact risk diagram method.*

Key words: *Construction quality and safety, risk analysis, concealed works, quality management.*

1. GENERAL CONSIDERATIONS REGARDING THE DANGERS AND RISKS THAT CAN AFFECT THE QUALITY AND SAFETY OF A CONSTRUCTION

The wide field of constructions is of particular importance and determinant in all activities of production, trade, transport, services, housing and any other human activity.

Construction safety, reliability, sustainability and quality in the broadest and most profound sense of the quality concept and management of constructions are constant concerns for all those involved, interested in and responsible for building safe, functional constructions, easy to maintain and with a lower risk for beneficiaries, investors, users or those responsible for their concept, design, execution, management and maintenance.

This article is the result and synthesis of the detailed study of concealed works and the risks they generate on constructions, a study conducted within the Doctoral School of the Technical University of Civil Engineering Bucharest.

Particularly for the case of our article, namely that of constructions, a hazard refers to a material factor or certain conditions of a physical, biological, chemical or environmental nature that may be the cause, and can determine an adverse effect on the quality and safety of constructions, beneficiaries, users or its occupants.

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The adverse effect should be understood as any situation, change or random occurrence on the form, structure, quality or functionality of the construction that may lead to something negative, undesirable, dangerous or injurious to both the construction itself and the persons associated with it, irrespective of the nature of this connection.

Risk is essentially a possible hazard and can be defined as the possibility of reaching a situation of distress, i.e. a situation where an adverse event occurs or adverse events occur in relation to a defined normality.

A certain risk can be defined, characterized and quantified by its two fundamental valences, namely:

- The likelihood of occurrence of the concrete effect of a hazard, that is, the possibility of occurrence of a situation or incident that endangers the integrity, security, quality or safety of a thing or a being;
- The possible and likely impact of the actual effect of the danger on that thing or that being, an impact that is usually expressed by its intensity or magnitude, that is, by the quantified gravity of the adverse event produced.

The dangers and risks that may affect the quality, safety, reliability, maintenance and function of a construction have been analyzed taking into account three fundamental building-specific characteristics in relation to all other products resulting from the application of manufacturing technologies, of the vast majority of other production areas, namely:

a) The unique character of a product of any construction and the lack of a repetitive production line, as it is in the manufacture of other products;
b) A fixed position, both during the execution and throughout the period of existence and use of the construction;
c) The existence of works that become concealed after the completion of the construction and the results of these works that

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Mrs. professor Niculiţă Lidia graduated from the Faculty of Machine Building Technology at the Polytechnic Institute of Bucharest, taking her degree of engineer in 1972, then following doctoral studies, and in 1979 she obtained the scientific title of doctor-engineer in the field of Engineering Sciences - Industrial engineering.

In 1972, she started as a trainee engineer in the technological design; from 1976 to 1999, she worked in the Machine Tools and Aggregates Company in Bucharest. In the period 1999-2002, she held the position of Principal Scientific Researcher, Grade I - Director of the subprogram and since 2001, she is professor and scientific coordinator in Industrial Engineering at the Technical University of Civil Engineering Bucharest - UTCB.

Niculiţă Lidia has signed 19 university books, over 43 guides and technical books, 56 papers presented at national and international conferences, of which 30 national conferences published in the proceedings and 26 international conferences published in proceedings and 32 articles published in national and international publications, of which 12 publications recognized ISI.

Niculiţă participated in 64 research projects as project manager or responsible for the project, out of which 14 won in a competitive system (1 European and 1 POS CCE, Priority Axis 2) and 26 research projects in quality member of the team, of which 10 won in a competitive system (3 European projects).

Professor Lidia is a member of the Association of Fine Mechanics and Optics of Romania, the Romanian Society of Mechatronics SROMECA, the World Scientific and Engineering Academy and Society, founder of two National Quality Organizations, QMS Auditor of the Quality Certification Body, SRAC and member of the editorial board of the magazine Access to Success, the magazine indexed by BDI (ISSN 1582-2559).

can not be directly observed, but by special means, expensive and most of the time invasive or destructive.

These three characteristics of the constructions determine specific approaches to quality control, quality management and risk analysis that can affect the quality and safety of the construction.

The quality and safety of constructions refer to their specific defined components such as foundations, vertical and horizontal strength structures, roofs and possible annexes, the necessary installations to ensure the functionality of the building according to its destination, as well as to the occupants and users of the construction, to its equipment and production facilities or to its utility suppliers.

In order to achieve a quality, safe and durable construction, both for those directly involved, but equally for all individuals and legal entities interested, it is necessary and important that throughout the design, execution, use and maintenance phases dangers and risks are minimized.

Risk assessment is the specific risk management activity that estimates and quantifies the possible losses of quality of the infrastructure or superstructure of a construction, as well as the effects on its safety, due to deficiencies in design or an inappropriate preparation of the execution conditions of the works, and especially in the practical part of execution of construction works. Risk assessment is especially important in the case of concealed works when natural calamities occur, under special weather conditions or if generated by other dangers.

Some of the most important sources of risk for a construction are the so-called "concealed works". These works should be given a very special attention in all phases and stages of the construction, as they may have negative, sometimes major effects on the quality, safety and effectiveness of the building's functionality.

Rece Laurentiu

Professor Rece Laurentiu attended the studies at the Polytechnic University of Bucharest, taking his degree in 1983, then following doctoral studies, and in 1999 he obtained the scientific title of doctor-engineer, in the field of technical science, the specialization of machine building technology.

In 1983 he started as a trainee engineer, in 1987 he started working as a research and design engineer at UTCB, in 1993 he became the head of the works, in 2000 he began his activity as a university lecturer and from 2004 until now he is a professor.

Professor Rece has signed over 70 published papers, including: 8 university books (1 treaty, 3 courses and 4 laboratory tutorials), 20 articles in specialized journals and 43 papers published in volumes of scientific events.

During his professional activity, professor has participated in more than 35 scientific research contracts, out of which 19 national / international grants (14 as responsible from UTCB or project director, of which 1 international and 13 national), as well as POSDRU projects of university management.

Rece Laurentiu is the author of 5 inventions and innovations, national and international, of which an innovation presented in 1985 called "Adjustable superfinishing device with abrasive blades, adaptable to the lathe" and 4 patents "Vibro Inertial generator with continuous variation of static momentum" (2005), "Motor vehicle luggage rack with tilting cross bars "(2014), "Massage bathtubs "(2016) and "Modular precast metallic balconies applicable to buildings and process for making the same" (2017). Rece Laurentiu is also a Type A Expert at the UTCB Doctoral School, Type B Expert for UTCB Master Programs, Member of the UTCB Academic College and UTCB Board of Directors, Member of the GISGUF Board of Directors.

