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CIVIL ENGINEERING MASTER THESIS

in

Structural Safety

LEARNING FROM EXPERIENCE: ANALYSIS OF THE CIVIL LITIGATION REGARDING BUILDING STRUCTURES ON THE COURT OF BOLOGNA IN THE YEARS 2011/2012

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To my lovely brother

my reference point

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Chapter I

Introduction

> *"The history of science, like the history of all human ideas, is a history of irresponsible dreams, of obstinacy, and of error. But science is one of the very few human activities—perhaps the only one—in which errors are systematically criticized and fairly often, in time, corrected. This is why we can say that, in science, we often learn from our mistakes, and why we can speak clearly and sensibly about making progress there." [K. Popper,1963]*

This sentence is very meaningful of the rationale behind the scientific method. Mistakes are sources of learning, moreover it is important to understand what are the causes that lead to the errors and correct them. In the building process the source of errors could be infinite and even if some studies are done, there is still a lot to do.

According to the agreement with the Court of Bologna it has been possible to analyze and study the real cases of litigations concerning building. The thesis, starting from the analysis of the defects detected in the civil structure and their causes, aims to create and develop instruments capable of helping the different actor involved in the building process. It is divided in three main sections.

The first part is focused on the analysis of the main aspects regarding the defects on existing buildings. The research center "Osservatorio Claudio Ceccoli" developed a system for the collection of the information coming from the civil proceedings of the Court of Bologna. Statistical analysis are been performed and the results are been shown and discussed in the first chapters.

The second part analyzes the main issues emerged during the study of the real cases, related to the activities of the technical consultant. The idea is to create documents, called "focus", addressed to clarify and codify specific problems

in order to develop guidelines that help the technician editing of the technical advice.

The third part is centered on the estimation of the methods used for the collection of data. The first results show that these are not efficient. The critical analysis of the database, the result and the experience and throughout, allowed the implementation of the collection system for the data that will be presented in the following chapter

Before discussing the topic above, remarking some of the basic and important concepts could be really useful.

1.1 Forensic engineering

Forensic engineering is a young and innovative discipline in the field of technical specialization. It combines Engineering and Jurisprudence applying the scientific method and principle for the solution of technical problems in the judiciary field.
The forensic engineer helps the juridical Authority in the resolution of a litigation where technical knowledge are strictly necessary. Its task is to inquire into the causes and responsibility that lead to a failure or to the formation of defects, damages, malfunctions of any kind of civil structures or products. The forensic engineering can be seen as a technical consultant for the judiciary authority or the parties involved in a legal arguments or penal proceedings. (AIF).
The forensic engineering was established the first time in the United States in 1982. The National Academy of Forensic Engineers (NAFE) has its first priority in educating professional engineers who will serve as technical consultants to the Judge or the Parties in civil and criminal cases. Only in the 2008, with the institution of "Second level Master course on Forensic Engineering" at University of Naples Federico II and the birth of the National Association of Forensic Engineers (AIF), the practice of forensic engineer developed in Italy. (Augenti and Chiaia).

1.2 The technical consultant

When the judge is not able to evaluate certain aspects of the litigation, due to the lack of technical competences, an expert is in charge to identify and analyze the technical problems. The technical consultant helps the judge to ascertain, reveal and analyze the elements related to a specific litigation. He makes a report called "technical advice" in Italian "Relazione peritale" where the response to the judge's questions is reported in an objective and incontrovertible way.
In the technical advice the trial and scientific rules have the same importance, for this reason, technical and juridical knowledge are requested to the consultant. The role of the technical consultant is crucial, in fact when litigation is based on technical problem, he is the responsible of the ultimate decision. The consultant has criminal and civil liability when there is no accordance with the procedural rules leading to undesirable effects as the invalidity of the technical advice. A

part for the technical knowledge and experience to the technical consultant are required other quality as the integrity, relational capacity as will be seen in the forthcoming chapters.

1.3 The civil proceedings

The civil judicial prosecutions can be divided into two main categories:

- Precautionary inquiry prosecution;
- Evidentiary inquiry prosecution.

The precautionary inquiry prosecution, also known as *Precautionary Technical Inspection*, in Italian *Accertamento Tecnico Prevenivo* (ATP), is the collection of evidences for the establishment of the arbitration in order to avoid their dispersion. In this way it is possible to ascertain the current situation, verify the presence or the causes of failures and defects, define the possible solution and quantify the costs and the duration of each activity. This kind of proceeding is required by the claimant party when there is the urgency to verify, before the final verdict, the state or the quality of the building system. It has two purposes: the conservation of the state of art and the anticipation of the effect of the sentence that will be emanated during the trial.

In this case the President of the Court(the judge), with an ordinance, appoints an *Office Technical Consultant* (in Italian Consulente Tecnico d'Ufficio - CTU) and schedules the data of start and finish, to carry out an appraisal in the presence of the court experts appointed by the parties called *Party Technical Consultant* (in Italian Consulente Tecnico di Parte - CTP). The CTU conducts all the inspections in presence of the CTPs and at the end he deposits its report, called *Technical Advice*, to the chancellor's office.

If the ATP does not verify the rationale of the claimant, the latter could be convinced to not proceed with the argumentation; in the other case it could easier decided for an agreement.

The Evidentiary inquiry prosecution is the phase of a civil lawsuit where all the necessary evidences are exposed in order to make the final verdict of the trial. If the judge needs extra help concerning technical issues, he will nomine a *Office Technical Consultant* (CTU). The warrant in this case is much wider compared to

the previous case of ATP. The *Party Technical Consultant* (CTP) supplies all the documents collected to the CTU and take part, in consultation, to the inspections. The CTU draws up a technical advice that is get across to the parties for possible observation before to be deposited in the chancellor's office.

1.4 References

[1] Augenti Nicola., Chiaia Berardino (a cura di) "Ingegneria Forense: metodologie, protocolli, casi di studio". Dario Floccari editore (2011) Palermo-Italy. Pp 17-31.

[2] Karl R. Popper, *"From Conjectures and Refutations: The Growth of Scientific Knowledge"* (1963).

[3] Trombetti T., Tattara S., Palermo M., Gasparini G., Silvestri S., Pieraccini L. (in publishig), *"The first year of activities of the "Ossesrvatorio Claudio Ceccoli", on the defects of building structures".* Italy

[4] *Associazione italiana di ingegneria forense (AIF*), http://www.aifitalia.it/

[5] *Civil, Chemical, Environmental and Material of Bologna– DICAM*, http://www.dicam.unibo.it/Ricerca/Centri/osservatorio-claudio-ceccoli

[6] Paolo Frediani. *"Guida CTU: dall'incarico alla perizia".* Gruppo 24 ore.
Società finanziare FINSUD,
http://www.finsud.eu

Chapter II

Previous studies: Background

The Department of Civil, Environmental and Material Engineering (DICAM) of the Faculty of Engineering at the University of Bologna formalized in the 2011, with a no-profit agreement, a collaboration with the Court of Bologna in order to share the data related to civil or penal lawsuits involving defect on the building structure. This is the starting point for the creation of the research center "Osservatorio Claudio Ceccoli". As mentioned before it is one of the few centers entirely devoted to the study of the forensic engineering issues, especially the ones related to the defect in the building object of litigations.

In this chapter, after a brief introduction of the history and the aims of the center, the results of the first years of activities will be reported and exanimated. The main topic will be the description of the system developed for the collection and the analysis of the data.

2.1 The agreement with the Court of Bologna

During these years the need to create a methodological and scientific reference for the execution of the activities necessary for a technical advice is strictly necessary. The solution of a civil litigations involves different branch of knowledge, on one hand there is the technical and scientific field and on the other hand juridical field. Two different realities that need to coexist into each other. The technical consultant applies his technical knowledge with the juridical one.

It is evident that the interest of the Court and University are exactly the same. For these reasons an "Agreement" between the Court of Bologna and the Department of Civil, Environmental and Material Engineering (DICAM) of the Faculty of Engineering at the University of Bologna was stipulated.

The idea is to identify the most common defects, their frequency, the economic impact and the involved people establishing a defect's taxonomy. This way it is possible to create a methodological reference for the development of a technical advice that helps the consultant and the judge. The analysis of the real case is the best way to create a common language that is able to merge the juridical and technical references, increasing the awareness of the people involved in the building process, as contractor, costumers and exerts, on the risks that are intrinsic of these kind of activities.

2.2 The research center "Osservatorio Claudio Ceccoli"

The center was built in January 2012, in memory of Claudio Ceccoli a pioneer of the forensic engineering. It became a section of the Department of Civil, Environmental and Material Engineering (DICAM) of University of Bologna specialized in forensic engineering issues.

The studies conduct on the defects in the civil structure, at national or international level, are very rare. Only few academic publication are available, particularly noteworthy are:

- Documents of the conferences IF CRASC, organized by the Italian Association of Forensic Engineering;

- "Bullettin des erreurs" a document publisced by the French society SOCOTEC;
- "Why buildings fall down?" a fomous text of Mario Salvadori.

The lack of references put under the light the need to share information, knowledge and experiences in these wide field in which many aspects are still unknown. An accurate analysis of the behavior of the civil construction, during each phase of the building process and the development of an well-structured knowledge of the defectiveness can enrich those knowledge.
This is the rationale of the activities of the research center that thanks to the experience gained increase the preparation and the culture of the technician. All the activities are based on a strict collaboration with the Court of Bologna. The members have access to the archive of the Court which provides the technical advices related having the goal to identify and point at the defects on building structure.

The researches listed below are the ones promoted by the center:

- Research activities and methodological supervision of the risk, implicit and explicit, related to the building process.
- Creation of a web database collecting the defect taxonomy of the building structure object of litigation. The database structure follows the steps necessary for the redaction of the technical advice, for this reason it is helpful to the technician to use a prescribed protocol. At the same time is possible to have a real time data storing. An experimental release of the database is already available and will be discussed in the next paragraph.
- Diffusion of a periodic "Bulletin of Defect on Construction" that starting from the expertise acquired through the analysis of the examined cases provides insights into a specific defect or class of defects.
- An updated (periodic) price list of the market list for typical building typologies installations, furniture, finishing.
- Redaction of period documents, called "Focus" that analyze specific problem emerged by the study of the real cases. A detailed description will be provided in Chapter VI.

In figure 2.1. is displayed a flow chart which describe the main interactions and activities between the DICAM department and the Observatory Claudio Ceccoli [1].

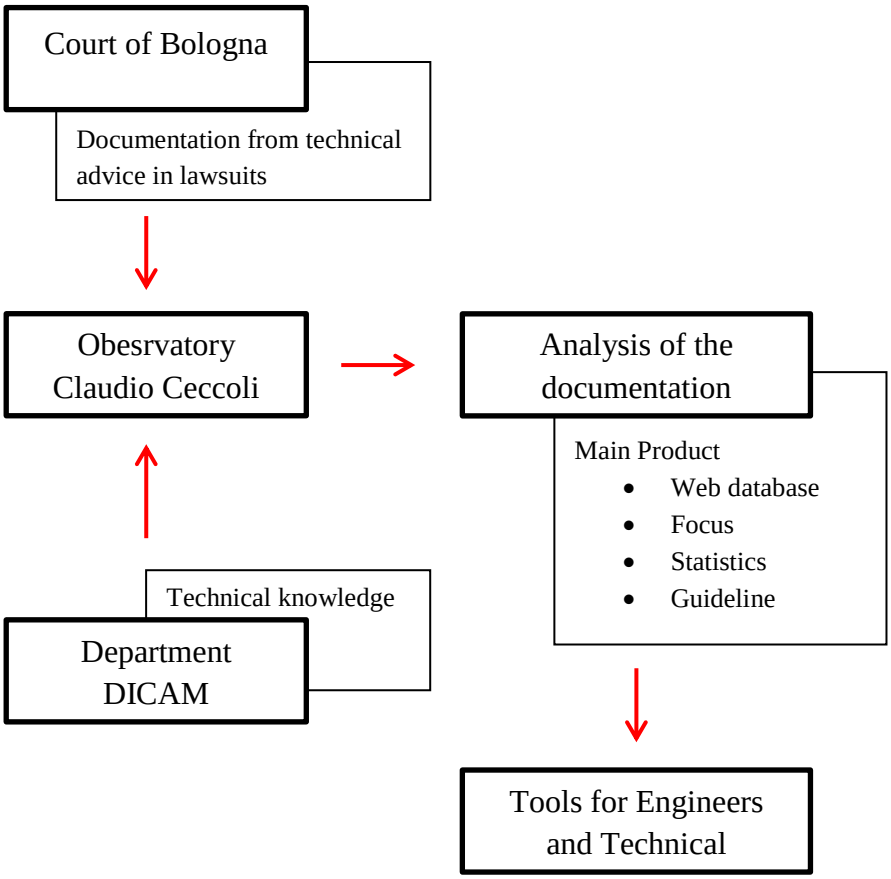


Figure 2.1 Flow chart of the main interactions and activities between the Court of Bologna, the department DICAM and the Observatory Claudio Ceccoli.

2.3 The database

The first years of activities of the center focused on the examination of the real cases available in the archive of the Court of Bologna, regarding the civil proceeding of the year 2011. The main goals are:

- Typical causes of the defects;
- Similarities between the cases;
- Possible deficiencies.

The center developed an instrument for the analysis that is able to manage and collect the huge amount of available data in an efficient and transparent way. The database is made by a system of matrices, specifically created and used to store the fundamental data. The information are organized in different sections and level of detailing. The matrix system has been arranged and computerized. The idea is to computerize all the process related to the litigation and increase the practicality of the Observatory.

2.3.1 The structure of the matrices

The matrices are tools able to describe in an scientific, efficient and accurate, way the complex descriptive protocol of the technical advice. The purpose of the rationale behind the proposal matrix-based structure is to obtain a cascade structure which may guide the technical consultant in the different phases of the process.

The matrices are divided in two or more columns, each one containing a different level of information. The first column contains the list of macro-areas, identified with a letter, that describes the kind of information required; The second column reports a list of the possible alternatives to insert the information required in the correspondent macro-area. In the first two columns are reported fundamental data that are mandatory; the next columns have the aims of detailing the information given earlier. In order to clarify better the rationale of the matrix structure the figure 2.2 as given as an example.

Matrix A: "General information about the construction work" → g. Property

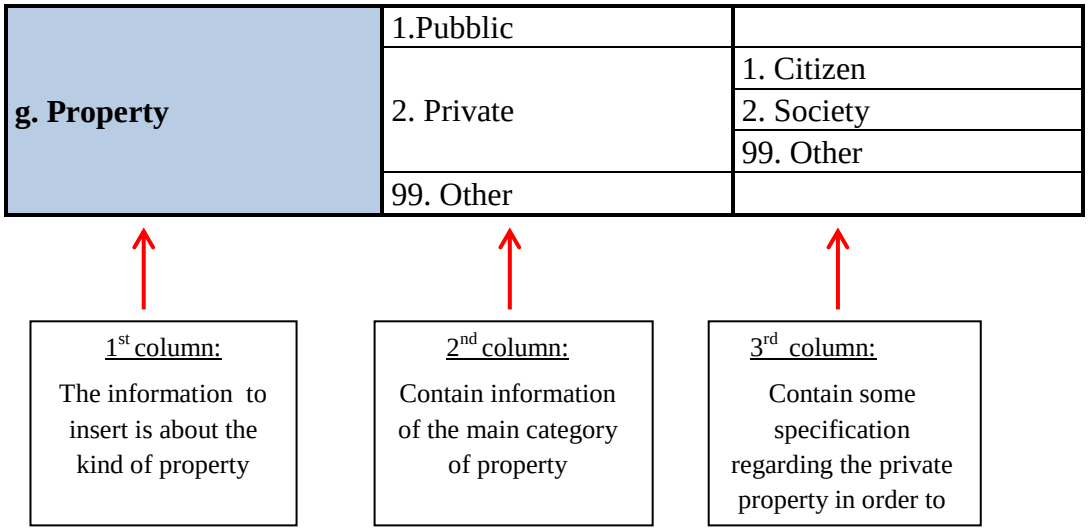


Figure 2.2 Illustrative schematization of the rationale behind the matrices' structure

The data base is made up by five matrices that have different and specific aim in order to describe all the aspects concerning the technical. Any matrix is described below

MATRIX A

The matrix is direct to the general description of the civil construction where the damages, the failure or defects are claimed. For each lawsuit there is only one matrix A, it is unique.

MATRIX B

The matrix B describes and locates the claimed defect. Each matrix B is related to a matrix A, and in this way connected to a specific lawsuit, since there could be more than on claimed defect, it is possible to have more than one matrix B for each lawsuit, each one identified by a progressive number.

MATRIX C

The matrix C describes the inspection method for the detection of the defect when is included in the chart describes the level of impairment, repairing cost and

repairing time. The defects are described in the previous matrix B for these reason each matrix C is associated univocally to a matrix B.

MATRIX D

The matrix D identifies the causes of the claimed defect. All matrices D are related to a matrix B that identifies the defect, but differently from matrix C, it is possible to have more than one matrix D associated to a defect, because the causes of it could be various.

MATRIX E

The matrix E identifies the responsibility. Each matrix E is related to a matrix B that identifies the defect, and since the responsibility could be ascribed to more than one person involved in the construction process, as in the previous case, it is possible to have more than one matrix E associated to a single matrix B.

In Figure 2.3 is reported an example describing the matrices structure.

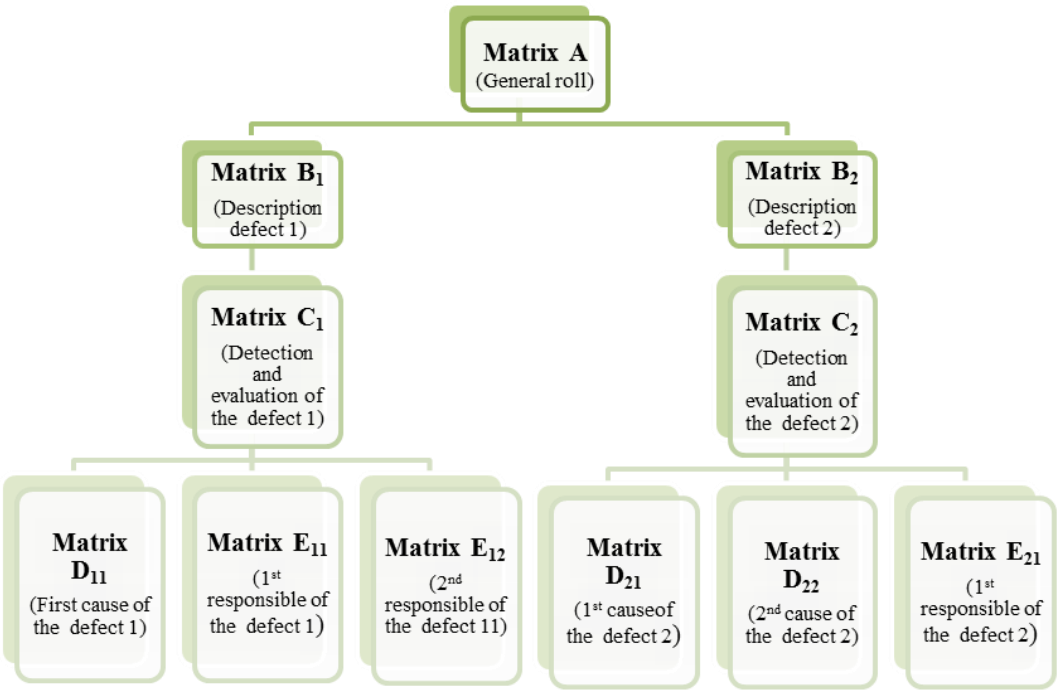


Figure 2.3 Connection between the matrices

2.3.2 The matrices of the 2011

MATRIX A: General information		
a. General Roll		
b. Brief description		
c. Address		
d. City		
d. Temporal detection	*1. Under construction*	
	2. In service	
e. Category of use	*1. Residential area*	
	2. Commercial area	
	3. Industrial area	
	99. Other	
f. Type of construction	*1. Reinforced concrete*	
	2. Steel	
	3. Masonry	
	4. Timber	
	5. Mixed	
	99. Other	
g. Property	*1.Pubblic*	
	2. Private	*1. Citizen*
		2. Society
		99. Other
	99. Other	
h. Indirect damage		

Matrix B: Description of the defect		
a. General Roll		
b. Progressive number		
c. Kind of defect	*1.Water infiltrations*	*0. General*
		1. Rainwater leakage
		2. Groundwater infiltration
		3. Leakage due to inner plant disease
		4. Leakage due to outer plant disease
		99. Other
	2. Dampness/Mold	*0. General*
		4. Dampness patches/Plasterwork degradation
		2. Mold growth
		99. Other
	3. Crack/Small crevices	*0. General*
		1. Crack greater than 3 mm
		2. Small crevices
		99. Other
	4. Poor workmanship	*0. General*
		1. Flooring and covering joint
		2. Plasterwork not flat
		3. Irregular joint in outer skirting-board
		4. Erroneous sewers
		5. Not-vibrated asphalt
		99. Other
	5. Impact	*0. General*
		1. Total collapse
		2. Partial collapse
		3. Sliding
		4. Crack
		99. Other
	6. Incomplete work	*0. General*
		1. Finishing
		2. Plant
		99. Other
	7. Deformation	*0. General*
		1. Sidewalk deformation
		2. Flooring deformation
		3. Deformation of inspection manhole
		4. Deformation of grid/ inspection manhole covering
		99. Other
	8. Deterioration/Damage	