From the analysis of the risks that may affect the quality and safety of a construction, it results a similar diagram to that shown in Figure 1, which presents the main groups of sources of the hazards and associated risks that may affect a construction.

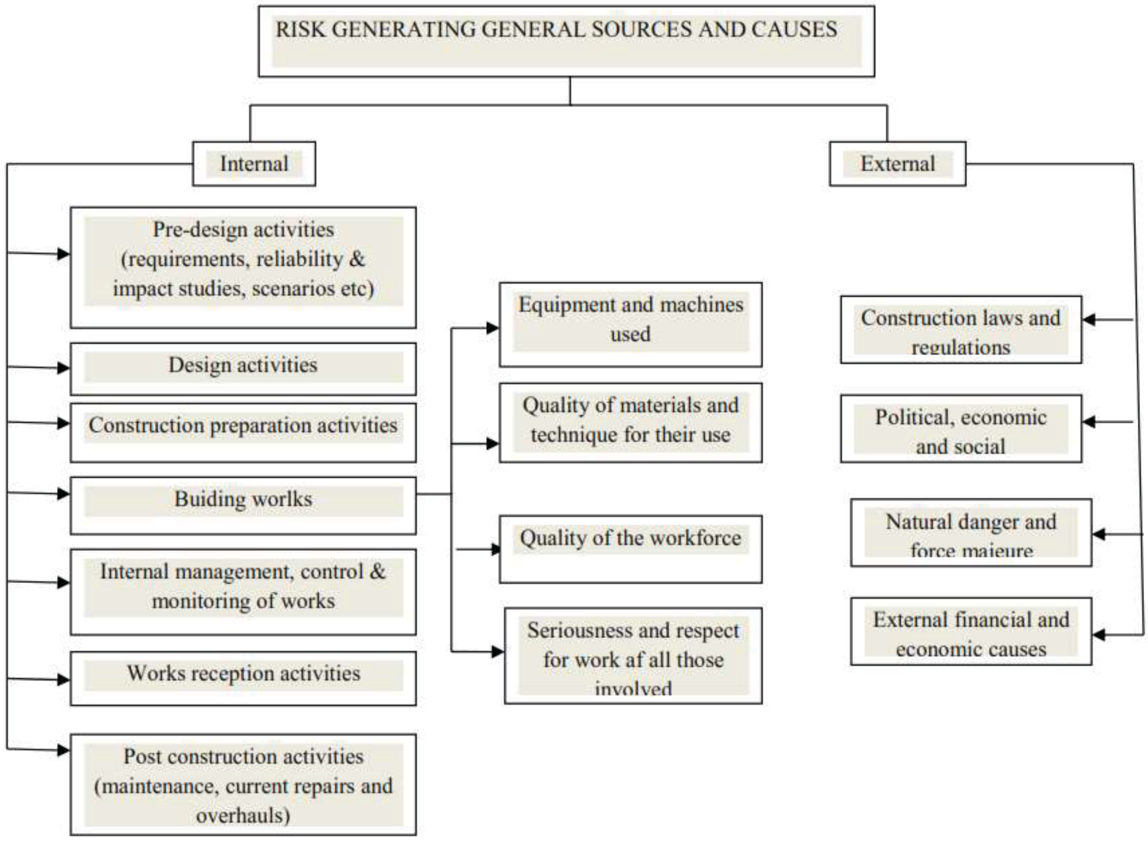

Figure 1: Sources and general causes that may generate risks regarding the quality and safety of a building for a construction company

2. CONCEALED WORKS OR WORKS ASSIMILATED TO THEM IN THE FIELD OF CONSTRUCTION

Concealed works or more correctly expressed the works that become concealed after their completion, are those executed works, components of the construction or complementary to a construction which, once executed and completed, can no longer be viewed, controlled or evaluated except by means of expensive intervention measures, sometimes destructive.

Potential hazards generated by concealed works are hard to monitor and manage because, as time passes since the execution of these works, assessments, expertise and investigations into the adverse effects of potential hazards become difficult, costly and sometimes inconclusive. Works that become concealed represent one of the most important sources of dangers and risks of a construction, which can affect its quality and safety.

For this reason, these works should be given increased attention throughout the execution period, starting with the elaboration of the design project according to requirements and continuing with the design, the approval of the project and the authorization of the construction, the execution at all stages, the completion, the partial and intermediate reception, the final reception, commissioning, use and exploitation, maintenance, repairs and post-completion modifications, irrespective of their nature.

It is imperative that any quality management system implemented in any construction work should take into account, in addition to the classical aspects of the quality approach, the execution, supervision, control and careful management of the works that become concealed.

Following the study of concealed works or assimilated to them, works that cannot be easily and safely observed, analyzed, investigated or evaluated in terms of the risk of negative effects on the quality and safety of the construction, they were synthesized and classified into nine distinct concealed works categories, as follows:

A. Foundations (F);
B. Concrete (B);
C. Elements and Welded joints (S);
D. Hydro isolations (H);
E. Thermal insulation and vapor barriers (IZ);
F. Annexes to sanitary installations (IS);
G. Annexes to electrical installations (IE);
H. Annexes to heating installations (IÎ);
I. Annexes to air conditioning and ventilation installations (ICV).

3. METHODS USED IN THE ANALYSIS OF THE RISKS GENERATED BY CONCEALED WORKS IN CONSTRUCTIONS

Among the qualitative risk analysis methods, the most commonly used are the probability-impact matrix method and the scenario method, and the main methods of quantitative risks analysis are the model-based testing method the method of analyzing the expected value, Monte Carlo simulation method.

The probability-impact matrix method is based on the idea that any risk can be defined by two essential elements, namely the likelihood that the risk will occur and the impact it may have on the quality and safety of a construction.

For example, Figure 2 shows a probability-impact matrix with three lines and three columns, the abscissa being the probability of the risk and on the ordinate, the impact of the risk.

IMPACT \ PROBABILITY	LOW (1)	MEDIUM(2)	HIGH RISK (3)
HIGH RISK (3)	a_{13} Medium risk 1	a_{23} Medium- high risk	a_{32} High risk
MEDIUM (2)	a_{12} Low-medium risk	a_{22} Medium risk	a_{32} High – medium risk
LOW (1)	a_{11} Low risk	a_{21} Medium-low risk	a_{31} Medium risk

Figure 2: Example of a probability-impact matrix with three lines and three columns: aij - the element at the intersection of the line i with the column j (i = 1, 2, 3; j= 1, 2, 3)

As the number of lines and columns grows, the accuracy of the qualitative assessment of the analyzed risks increases.