	9. Code violation	
	10. Agreement violation	
	11. Unexpected behaviour	
	99. Other	
d. Location in the building	*1. Basement*	
	2. Elevation (excluding roofing)	
	3. Roofing	
	99. Other	
e. Kind of element	*1. Framework*	*0. General*
		1. Foundation element
		2. Vertical structural element
		3. Horizontal structural element
		99. Other
	2. Finishing	*0. General*
		1. Outer (Covering, coating, ecc)
		2. Inner (Plasterwork, flooring, fixture, etc)
		99. Other
	3. Plant	*0. General*
		1. Plumbing/Gas plant
		2. Electrical system
		99. Other

Matrix C: Detection of the defect and evaluation of the damage		
a. Detected defect		
a. Detected defect	*1. Yes*	
	2. No	
b. Inspection method	*1. Visual inspection*	
	2. In situ test	
	3. Specific test	
	4. Drawing check	
	99. Other	
c. Expected behaviour	*1. Yes*	
	2. No - Relevant defect according with art. 1669 cc	
	3. No - Poor ordinary/extraordinary Maintenance	
	4. No - Code violation	
	5. No - Agreement violation	
d. Level of impairment	*1. Structural safety/stability*	
	2. Functionality/Usability	
	3. Appearance	
	99. Other	
e. Repairing time	*1. Free text*	
	2. Incomputable	
	3. Already evaluated in another matrix	
	4. Null	
	2. Incomputable	
f. Repairing cost	*1. Price or insurance value*	
	3. Already evaluated in another matrix	
	2. Incomputable	
	99. Other	
g. Removal method	*1. Remedial work by the guilty party*	
	2. Monetary compensation	
	99. Other	

Matrix D: Causes of the defect		
a. Cause of the defect	*1. Poor materials*	*1. Concrete*
		2. Steel
		3. Bituminous sheath
		4. Paperwork
		5. Flooring
		6. Covering
		7. Tinsmithery
		8. Glass
		9. Plywood
		10. Wood
		11. Reinforcement
		12. PVC tubing
		99. Other
	2. Poor execution	*1. Concrete installation*
		2. Concrete supply
		3. Reinforcement installation
		4. Plasterwork installation
		5. Bituminous sheath installation
		6. Flooring/Covering installation
		7. Window installation
		8. Door installation
		9. Sheet pile installation
		10. Excavation
		11. Drainage of water
		12. Vibration
		13. Screed coat adjustment
		14. Exhaust pipe installation
		15. Heating plant
		16. Absence of spigot for cold/hot water
		17. Wrong location of the valve
		99. Other
	3. Design errors	*1. Geological/geotechnical relation*
		2. Structure calculation
		3. Executive design
		4. Lack of detailing
		5. Urban restriction violation
		99. Other
	4. Site manager errors	
	5. Negligence	*1. Poor ordinary maintenance*
		99. Other

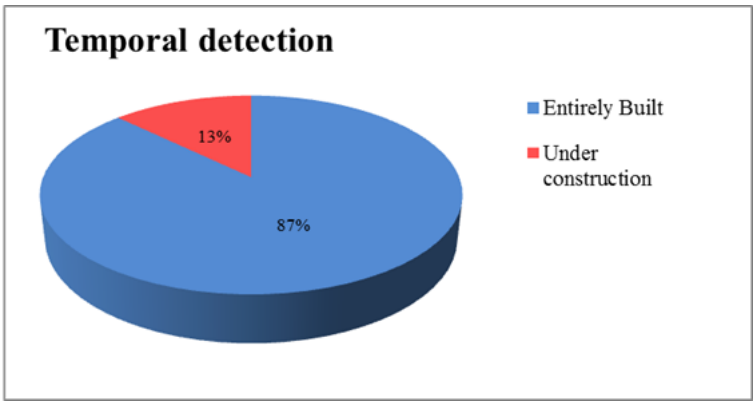
	6. Collision	*1. Impact with a vehicle*
		99. Other
	7. Incomplete works	
	99. Other	

Matrix E: Responsability		
a. Responsability	*1. Designer*	*1. Geological*
		2. Geotechnical
		3. Foundation
		4. Structural
		5. Architectural
		6. Finishing
		7. General
	2. Site manager	*1. Structural site manager*
		2. Architectural site manager
		3. General site manager
	3. Construction firm	*0. General*
		1. Contractor firm
		2. Subcontractor firm
		3. a.t.i Firm
		99. Other
	4. Tenant	
	5. Condominium	
	6. Seller	
	7. Adjacent property	
	99. Other	

2.4 Statistical analysis of the 2011 data

From the database are been extracted some statistic related the cases of the 2011. In the statistic are included:

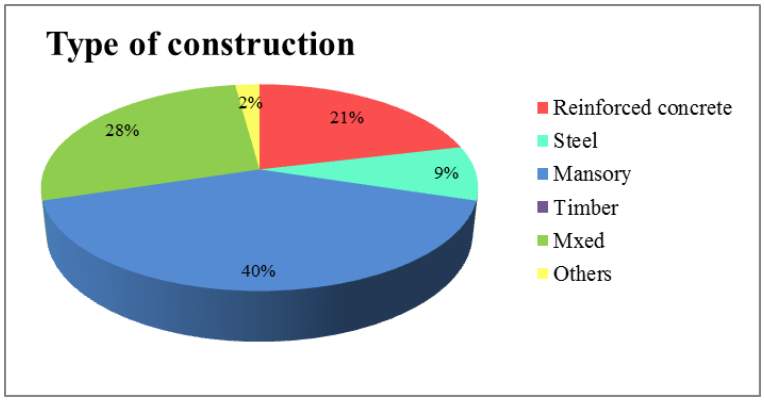
- Temporal detection of the defect



Graph 2.1 Statistic related to the analyzed cases (2011): Temporal detection

The majority of the defect, as shown in the graph are discovered during the service life of the structure.

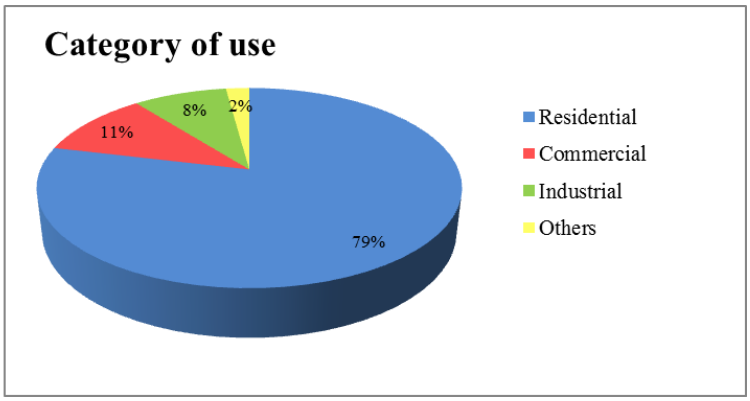
- Type of construction



Graph 2.2 Statistic related to the analyzed cases (2011): Type of construction

The majority of the defects are found in masonry building. This does not mean that the masonry building are the most vulnerable but, perhaps the percentage shown in the graphic below is due to the fact that the majority of building is made of masonry structure.

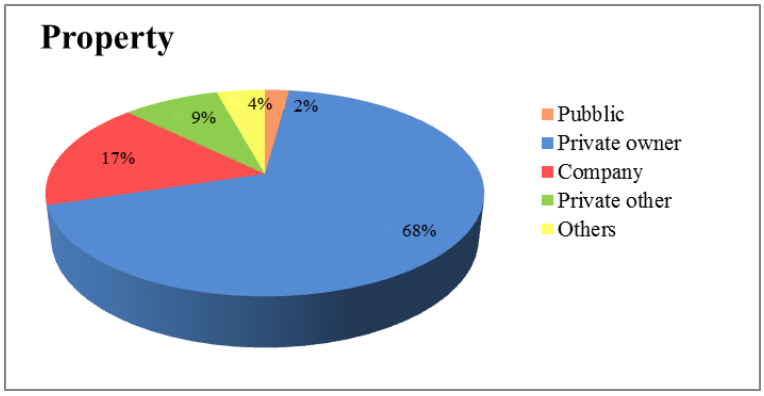
- Category of use



Graph 2.3 Statistic related to the analyzed cases (2011): Category of use

The largest part of defect is detected in residential building (79%); The remaining parts between industrial and commercial.

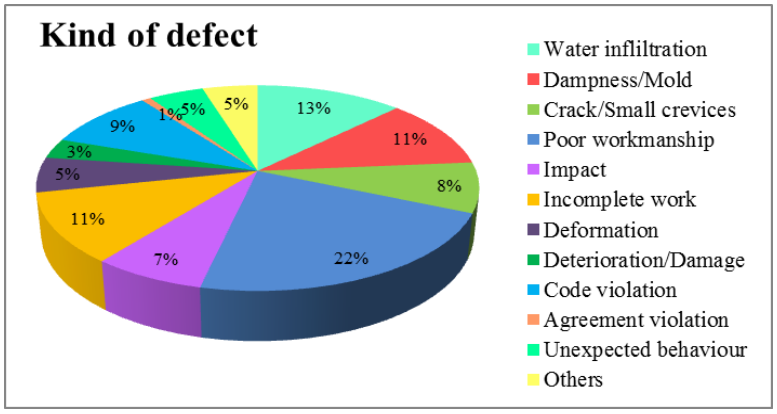
- Property



Graph 2.4 Statistic related to the analyzed cases (2011): Property

The private owner are the most involved in litigation with a percentage of about 70 % . Instead in only few cases (less than 5%) are involved public property.

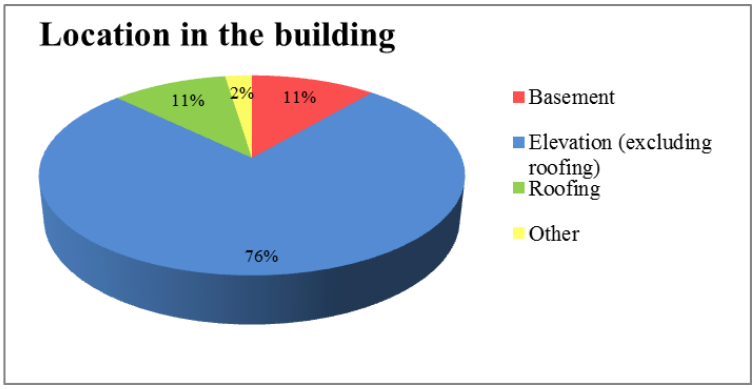
- Kind of defect



Graph 2.5 Statistic related to the analyzed cases (2011): Kind of defect

The defects claimed and their types are quite large. Looking at the graph below it is possible to observe that one half of the total is due to poor workmanship (22%), water infiltration (13%) and incomplete work (11%).

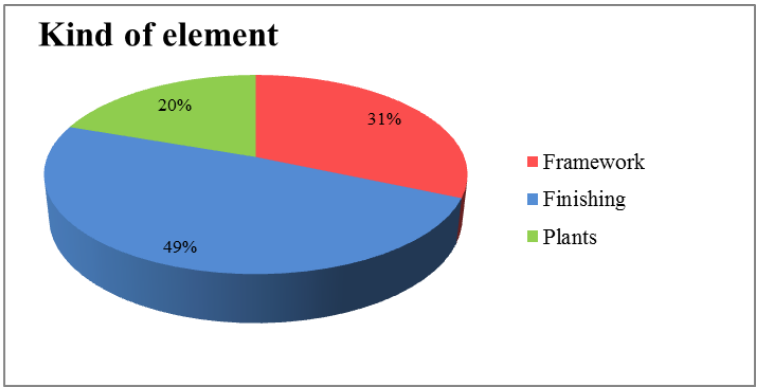
- Location of the defect in the building



Graph 2.6 Statistic related to the analyzed cases (2011): Location in the building

The majority of the defects (76%) involves the elevated part of the building, and the remaining part is equally distributed between foundation and covering.

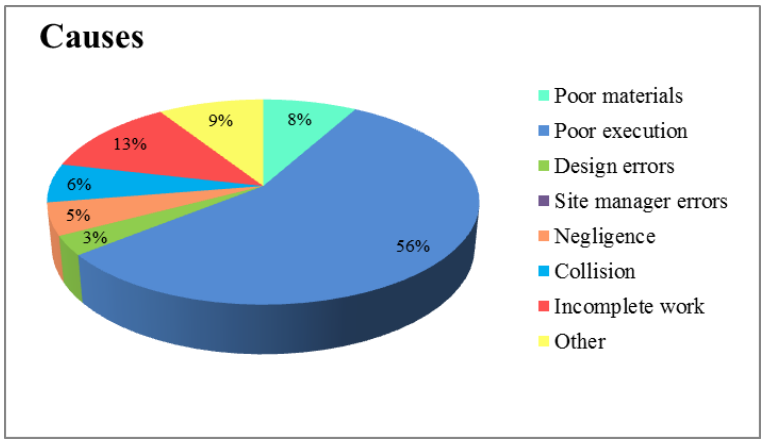
- Kind of element



Graph 2.7 Statistic related to the analyzed cases (2011): Kind of element

The defects are quite uniformly distributed among the element of the building. Almost the 50% is concentrated in the finishing, the remaining part in the structural elements and plants.

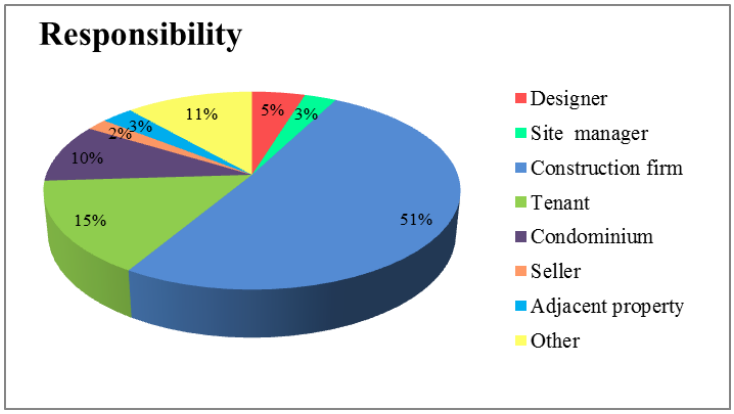
- Causes



Graph 2.8 Statistic related to the analyzed cases (2011): Causes

More than one half of the cases the defect is given to an adequate execution. It is possible to observe that just few cases the responsibility is due to an incorrect design (3%). The remaining causes have almost the same percentage.

- Responsibility

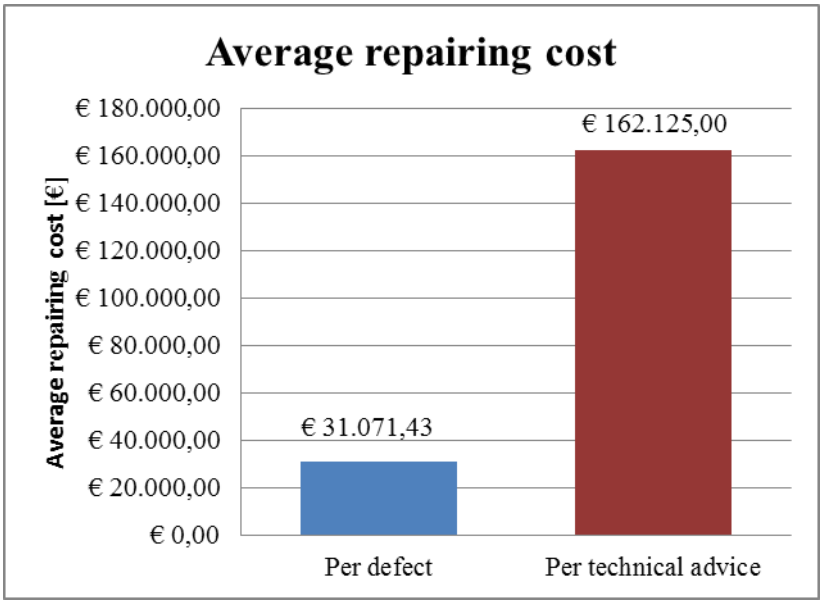


Graph 2.9 Statistic related to the analyzed cases (2011): Responsibility

The causes of the majority of the defects are due to an execution error, as expected, in more than one half of the cases the responsibility is attributed to the construction firm.

- Repairing costs

By inquiring the data base, the repairing cost can be obtained only in aggregate form: It is an average of all the defects, without distinguish them in categories (cost per defect), and repairing cost for technical advice.



Graph 2.10 Average repairing cost (2011)

2.5 References

[1] Trombetti T., Tattara S., Palermo M., Gasparini G., Silvestri S., Pieraccini L. (2014), *"The first year of activities of the "Ossesrvatorio Claudio Ceccoli", on the defects of building structures".* Italy

[2] *Civil, Chemical, Environmental and Material of Bologna– DICAM,* http://www.dicam.unibo.it/Ricerca/Centri/osservatorio-claudio-ceccoli

Chapter III

The new studies

The first step for the editing of the present thesis was the collection of the data related to the cases of the year 2012 on the Court of Bologna. The aim of this activity is to increase the knowledge of the defects in building construction.

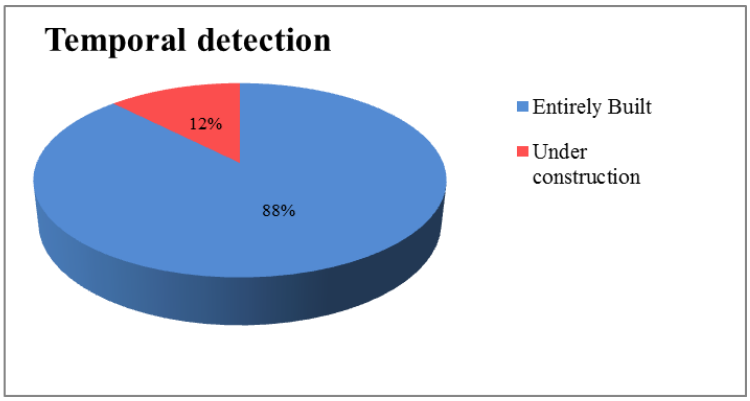
Despite the difficulties encountered, discussed better in the following chapters, the data collected until the 2012 are and descriptive of the most commons defect, occurring in the civil works, their frequencies, causes and responsibilities.

In this chapter will be reported the result obtaining by the collection and the analysis of the cases of 2011 and 2012. Then will be compared the data related to these two years in order to understand how the results are been changed.

3.1 Statistical analysis of the 2011 and 2012 data

The analysis of the civil proceeding collected, between the 2011 and 2012, in the Court of Bologna shows the following results.

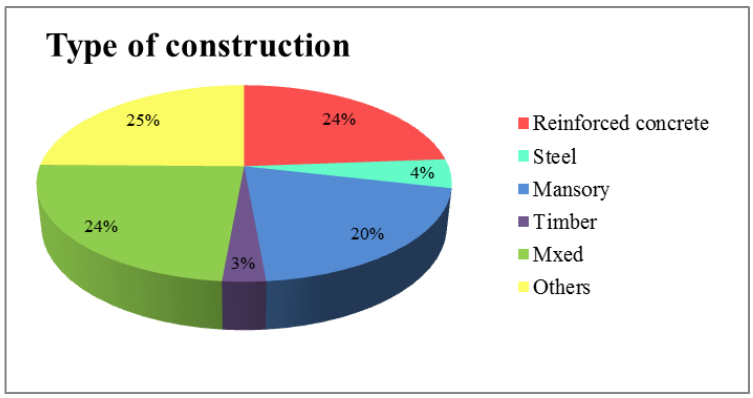
- Temporal detection of the defect



Graph 3.1 Statistic related to the analyzed cases (2011 and 2012): Temporal detection

The majority of the defects is observed during the service life, only the 10% is detected during the construction phase.

- Type of construction

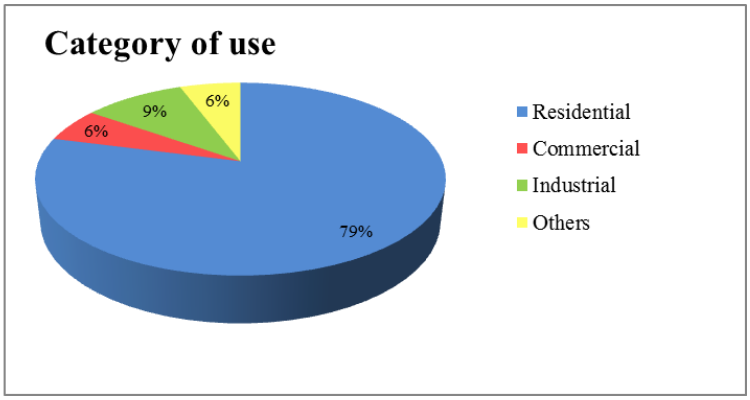


Graph 3.2 Statistic related to the analysed cases (2011 and 2012): Type of construction

Excluding steel and timber structure, the percentage of the defects among the remaining structural types is uniformly distributed. The efficiency of this section has been analyzed and treated in the previous chapter of the work. The percentage of the other section is quite high compared to the amount of data belonged to this

category. It is possible to affirm that the accuracy of the results has been compromised thanks to the fact that in many technical advices this information is not reported.