4. ANALYSIS OF THE RISKS GENERATED BY THE CONCEALED WORKS OR ASSIMILATED TO THEM WITH THE HELP OF THE PROBABILITY-IMPACT DIAGRAMS

Starting from the qualitative risk analysis method, using the probability-impact matrices, we can conceive a new method, this time a qualitative and quantitative method that we will call the method of the estimated risk diagram or the probability-impact diagram.

This method of risk analysis is a combination of the qualitative analysis method using the probability-impact matrices and the method of quantitative analysis of the expected value.

The probability-impact diagram can be viewed as a probability-impact matrix with an infinite number of lines and an infinite number of columns, and the quantification of the expected value of the risk results from the product of the coordinates of the point representing the risk in the diagram field, i.e. the product between the probability risk (the abscissa of the risk point) and the impact of the risk (ordinate of the risk point).

In the case of the expected value method, the expected value VAA of the risk A, i.e. the occurrence of the undesired event A, is obtained by the calculation relation:

$$VAA = PA \, . \, IA \qquad (1)$$

where PA is the probability of occurrence and materialization of risk A and IA is the value of the impact of risk A.

In the case of the estimated risk diagram method, the estimated risk value results from the product of the abscissa XA of the point in the diagram afferent to the A risk and its ordinate YA:

$$VAA = XA \, . \, YA \qquad (2)$$

In order for a risk to be represented in the risk diagram, it is necessary to quantify both the likelihood of occurrence of the risk event and the value of its impact.

For the risk probability represented on the abscissa of the diagram, a percentage scale is used, with values from 0 to 1. The extreme values, 0 denotes the probability of zero occurrence of the risk event, and 1 signifies the probability of occurrence of the event.

To represent the risk impact on the ordinate of the risk diagram, the scale of percentages is used, with values between 0% (defining a null impact) and 100% (defining the greatest possible impact for that risk).

These scale ranges have been chosen in the diagram so that the estimated value of the risk resulting from the multiplication of the two coordinates of the point has a range of possible variation between 0 and 100. In this way, the interpretation of the estimated risk values is much easier and more suggestive, and can be compared to a 0% to 100% scale.

The probability of the risk for a particular case is analyzed, estimated and quantified by statistical processing of the data and information in the field and the category of works related to the analyzed risk, of the accumulated experience and on the basis of consultation of the specialized literature (books, treaties, articles from journals, scientific communications, previous technical expertise).

The impact of the risk is assessed and quantified based on impact studies, through studies on the costs of the effects produced and the costs necessary to restore the situation prior to the effects of the undesirable event.

The representation of a risk A that has the probability of PA and the impact of IA is shown in Figure 3.

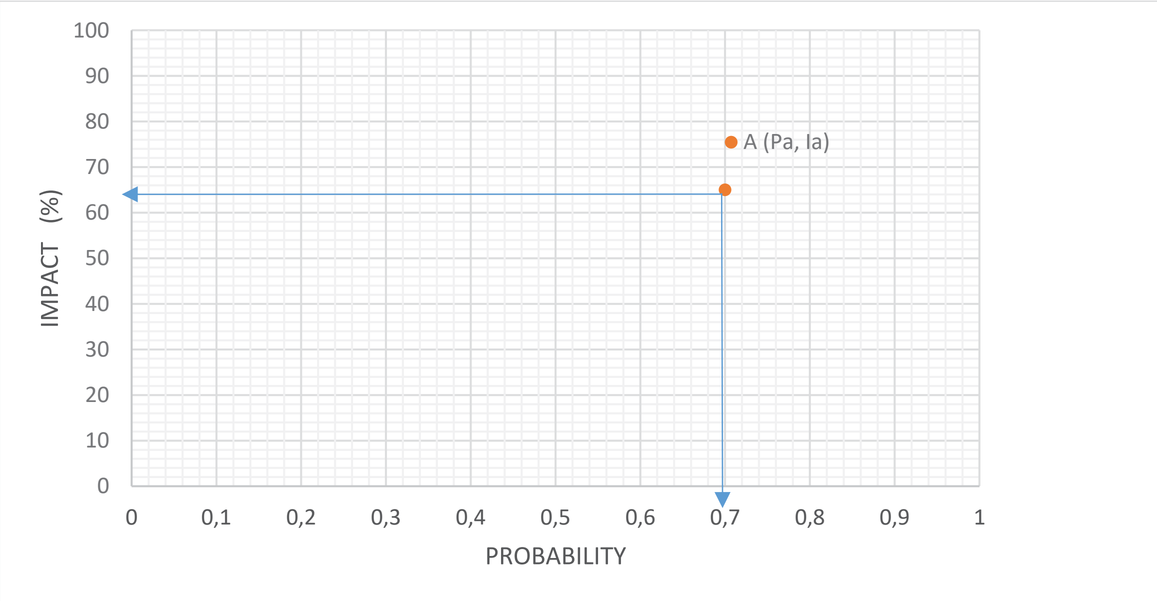

Figure 3: Probability-impact risk diagram: *A* –point *A* for risk *A*; P_A – probability of risk *A*; I_B – impact of risk *A*

As in the case of the probability-impact matrix method, it is possible to establish in the diagram field, probability and impact zones to delimit their qualitative categories using, for example, a five-intervals scale:

- Area with very high risks (with values ranging from 100% to only 80%);
- Area with medium to high risks (with values ranging from 80% to 60%);
- Area with medium risks (with values ranging from 60% to 40%);
- Area with medium to low risks (with values ranging from 40% to 20%);
- Area with low risks (with values ranging from 20% to 0%).

In the idea of simplifying things, we identified the works that can generate hazards and can be sources of risk, without specifically naming the risk or the related risks, but understanding these works as risks, expressed by the estimates and quantifications of the probability and impact values indicated by the percentages of each category of works.

To illustrate the use of the probability-impact diagrams, Table 1 shows a list of concealed works that are generating risks corresponding to the nine main categories of works presented in point 2 and the related percentages of risk and impact probabilities.