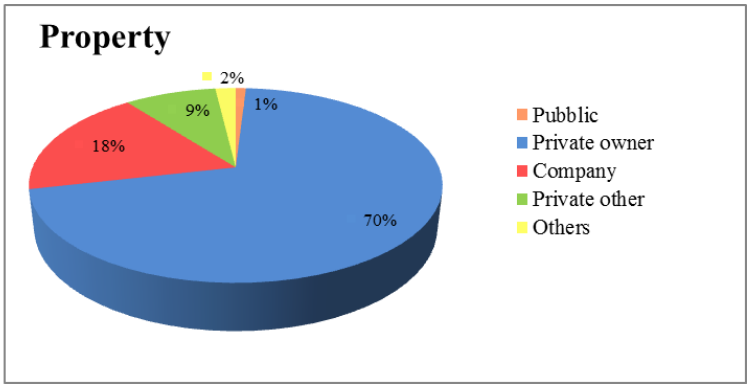
- Category of use



Graph 3.3 Statistic related to the analyzed cases (2011 and 2012): Category of use

The largest part of defect is detected in residential building (79%), followed by industrial uses (9%) and commercial uses (6%). The list could be improved but in any case the results are meaningful.

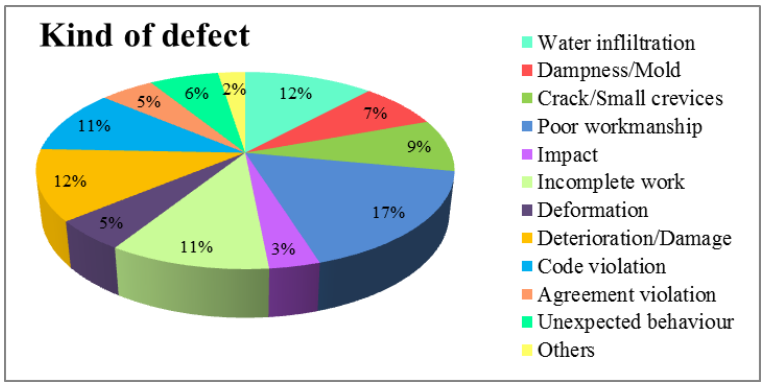
- Property



Graph 3.4 Statistic related to the analyzed cases (2011 and 2012): Property

The private owner involved in the litigation with a percentage of 70 % . Few cases (1 %) involve public property.

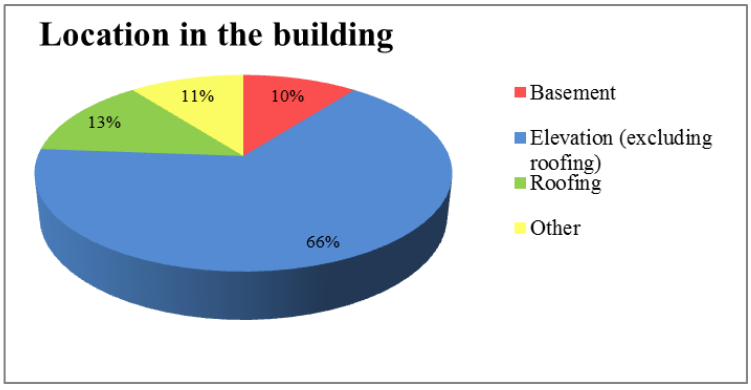
- Kind of defect



Graph 3.5 Statistic related to the analyzed cases (2011 and 2012): Kind of defect

The kind of defects claimed are quite large. Looking at the graph it is possible to observe that the poor workmanship is the most frequent cause of a defect (17%) followed by water infiltration, dampness, incomplete work and cracks (each one with a percentage between 11-12%). The differences of the percentage is really small. Significant results could be reached collecting a greater amount of data.

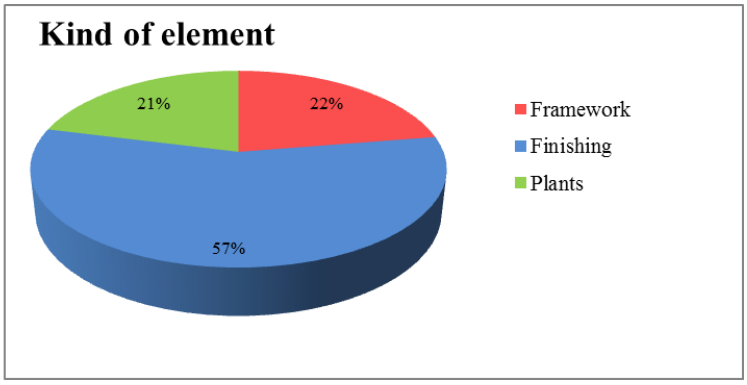
- Location of the defect in the building



Graph 3.6 Statistic related to the analyzed cases (2011 and 2012): Location in the building

The majority of the defects (66%) involves the elevation part of the building, the basement and the roofing have roughly the same amount of percentage. Despite in the matrix are not be considered the elements that are outside from the building system, the results are quite good, considering that the percentage of "other" is comparable to the other.

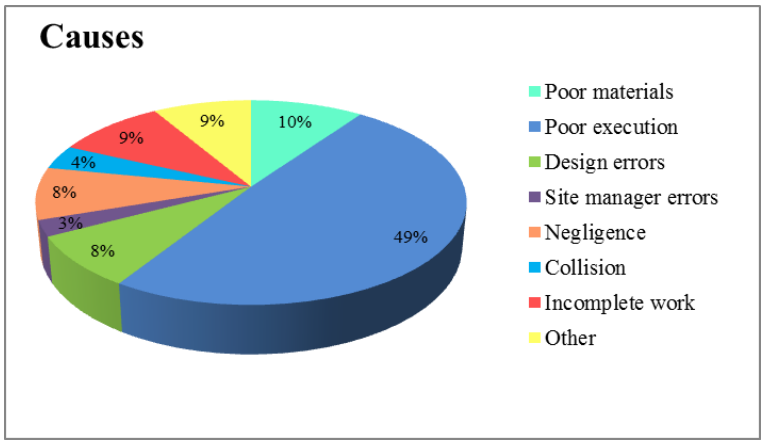
- Kind of element



Graph 3.7 Statistic related to the analyzed cases (2011 and 2012): kind of element

The defect are quite equally distributed to the elements of the building. Almost the 57% is concentrated in the finishing, the remaining part distributed between the structural elements and plants.

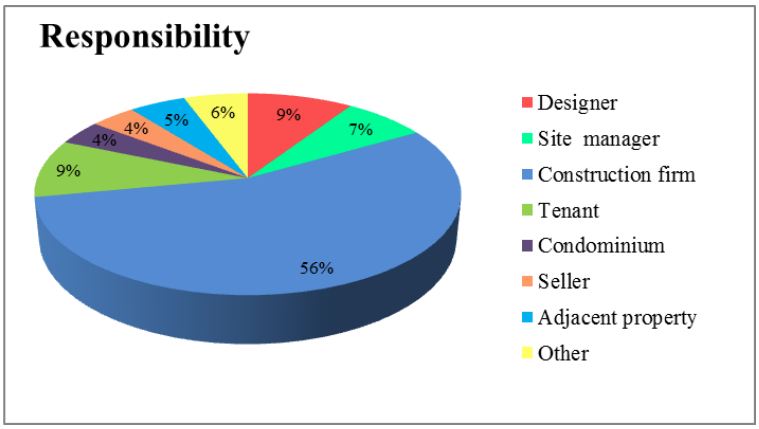
- Causes



Graph 3.8 Statistic related to the analyzed cases (2011 and 2012): Causes

In the 50% of the cases the defects can be attributed to an adequate execution. The remaining causes have almost the same percentage, excluding error due to an incorrect design, that has the lower concurrency.

- Responsibility



Graph 3.9 Statistic related to the analyzed cases (2011 and 2012): type of construction

The construction firm is in the almost the 60% of the cases responsible of the formation of defects.

3.2 Comparison of the data

The data available are related to a relative short period and the uncertainty concerning the accuracy of the results is high. For this reason in the following a the results of the 2011 and 2012 will be analyzed and compared in order to understand how the statistics have changed and try to determine, if it is possible, the common typology of defects, their causes and the responsibility.

MATRIX A

		2011	2012
d. Temporal detection	1. In service	88%	87%
	2. Under construction	12%	13%

Table 3.1 Comparison between the statistic of 2011 and 2012: Temporal detection

The data is stable for both years. This means that the data reported in the chart are trustworthy . It is possible to assert that the larger amount of defects occur after the construction.

		2011	2012
e. Category of use	1. Residential area	79%	77%
	2. Commercial area	6%	3%
	3. Industrial area	10%	12%
	99. Other	6%	8%

Table 3.2 Comparison between the statistic of 2011 and 2012: Category of use

Regarding the category of use the defects, they occurred in residential structure, the data are very similar. For the other category, it's possible to observe that the results change from one year to another. It is necessary to collect other information and understand accurately what happens in the reality.

		2011	2012
f. Type of construction	1. Reinforced concrete	21%	25%
	2. Steel	9%	3%
	3. Masonry	40%	5%
	4. Timber	0%	5%
	5. Mixed	28%	20%
	99. Other	2%	42%

Table 3.3 Comparison between the statistic of 2011 and 2012: Type of constuction

The observation made in the previous paragraph show that this section is not able to capture all the possible cases , especially because in many technical advices the typology of structure is not mentioned. The results are in this case meaningless. The only possible consideration is that the amount of defect detected in reinforced concrete structure and in steel structure is of the same entity.

		2011	2012
g. Property	1. Public	2%	2%
	2. Private	94%	98%
	99. Other	4%	2%

Table 3.4 Comparison between the statistic of 2011 and 2012: Property

			2011	2012
g. Property	2. Private	1. Citizen	68%	70%
		2. Society	17%	20%
		99. Other	9%	8%

Table 3.5 Comparison between the statistic of 2011 and 2012: Private property

Almost the totality of the defects are claimed by the citizen on private property . The veracity of these results is confirmed not only by the stability of the data but also by those values in accordance with the ones related to the category of use. The residual building, generally, are owned by private citizen.

MATRIX B

		2011	2012
c. Kind of defect	1.Water infiltrations	13%	12%
	2. Dampness/Mold	11%	6%
	3. Crack/Small crevices	8%	9%
	4. Poor workmanship	22%	15%
	5. Impact	7%	1%
	6. Incomplete work	11%	10%
	7. Deformation	6%	5%
	8. Deterioration/Damage	3%	16%
	9. Code violation	9%	11%
	10. Agreement violation	1%	7%
	11. Unexpected behaviour	5%	7%
	99. Other	5%	1%

Table 3.6 Comparison between the statistic of 2011 and 2012: Kind of defect

Excluding some entries in which the changes are evident, the data have a certain stability. The typology of defect is very wide, for this reason it is necessary to collect more evidence to have meaningful results.