Category of concealed works	Works or cause the generates risks	Risk probability	Risk impact
F. Foundations	F1. Lack of a geotechnical study	0.65	79
	F2. Foundation on sensitive soil	09.5	97
	F3. Inadequate and insufficient dimensions of the foundation	0.81	97
	F4. Compaction deficiencies	0.70	71
	F5. Inadequate execution of foundations	0.62	65
	F6. Execution of foundations above the channels made for installations without safety measures	0.62	65
B. Concrete	B1. Inappropriate concrete works	0.61	91
	B2. Cessation of concrete works without adequate conservation measures	0.95	99
	B3. Excess water	0.90	87
	B4. Insufficient water	0.65	65
	B5. Insufficient vibration	0.98	97
	B6. Lack of compaction or insufficient compaction	0.85	91
	B7. Inadequate execution of the reinforcement	0.62	93
	B8. Inadequate montage of the reinforcement	0.60	89
	B9. Insufficient anchoring of the reinforcement bars	0.83	95
	B10. Adding water during pouring	0.81	79
	B11. Sand, with fine granulation, added into concrete, during casting	0.62	65
S. Elements and welded joints	S1. lack of preheating or welding with insufficient pre-heating temperature	0.61	91
	S2. Inadequate welding order	0.61	93
	S3. The use of too high welding speed	0.63	80
	S4. The using of too reduced welding current	0.64	85
	S5. Incorrect placement of welded layers	0.78	81
H. Hydro insulations	H1. Insufficient hydro insulations layers	0.61	81
	H2. Montage of the hydro insulations in inadequate conditions	0.90	91
	H3. Insufficient overlapping of layers of hydro insulation membranes	0.95	99
IZ. Thermal insulation and vapor barriers	IZ1. The outer layer that protects the thermal insulation material does not meet the requirements	0.61	61
	IZ2. Non-compliant application of the adhesive	0.90	91

	IZ3. Incorrect mounting of boards (lack of continuous cord, uncovered spaces, no interposition)	0.95	95
	IZ4. Anchoring and insufficient number of dowels	0.81	87
IS. Annexes to sanitary installations	IS1. Failure to comply with the project and execution stages	0.70	91
	IS2. Mounting of buried pipes not respecting the freezing depth of the earth	0.95	97
	IS3. Lack of pipe protection tubes	0.70	85
	IS4. Inadequate connection between two pipes made of different materials	0.60	85
	IS5. Lack of gaskets or faulty assembly at pipe joint	0.95	91
	IS6. Mounting of metallic parts embedded in aggressive and high-humidity environments, unprotected	0.70	71
IE. Annexes to electrical installations	IE1. Lacking or defective mounting of the protective layer against strong mechanical actions	0.70	85
	IE2. Insufficient compaction of layers of filler on the location of the conductors	0.90	91
	IE3. Poor conductivity in the cable	0.65	65
IÎ. Annexes to heating installations	IÎ1. Lack of inspection and piping before installation	0.70	71
	IÎ2. Fitting the pipes in a way that does not respect the depth of frost and the lack of the thermal insulation layer	0.95	97
	IÎ3. Fitting the pipes directly to the soil without protective layers	0.90	65
	IÎ4. Pipelines connection faulty	0.72	89
	IÎ5. Lack of supplementary thermal insulation on the joints surface	0.62	89
	IÎ6. Lack of tightness at joints between elements	0.68	95
ICV. Annexes to air conditioning and ventilation installations	ICV1. The use of flexible pipes generating an additional friction effect between the dust particles and the surface of the pipe in relation to the flat surface fixed pipes	0.62	61
	ICV2. Unauthorized modifications of the system by adding supplementary branches or hoods	0.81	81

Table 1: List of the concealed works or causes of the risks and the estimated probability and impact of each risk

On the basis of the estimated of the probability and impact values presented in Table 1, the nine risk assessment diagrams presented in Figures 4 to 12 were prepared, in which the points for each risk considered are represented.

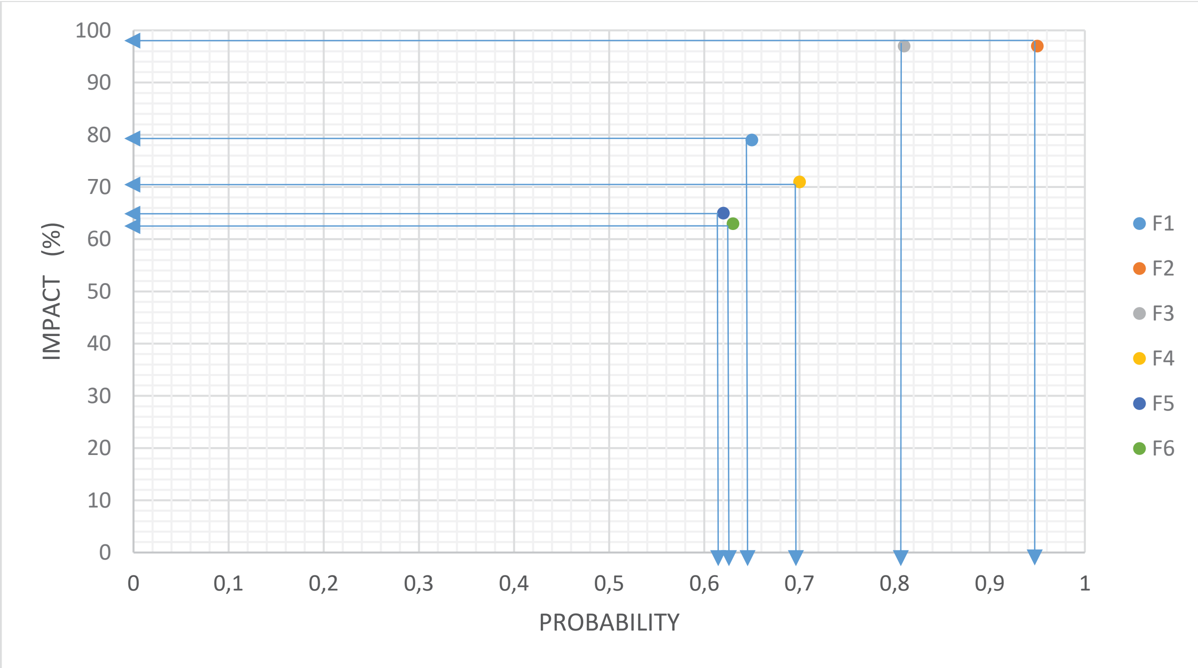

Figure 4: Diagram of estimated risk for the execution of foundation work (F)