		2011	2012
d. Location in the building	1. Basement	11%	9%
	2. Elevation (excluding roofing)	76%	61%
	3. Roofing	10%	15%
	99. Other	2%	15%

Table 3.7 Comparison between the statistic of 2011 and 2012: Location in the building

		2011	2012
e. Kind of element	1. Framework	31%	18%
	2. Finishing	49%	61%
	3. Plant	20%	22%

Table 3.8 Comparison between the statistic of 2011 and 2012: Kind of element

Although the percentage change from during the two years, the greater amount of the defects is shown in elevation and in particular in the finishing. Since this percentage is more relevant with respect to the other, the result can be considered stable.

MATRIX C

		2011	2012
b. Inspection method	1. Visual inspection	87%	69%
	2. In situ test	2%	13%
	3. Specific test	3%	9%
	4. Drawing check	0%	9%
	99. Other	8%	1%

Table 3.9 Comparison between the statistic of 2011 and 2012: Inspection method

A part from the specific cases in which particular test or analysis are required, the visual inspection remains the most useful method, with percentages that are always equal or higher than the 70%.

		2011	2012
d. Level of impairment	1. Structural safety/stability	12%	11%
	2. Functionality/Usability	47%	69%
	3. Aesthetical	35%	8%
	99. Other	7%	11%

Table 3.10 Comparison between the statistic of 2011 and 2012: Level of impairment

For the lack of a specific references in order to classy the compromising level this section can be considered useless, despite the greater amount of defect reduce the serviceability of the elements.

MATRIX D

		2011	2012
a. Cause of the defect	1. Poor materials	8%	11%
	2. Poor execution	56%	49%
	3. Design errors	3%	11%
	4. Site manager errors	0%	4%
	5. Negligence	5%	7%
	6. Collision	6%	0%
	7. Incomplete works	12%	9%
	99. Other	9%	9%

Table 3.11 Comparison between the statistic of 2011 and 2012: Cause of the defect

The statistics comparing two different years are almost the same. In both cases the execution that doesn't follow the best practice rule is the cause of the majority of the defects.

MATRIX E

		2011	2012
a. Responsibility	1. Designer	5%	11%
	2. Site manager	3%	10%
	3. Construction firm	51%	55%
	4. Tenant	15%	6%
	5. Condominium	10%	1%
	6. Seller	2%	10%
	7. Adjacent property	3%	6%
	99. Other	12%	2%

Table 3.12 Comparison between the statistic of 2011 and 2012: Responsibility

According with the causes of the defects, the greater amount of responsibilities are attributed to the construction firm. The increasing of the data collected can give a clear explanation of the results of other element of the list.

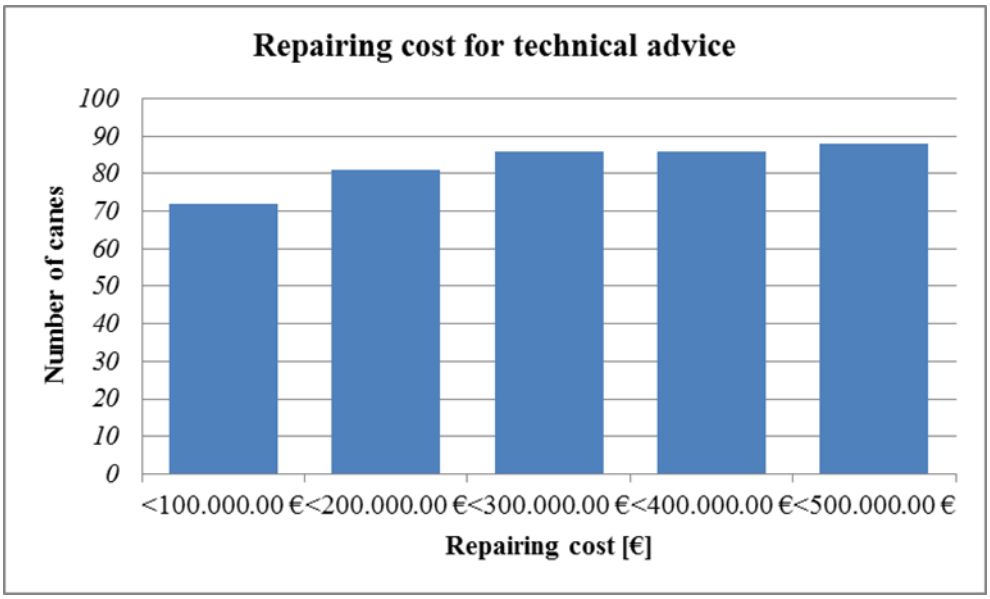
3.3 Analysis of the costs

The analysis of the repairing cost is not a simple operation. First, the database available and its structure cannot give a deepened analysis of the costs. Second, in many case, the consultant reports the cost to repair all the defects claimed on a civil works, without distinction between the different kind of defects. Two types of analysis have been studied and developed.

Repairing cost for technical advice

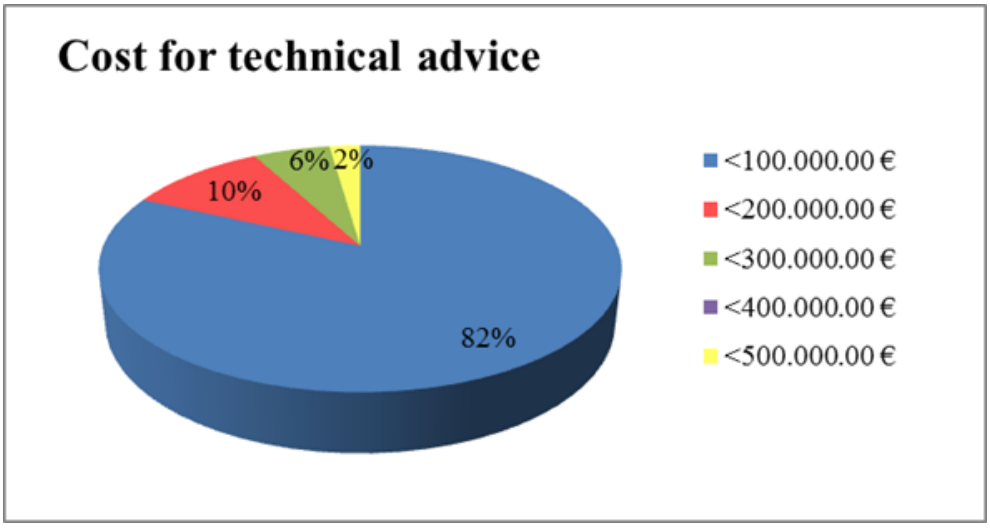
In this analysis are reported the repairing costs for technical advice, without considering the specific cost for each kind of defect.

The graph 3.10 shows on the horizontal axis the incremental costs (step of 100.000 €) and on the vertical axis the number of real cases that are in the specific range.



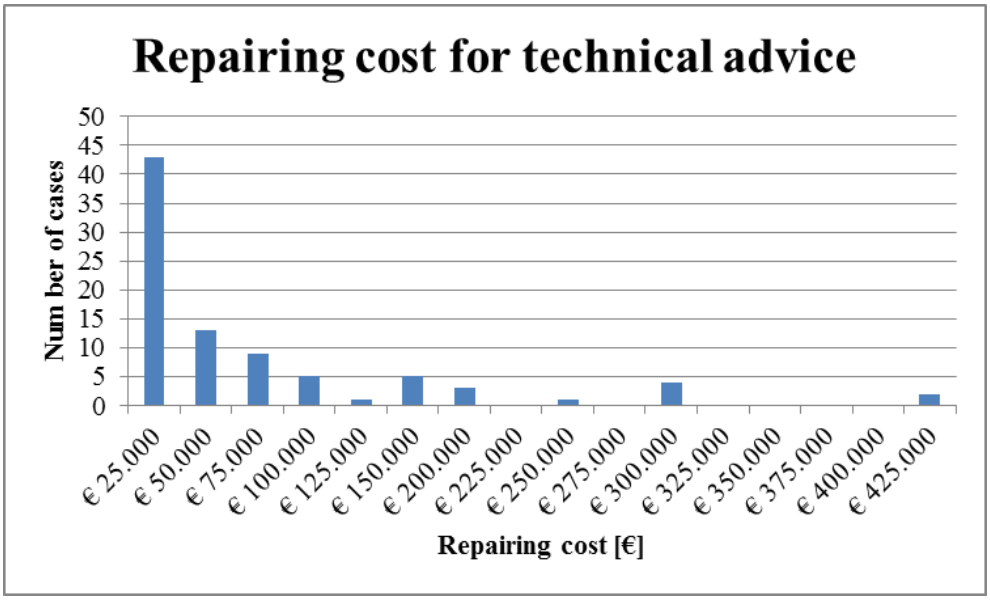
Graph 3.10 Repairing cost for technical advice (step of 100.000 €)

The graph 3.10 and 3.10 show that in the majority of the costs for technical advice are small than 100.000 €, only in few cases (less than 18%) the costs are exorbitant. The average repairing cost for technical advice is equal to 62.775€.

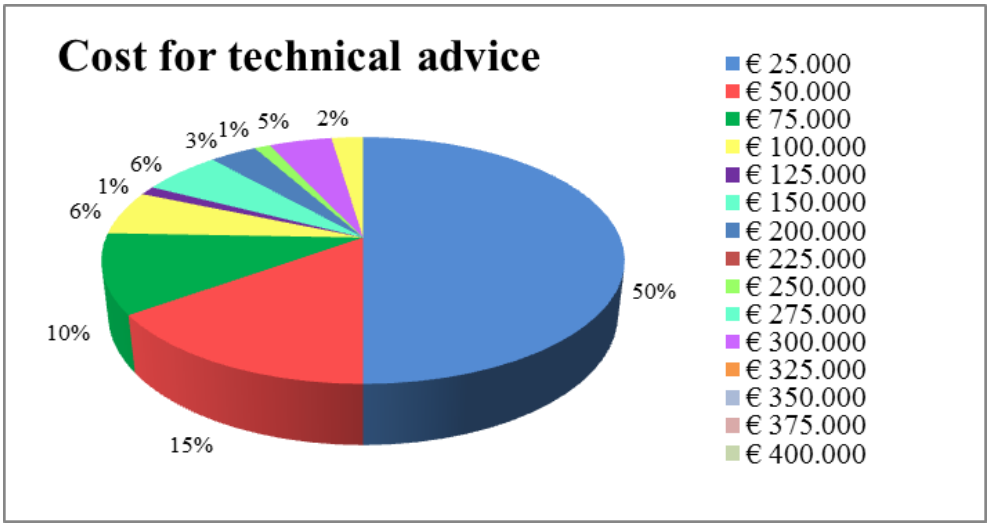


Graph 3.11 Percentage of costs for technical advice (step of 100.000 €)

A similar analysis is been carried out considering a smaller increment of costs. The the graph 3.12 are not displayed the incremental costs but the number of cases that are included in a certain range in the graph 3.13 are instead reported the relative percentage.