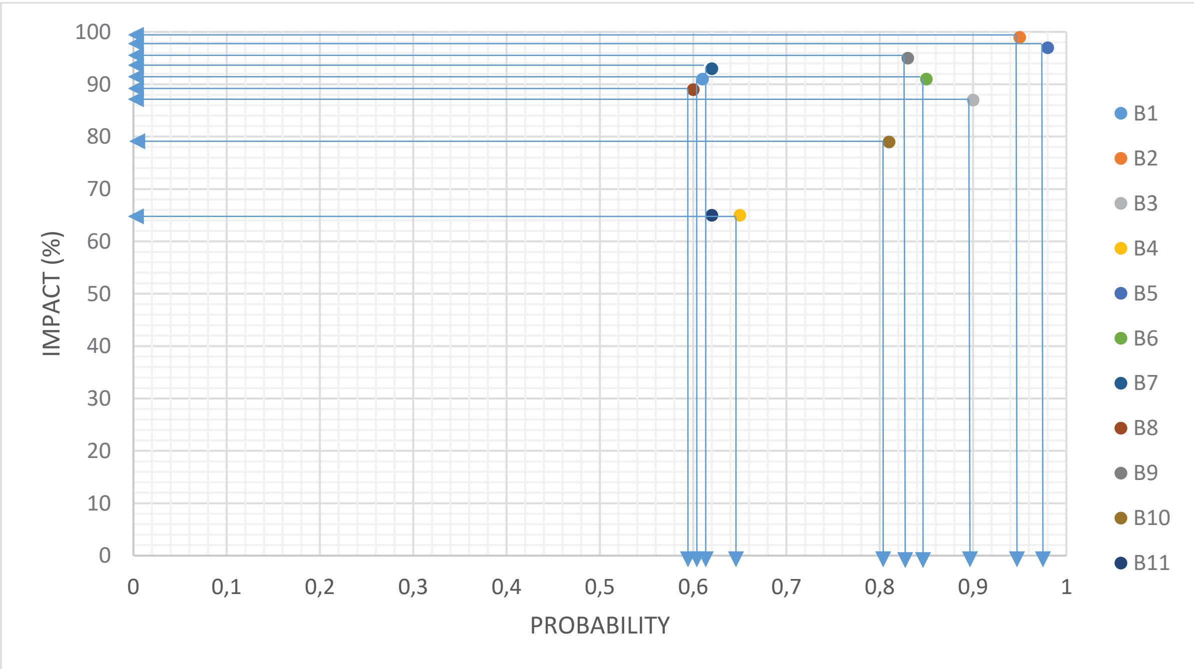

Figure 5: Diagram of estimated risk for the execution of concrete works (B)

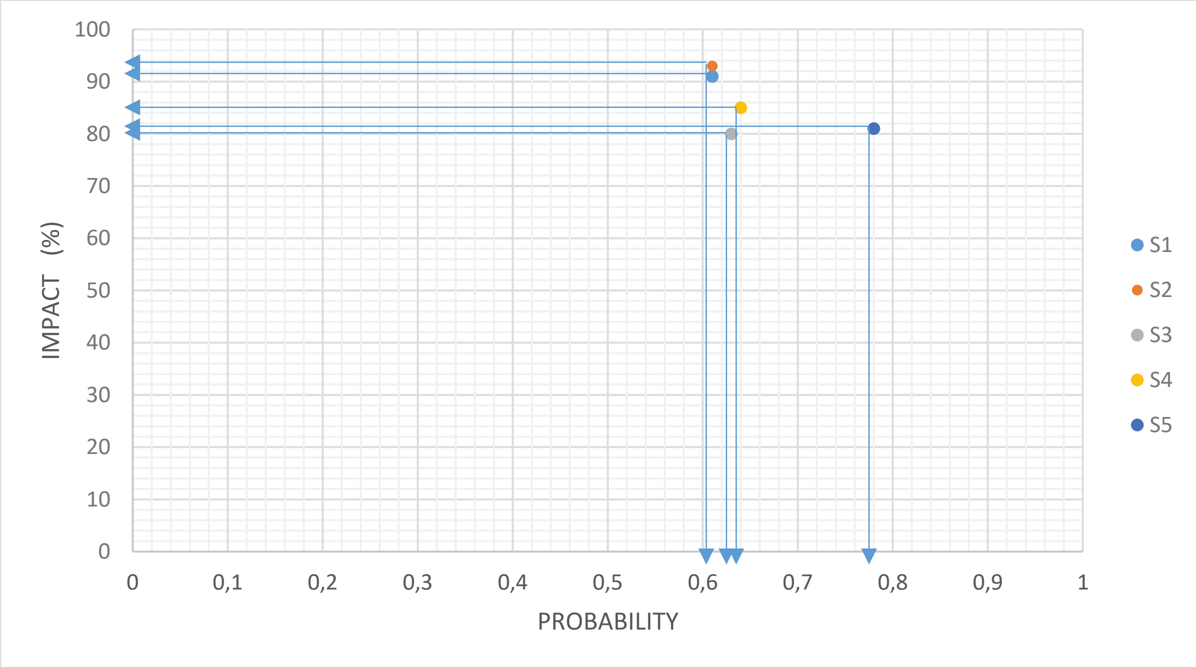

Figure 6: Diagram of estimated risk for the execution of welded joints (S)

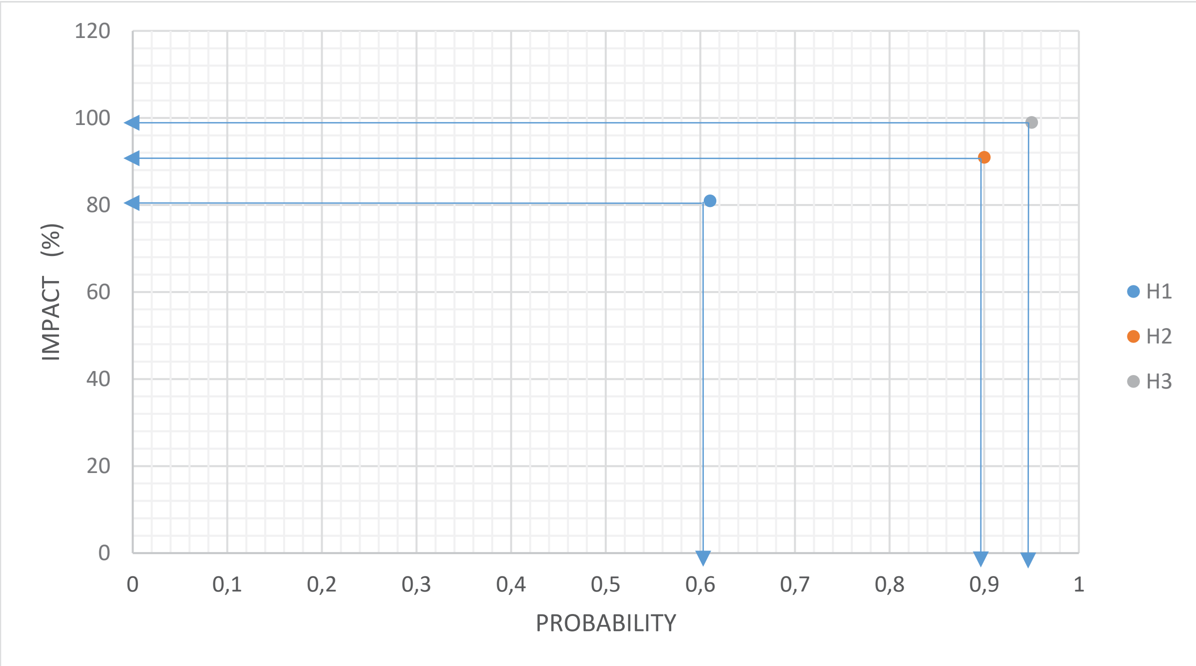

Figure 7: Diagram of estimated risk for the execution of hydro insulations (H)

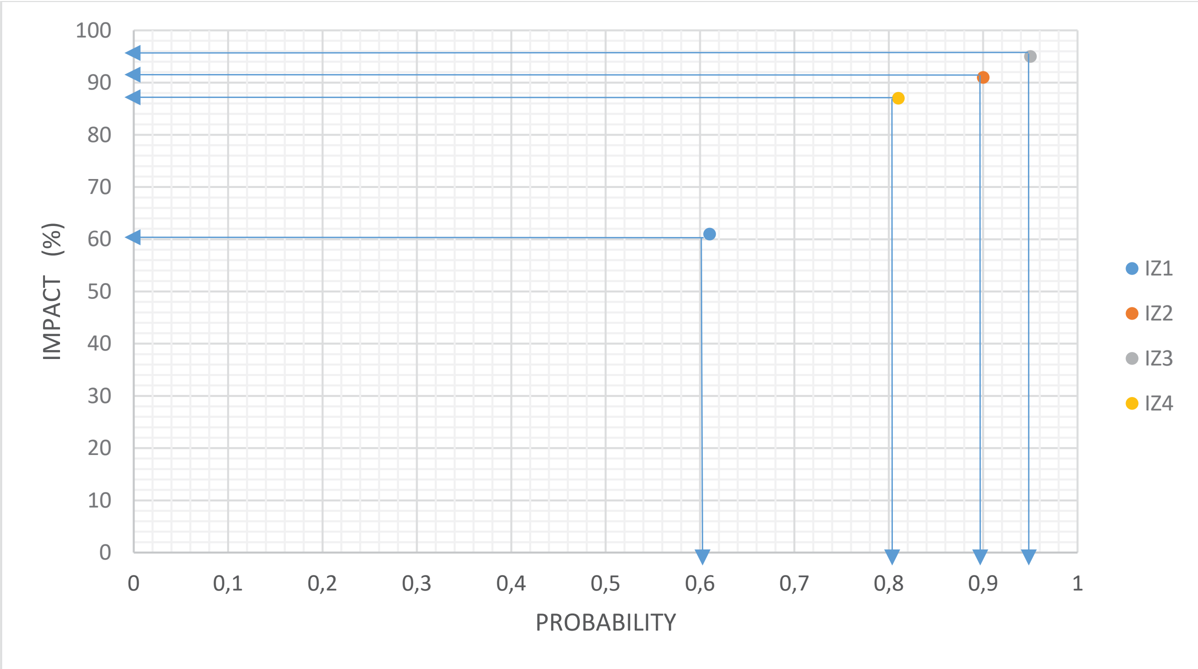

Figure 8: Diagram of estimated risk for the execution of thermal insulations and vapor barriers (IZ)

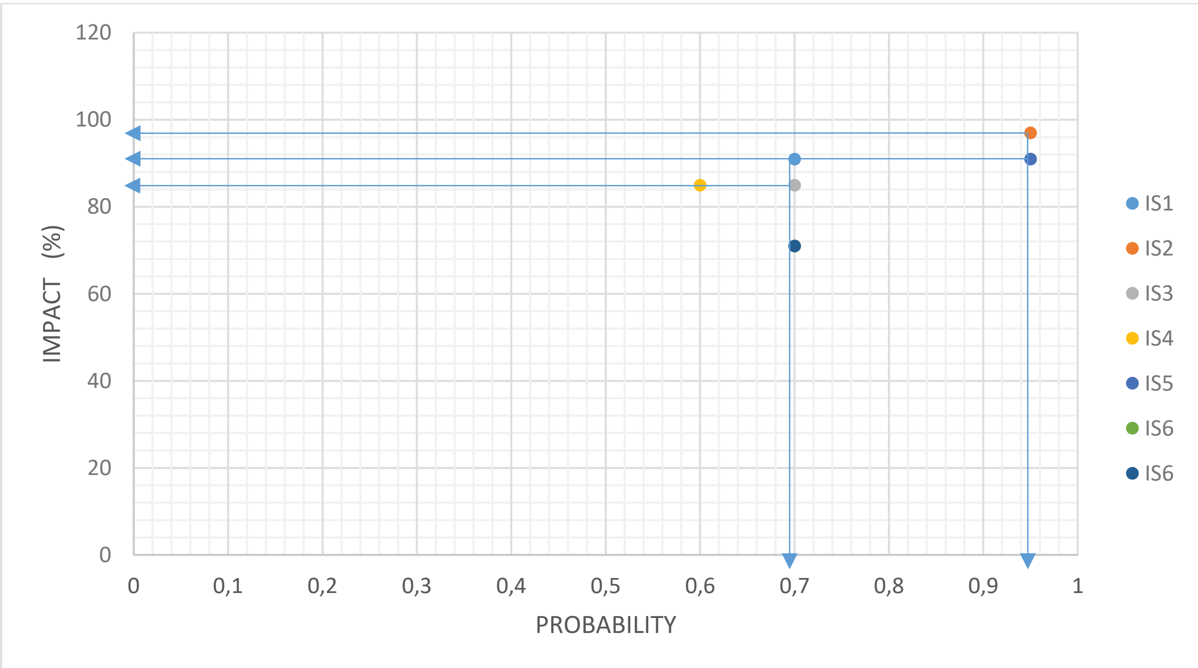

Figure 9: Diagram of estimated risk for the execution of annex works to sanitary installations (IS)