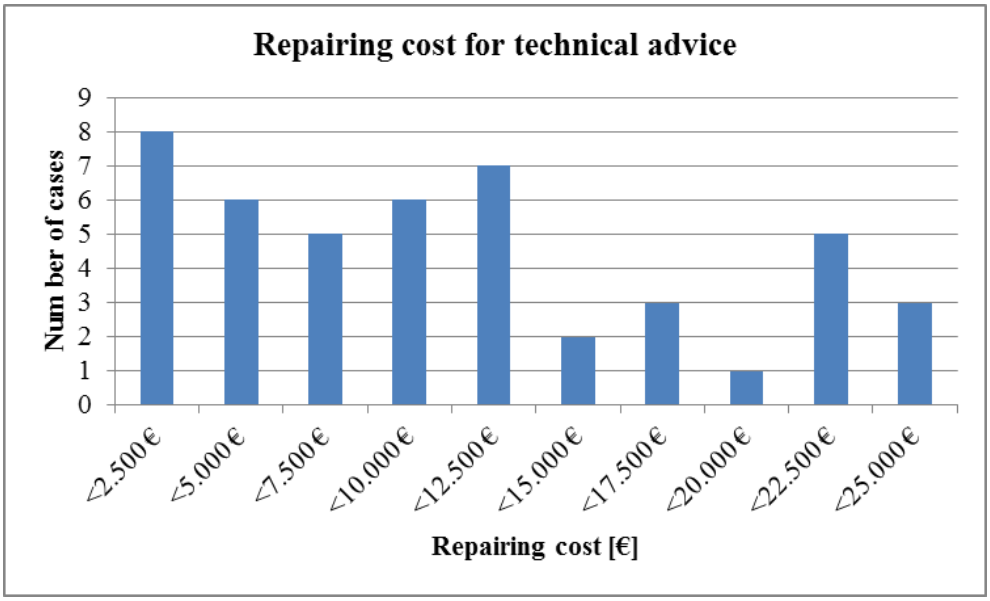
Graph 3.12 Repairing cost for technical advice (step of 25.000 €)



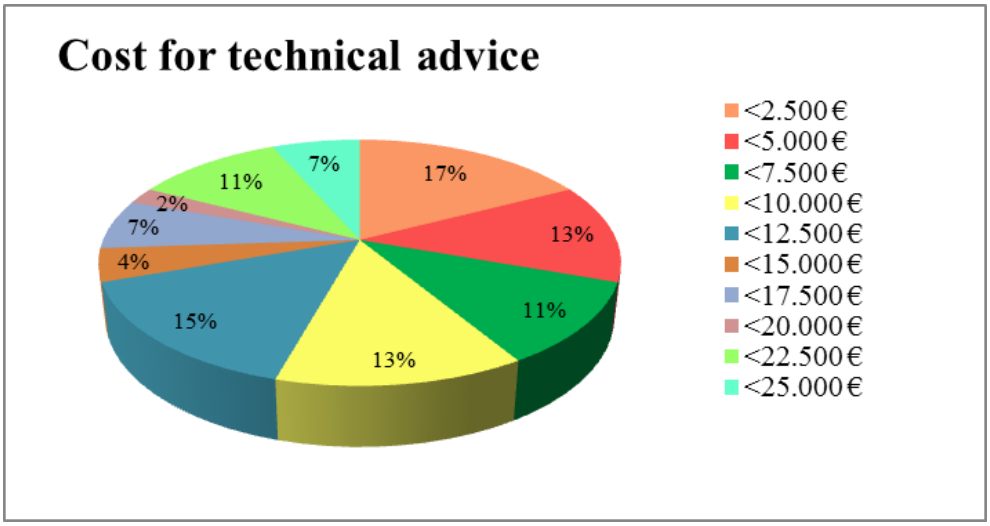
Graph 3.13 Percentage of costs for technical advice (step of 25.000 €)

The graphs show that in one half of the case the costs are smaller than 25.000€. For the remaining part, in the majority of cases the costs are smaller than 100.000 €, as mentioned before.

Since in one half of the case the costs are smaller than 25.000 €, could be important to develop a deepened analysis for this range considering a smaller cost step. The results are shown in graph 3.14 and 3.15



Graph 3.14 Repairing cost for technical advice smaller than 25.000 € (step of 2.500 €)



Graph 3.15 Percentage of costs for technical advice smaller than 25.000 € (step of 2.500 €)

The graph shows that the number of technical advice having a cost smaller than 5.000 € is the majority. In this range are included the 25% of the case.

Should be noticed that the number of cases having a cost greater than 12.500 € is quite decrease. The percentage of cases having a cost greater than this value is only of the 31%.

Anyway considering the few data available and the minimum variance between different cost step, this elements could not be considered significant.

Average repairing cost for kind of defects

For each kind of defect are been considering the minimum and the maximum value of repairing costs. The average repairing cost is obtained as the mean of these values. The results are displayed in Table 3.13.

Lawsuits of 2011 and 2012			
Kind of defect	**Max**	**Min**	**Average**
Water infiltration	*€ 125.534,02*	*€ 760,00*	*€ 63.147,01*
Dampness/Mold	*€ 54.000,00*	*€ 130,00*	*€ 27.065,00*
Crack/Small crevices	*€ 429.809,41*	*€ 240,00*	*€ 215.024,71*
Poor workmanship	*€ 114.000,00*	*€ 30,00*	*€ 57.015,00*
Impact	*€ 242.827,40*	*€ 383,00*	*€ 121.605,20*
Incomplete work	*€ 180.010,00*	*€ 90,00*	*€ 90.050,00*
Deformation	*€ 295.581,80*	*€ 7.832,16*	*€ 151.706,98*
Deterioration/Damage	*€ 265.200,00*	*€ 90,00*	*€ 132.645,00*
Code violation	*€ 145.000,00*	*€ 1.000,00*	*€ 73.000,00*
Agreement violation	*€ 84.258,00*	*€ 499,20*	*€ 42.378,60*
Unexpected behaviour	*€ 52.000,00*	*€ 300,00*	*€ 26.150,00*
Others	*€ 231.667,00*	*€ 20.800,00*	*€ 126.233,50*

Table 3.13 Average repairing coasts for each kind of defect

The structure of the matrix shows and puts in light that the maximum value for each kind of defect includes all the works that are necessary, including those for the reparation of other defects. When the elimination of two or more defects require the same activities, the technical consultant has to consider them all. For this reason the results of these kind of analysis should be considered with the proper attention. Despite that some results are meaningful. The higher repairing costs regards the elimination of cracks, deformations or other phenomena that could implied structural problem. Instead the minimum cost is shown for the elimination of dampness that certainly does not involve the safety of the structure.

Chapter IV

Focus

Ones of the main activity of the research center is the institution of periodic focus to answer specific question which arise from the analysis of the examined cases[1].

The world “Focus” indicates a person, a thing or a situation to which is given a certain importance. In the context of the Technical Advices, the focus are in-depth analysis regarding topics that are useful for the activities of the various actors involved in the field. These documents have different nature, they could analyzed recurrent issue encountered during the investigation of the real lawsuit or could clarified some aspects related to the investigation process. It is possible to identify two main typologies:

- Thematic focus;
- Methodological focus;
- Technical focus;

In this chapter, after a brief explanation of the main characteristic of the focus will be reported the documents developed on some specific aspect of the technical advices.

4.1 Typology of focus

During the investigation in the civil lawsuits the Technical Consultant has the task to joint technical knowledge and juridical notions, using a unique language which have to be shared by the different actor involved in the process. The lack of references, for a correct an univocally interpretation of the various issues, makes this assignment difficult.
The aim of the thematic focus is to create a guideline that helps, in the one hand, the consultant in the analysis of data and, on the other hand, the judge in the interpretation of the results, creating a common tendency that unify the overall view regarding the main and frequent issues.

The technical advice is the result of a set of investigations carried, together with the parties involved in the litigation, to respond to a specific question. The methodological focus have as topic the activity of the technical consultant. The goal is to help the management of the investigative operations and the relationships with the other professional figure involved in the process. The knowledge of the inevitable critical aspects is helpful for the development of a correct and rapid technical advice.

The aim of the technical focus is to establish, following an univocally tendency, specific technical information and references for the analysis of the common defects The typical structure of the this kind of focus is based on the data of one or few technical advice, that constitute the main reference, integrated by additional information from other technical advice, called satellite reference. Are included references from scientific literature or codes and alarge photographic documentation.

4.2 Methodological focus: The technical consultant in the civil lawsuits

The nomination of an expert in a civil lawsuit is necessary when the objects of the litigation require specific technical knowledge and could not be ascertain by the judge by the analysis of the deeds and documentations. In this case the judge

could avails himself of a technical consultant, in Italian "Consulente Tecnico d'Ufficio (CTU)"

The art. 61 of the Civil Procedure Code [2] regular the technical advice, more in depth the activity of the expert, that recites:

> *When it is necessary the judge could be helped, for the attainment of a single deed or of the entire trial, by one or more technical consultants having specific knowledge in that field.*
> *The choice of the expert must be done within the people registered in specified professional register that are regulated by the present code"*

The process of the technical advice is divided in different phase.

Designation

The designation is made by an ordinance of the judge. He fixes an appearance judicial hearing for the consultant to swear in, formulate the question and confer the task (art. 191 c.p.c [3].). The designation is discretional deed. It could be required form the parties or from the judge himself.

The first judicial hearing

In the first hearing the consultant after the admonition of the judge, takes an oath according with the art. 193 c.p.c. . At this point the judge formulates officially the questions, that were already fixed, that could be some modifications or integrations. The judge has freedom in the formulation of the question, also when of the parties requests the nomination of a technical consultant to analyzed some specific problems. The definition of them is fundamental for the investigation procedure carried with the parties (In Italian "Operazioni peritali"). At the end of the reading the consultant could decide to fix immediately the date of starting of the operation or in another time. The communication of the starting data is crucial since could a reason for the invalidation of the technical advice.

The parties could nominate own consultant called " Party consultant" in Italian "Consulente tecnico di parte (CTP)" to be helped during the operation of the technical advice.

Investigation activity in consultation with the parties

The activities throughout which the consultant investigate on the problems to respond to the question of the judge are divided in:

- Operation in the office: in which generally are made studies, deductions and evaluation in presence of the parties or their attorney;
- In situ operation: developed in the places object of the litigation.

Important aspects of the activity of the consultant are:

- The documents that he could acquire in the pursuance of his task to obtain useful elements for the anwers to the questions;
- The injunctions, that are required by the parties in order that the consultant consider some specific aspects or circumstances or carried out particular investigation or tests.
- The observations: scientific, methodological or technical evaluation made by the parties on the activities of the consultant. An example are the memories arranged by the party consultants.