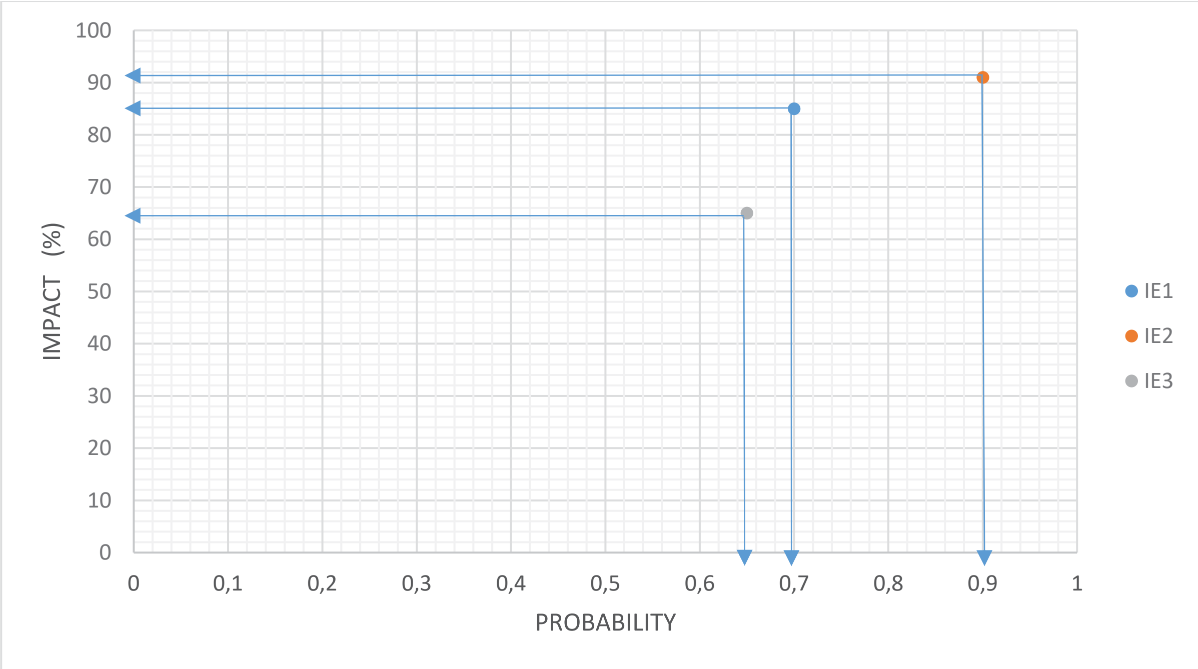

Figure 10: Diagram of estimated risk for the execution of annex works to electrical installations (IE)

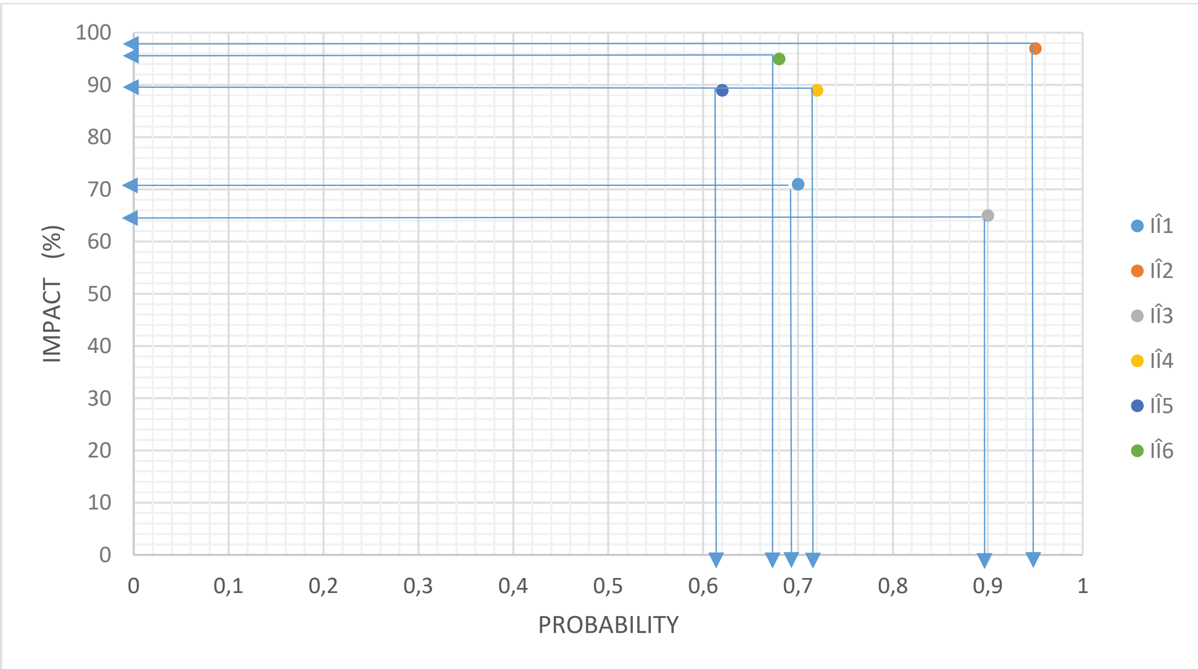

Figure 11: Diagram of estimated risk for the execution of annex works to heating installations (IÎ)

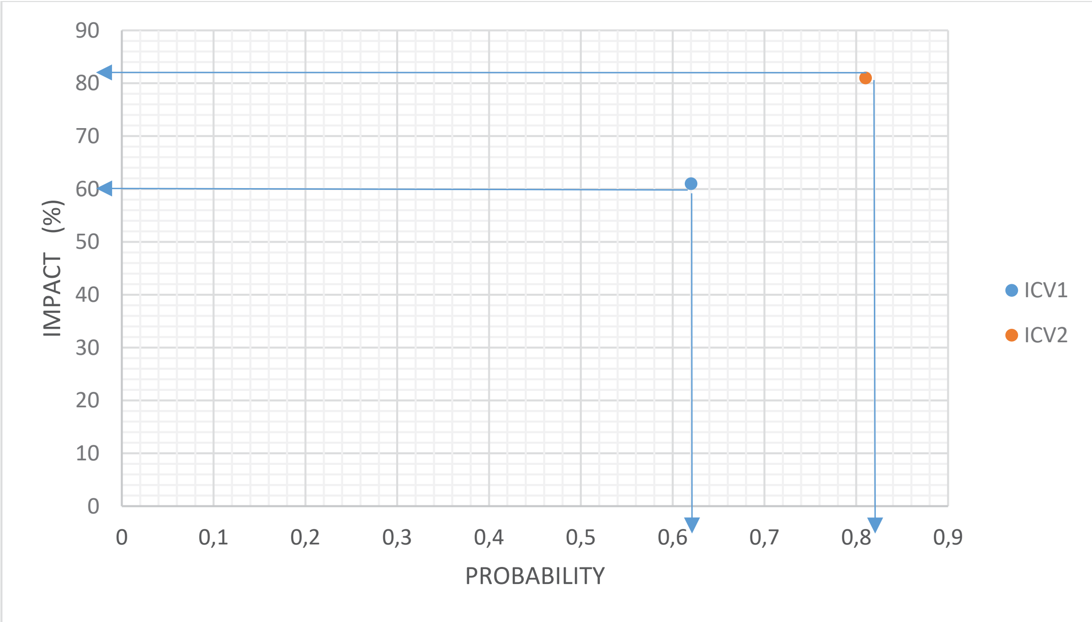

Figure 12: Diagram of estimated risk for the execution of annex works to air conditioning and ventilation installations (ICV)

After we had estimated the probability for each risk, a probability quantified by values between 0 (probability zero) and 1 (maximum probability, i.e. certainty), the risk is represented in the risk diagram by a point.

The point position in the diagram field, relative to its four corners (defined by the minimum probability 0 and the minimum impact 0, the maximum probability 1 and the minimum impact 0, the maximum probability 1 and the maximum impact 100 and the minimum probability 0 and the maximum impact 100) provides an image that can qualitatively assess the risk, analogous to the probability-impact matrix method, and the risk can be compare with other risks represented on the diagram field.

The point coordinates (the abscissa value between 0 and 1 and the value of the ordinate between 0 and 100 respectively) offer the possibility to calculate the value of the estimated risk as a product between the values of the two coordinates.

Since the extreme values of this product are between 0 and 100, the estimated risk will have values between 0 and 100, that is, in a scale similar to a scale expressed as a percentage with values between 0% and 100%.

Based on the facilities offered by the probability-impact risk diagram, one can easily analyze, compare and classify the estimated risks for a category of concealed works assimilated to them that may affect the quality and safety of a building.

In this way, for each of the nine risk charts presented above, related to the nine categories of concealed works, we can analyze, compare and rank risks.

5. CONCLUSIONS REGARDING THE PROBLEMATICS OF RISKS ARISING FROM CONCEALED WORKS IN CONSTRUCTIONS AND THE USE IN THE ANALYSIS AND RISK ASSESSMENT OF PROBABILITY-IMPACT RISK DIAGRAMS

Following the analysis of the works that become concealed and the works assimilated to them in the construction field as well as the dangers and the risks generated by them, a first general conclusion was reached that the problem and the possible negative consequences of the hidden works in constructing a building over its quality and safety must be a major, permanent concern, materialized through preventive measures, identification and risk assessment studies and monitoring by all the participants directly involved in building a construction, and in particular through a fair division of responsibilities, on legal entities, collective and physical persons involved, and by developing a concrete plan for monitoring and controlling the performance of the works that become concealed and those assimilated to them.

This article presents and proposes an original method of qualitative and quantitative analysis of the risks associated with concealed works in the field of construction, which we have named estimated probability-impact risk diagram method which can be used in other fields of activity. This method of analysis comes from a combination of the qualitative risk assessment method, the probability-impact matrix method and the expected risk-weighted method.

Pironea Andreea Dora Bianca

Doctoral student Bianca Pironea attended the courses of "Neagoe Basarab" Theoretical High School, then studied at the Faculty of Civil Engineering in Foreign Languages of the Technical University of Civil Engineering in Bucharest, obtaining his license in 2013, with the title of engineer, specialization - civil engineering in English language. After this she went on to master studies, and in 2015 she obtained the master's degree. At present, Bianca Pironea is a doctoral student, in the third year, beneficiary of a state scholarship, within the Doctoral School of the Technical University of Civil Engineering, Bucharest, "industrial engineering" specialization.

In the framework of her contract assignments as a doctoral student with a scholarship, she held laboratory classes in the "Quality Assurance in Installations" discipline during the academic year 2015-2016 and 2016-2017 at the Faculty of Building Services at the 1st cycle, the year IV study, averaged 4 / hours per week.

In 2017, under the coordination of the vice rector of U.T.C.B. Professor Rece Laurentiu, PhD, Bianca Pironea participated in the preparation of the patent documentation named "Modular precast metallic balconies for buildings and processes for making the same", patent proposal no. RO132314-A0, dated 05 Jul 2017.

The main findings of the analysis can define some of the most important sources of dangers and risks of producing negative events that affect the quality and safety of a construction;

As a consequence, it becomes strictly necessary and of particular importance to apply the methods, techniques and procedures for identifying, assessing and quantifying the dangers and risks generated by concealed works and taking measures to prevent or mitigating the effects of event occurrence which may affect the quality and safety of construction under various forms and intensities; The whole issue, theory and practice of risk refers to estimates of adverse effects that affect the quality and safety of a construction, and therefore the whole of these represent predictions, ante-factum;

During the erection of a construction, the general management and quality, management must include, by all means, as a major component the risk management with all its implications. Risks management involves and requires complex, continuous and coordinated actions involving all the participants in the construction project, such as the identification, definition, assessment, estimate, quantifying of potential risks, as well as the required risk revention methods and the continuous monitoring of risk-generating works, both ante-factum and post-factum.

REFERENCES

[1]. x x x - Standard SR ISO 31000:2010, Managementul riscului – Principii si linii directoare.
[2]. x x x - Standard SR EN 31000:2010, Managementul riscurilor – Tehnici de evaluare a riscului.
[3]. Hopkin, P., Fundamentals of Risk Management, 2nd Edition, Kogan-Page (2012), ISBN:978-0-7494-6539-1.
[4]. Ciocoiu, C., N. (2008) Managementul riscului, vol. 1, Teorii, practici, metodologii, Editura ASE.
[5]. Ciocoiu, C., N., (2008) Managementul riscului, vol. 2, Modele economic-matematice, Instrumente si tehnici, Editura ASE.
[6]. Crouhy, Michel, (2003) Risk Management, New York, McGraw-Hill, 2001.
[7]. Lam, James, Enterprise Risk Management: From Incentives to Controls, Hoboken, John Wiley and Sons.
[8]. Waters, Donalds, (2007) Supply Chain Risk Management – Vulnerability and Resilience in Logistics, London, Kogan-Page.
[9]. Niculita, L., (2013) Nou sistem de management al calitatii pentru siguranta constructiilor cu utilizarea analizei riscurilor si a punctelor critice de control, Calitatea Acces la Succes, Vol. 14, nr.134, pag. 7-15.
[10]. Niculiţă, L., (2005) Management and quality engineering, Romanian Academy, Bucharest.
[11]. Georgescu, D., Rece, L., Pironea, B., Apostu, A., (2018) Metodologie de evaluare a caracteristicilor de rezistenta ale betonului bazata pe analiza punctelor critice generate de specificul lucrarilor care devin ascunse, Revista Romana de Materiale, Nr. 2.