Conciliation attempt

The technical consultant could make an attempt of conciliation between the parties involved in the litigation. The art. 199, , c.p.c [3]. envisages that when the parties reach an agreement, they have to sign an conciliation memorandum written by the consultant that should be included in the office file

Register of the technical advice

A proof copy of the report, containing all the different parts, must be sent to the parties within the terms prescribed by the judge in the first hearing (excluding the case in which a deferment is required) . The parties have to post their observation to the consultant and to the other part involved in the litigation. Finally the technical consultant could register the final report called technical advice (in Italian "Relazione peritale") in which are taking into account, so accepted or denied, the deductions of the parties that should be attached.

After the description of the consultancy process it is reported the typical structure of the technical advice:

Introduction

In this part are summarized the main topic debated in the first judicial hearing. The designation of the technical consultant, the oath, the parties involved in the litigation, the starting and finishing gate of the investigation activities.

The question

In this section are reported the questions formulated by the judge after the oath of the technical consultant.

Description and chronology of the events

Are briefly reported all the meaningful information that describes the circumstances that lead to the litigation and the different role of the involved parties. This information could be inferred by the documentations and files delivered by the claimant and the defendant.

Investigation activities

Are reported, in a synthetic way, all the meeting between the parties and the consultant during the investigative operation. In this way it is possible to have a simplified scheme of all the activity developed. The memorandums are integrally reported ad attached file in the technical advice.

Description of the place

In this section are reported the main information regarding the property or the civil work on which the defects are claimed. In particular:

- General overview: site and assessed valuation;
- Category of use;
- General description of the building.

Answer to the question

The examination of the different claimed defects is made following the list presented by the claimant. To simplify the reading could be useful reporting the answers to the different part of the question, regarding a specific defect, all together, avoiding cross-reference that could be confusing. In particular for each defect are reported its detection and the description, its causes, the responsibility, time and repairing costs, reporting also what is been reported during the investigation and the observation of the parties with reference to the specific aspect analyzed.

Preliminary memories and observation

In this section is reported a synthesis of the memories if the partiy consultans developed during the investigation activites and the observation to the proof report written by the consultant and preliminary send to the parties.

Conclusion

The technical consultant reports a brief summary of what he has previously explained in depth.

4.3 Methodological focus: The question

The judge has freedom in the formulation of the question, also when of the parties requests the nomination of a technical consultant to analyzed some specific problems. The questions depend on the exanimated case. However they could always be divided in three main parts:

1. Introductive part;
2. Central part;
3. Conclusive part.

In the introduction the judge asks officially to the technical consultant to proceed with the verification defining the boundaries of its action. This part is generally standard and has the formulation reported in the following:

> *"Accerti e verifichi il CTU, esaminati gli atti e i documenti di causa ed espletati i necessari accertamenti, richiesti eventualmente chiarimenti alle parti o assunte informazioni da terzi ex art. 194, 1 comma c.p.c."*

The judge authorizes the consultant to eximanate the deeds and documents necessary to carry out the investigation.

In the central part the judge specifies the element to analyzed (existence of the defects claimed, their description indicating causes and responsibility). Depending on the circumstances this part could be formulized in two different ways:

- Generic

The typical form is the following:

> *"Se sussistano o meno i vizi lamentati e assertivamente descritti dal ricorrente ed in caso di riscontro positivo, provveda alla loro analitica descrizione individuandone le cause e la loro concreta imputazione alle parti in giudizio costituite in relazione alla veste assunta nella realizzazione delle opere edili dedotte in atti;"*

The objects of the expert are facts in which all the elements are already been proved by the parties. The consultant should evaluate data that are been already ascertain, he should describe the state of the works, the defects and determine causes and responsibilities.

- Specific

The consultant has the task to ascertain situations that are not verifable without the use of specific and technical knowledge. The judge asks to clarify specific technical aspects. Some example are reported:

> *"Quali siano le opere ad oggi realizzate rispetto al contratto di appalto intervenuto tra le parti;"*

It is asked to determine which works, defined in the contract, were realized.

> *"Secondo quali modalità, direttive e progettazioni tecniche siano state eseguite"*

Which are the design technique and the executive procedures used for the construction of the works.

> *"Se dal … al … si siano verificati cedimenti o modificazioni delle opere realizzate da …: in caso affermativo, indicandone le cause e specificando se ciò abbia pregiudicato la sicurezza del cantiere e dei luoghi limitrofi"*

Ascertain the presence of excessive deformation of alterations that compromised the stability of the structure and the safety of people and things.

If the question are too generic the consultant on the one hand has the possibility of conduct the investigation without many constrains on the other hand it could encountered the opposition of the parties that want that the analysis is conduct following their presuppositions. In the opposite case, if the question is too specific and detailed, the consultant has difficulties in the analysis of the real issues. In fact during the operation carry with the parties the defect and problems found could be different with the one claimed at the initial inquiry. The consequence is an useless and misleading technical advice. In this case, when the consultant does not see fit the question to the description of the situations and the defects, could ask specification to the judge throughout an injunction. An optimal solution is the compromise between the specific and generic question. In which inside the formulation of the generic question are reported specific point that the consultant should analyzed.

In the final part the judge asks to the technical consultant to evaluate the time and the construction cost of the repairing works and their consequences, that means the habitability during the operations or an eventual reduction in the market value of the property. Should be notice that this evaluation is approximate and based on the experience and knowledge of the technicians. The consults has not the assignment of draw up an executive project and for this reason has no responsibility on it. If there is the need of develop an executive design the judge

will explain in the question. The typical conclusion part has the following formulation:

> *"Indichi i lavori necessari per il ripristino di tutti i vizi riscontrati (senza che tale indicazione assurga all'estremo di progetto) proponendone le modalità di massima e quantificandone i costi (specificando se si tratta stima dei costi comprensiva o meno di iva e quale sia il grado di variabilità della stima stessa), ivi compreso, ove possibile, il minor valore degli immobili realizzati, i costi per i professionisti e le eventuali sanzioni, suggerendo anche la stima del tempo necessario per eseguire le opere di ripristino e specificando se in concomitanza dell'esecuzione di tali opere l'immobile per cui è causa potrà essere abitato o dovrà essere sgomberato."*

The judge asks an approximate evaluation of the works necessary for the elimination of the defects, without the development of an executive design. The evaluation of:

- the repairing costs, giving specific references for the different items and indication how they were estimated ;
- Loss of market value of the property;

Estimation of the duration of the works, specifying if during the operation the property could be used.

4.4 Methodological focus: The reference profile of the technical consultant

The operations of technical advice require the adoption of a series of rigorous procedure characterized by a judgment well-structured, logical and progressive.
The technical consultant should have particular requirements, as reported in [1]:

- Proved and incontestable professional practice;
- Good knowledge of juridal process in order to respect the rights of the parties;
- Capacity of analysis and synthesis;
- Sensitive to human relationship;
- Integrity and impartiality;

- Constant update;
- Independency in the judgment.

With the investigation activities, carry out with the parties, the consultant develop all the verification necessary to answer to the question of the judge. Give a definite and univocal answers to complex issue is not easy due to the presence of intrinsic criticality.
Could be useful the redaction of a protocol to unify and clarify the investigation procedure. The typical problems that a consultant has to solve are:

1) Evaluation of the existence of the claimed defects;
2) Identify the causes of the defects and the responsibilities of the parties;
3) Evaluation of time and costs of reparation.

Evaluation of the existence of the claimed defects

In the first meeting of the investigation activities the consultant reads the questions, examines deeps and documentations reported in the party files, decide the investigation procedure, schedule the timing of the future activities and accepts eventual injunctions of the parties.
In these phase it is suitable:

- The redaction, in accordance with the parties, of a list of the defects
- Identify code, contractual or technical references in order to verify, in an incontrovertible way, the presence of defects.
- Agree with the parties on the modality with which the investigative activities will continuous, in particular on the inspection method to use (visual inspection, in situ test, laboratory test etc…).

The technical consultant should interrupt the activities and ask an additional hearing when:

- the questions formulated by the judge are not sufficiently clear or there is no agreement between the parties on their interpretations;
- The first results of the tests show the need of a board of experts having specific knowledge of some aspects emerged during the verifications;

- One of the parties makes impossible the verifications.

The main criticality emerged during this phase are the identification of precise reference parameter, especially when it is required to evaluate that the works are realized in accordance with the best practice. In this latter case the subjective interpretation are more frequent since the specific knowledge are strictly dependent on the experience of the technician and are not always codified in regulation or manuals. Another problem is related to the extension of the defects. In this case the consultant cannot conduct verification on the entire area, especially if in situ or laboratory tests are required. This is because the costs would be comparable with the one for reparation, so from an economical and technical point of view it is not convenient. Typically the consultant carry some tests on specified area whose choice should be made in accordance with the parties to avoid opposition or complaints.

Identify the causes of the defects and the responsibilities of the parties

The detection of the defect is not always sufficient for the identification of the causes and responsibilities. In this case additional tests should be performed. The interaction with the parties is fundamental to decide the best and easier way of verification. In absence of agreement the consultant or in the case of expensive tests the consultant have to request a specific injunction to the judge to obtain the necessary permissions.

In some cases the analysis of all the possible causes is too complicated and would lead to extremely long time and the consultant is forced to verify only the most probable hypothesis from a technical point of view. In this case is suitable that the party consultant indicate the causes that they retain appropriated to verify. In this way it is possible to reduce the time of the investigative operations.

Evaluation of time and costs of reparation.

The evaluation of the repairing costs should be performed by the technical consultant on the base of objective values as the one take form "The regional pricelist" for the different kind of works. The estimation of the repairing costs is

often the real reason behind the technical advice and the variability of all the concomitant factors makes very complex this operation.

The estimation of the repairing costs has the greater number of uncertainties, including also the ones discussed in the previous point. Evaluate with precision the repairing work necessary for the elimination of a defect, and the consequent costs, is almost impossible if the causes or the extension of the damages are not univocally determined.

If the origin of the defect is not clear, reasonably, the consultant is oriented toward the reparation of the entire portion where the damage is claimed. Considering the case in which a waterproofing is not installed correctly, leading to infiltration of water. In order to identify the exact point in which there is the disconnection would be necessary the removal of the entire sheats, with costs that are comparable with the repairing one.

The uncertainties are related to:

- Identification of the proper design solution for the elimination of the defect. It is only indicative since the consultant is not in charge of the executive design.
- The costs' variality of the repairing works. The reference costs could change in time, furthermore some quantities are completely defined only during the execution of the works.

After this dissertation on defects, causes responsibilities and cost it is important to underline some peculiar aspects:

- It is important to report in the technical advice the references to code, manuals or contracts on which is based the analysis of the defects. In also important to include the comments and the observation of the party consultants;
- It is important to define the investigation modality in accordance with the parties, indicating also in this case eventual references to the code or to the techniques to adopted;
- It is fundamental to take notes of all the activities and test performed with a suitable memorandum elaborated in consultation with the parties.

In the figure 6.43 is displayed a graphical scheme reported the main activities and criticalities of the investigation process.

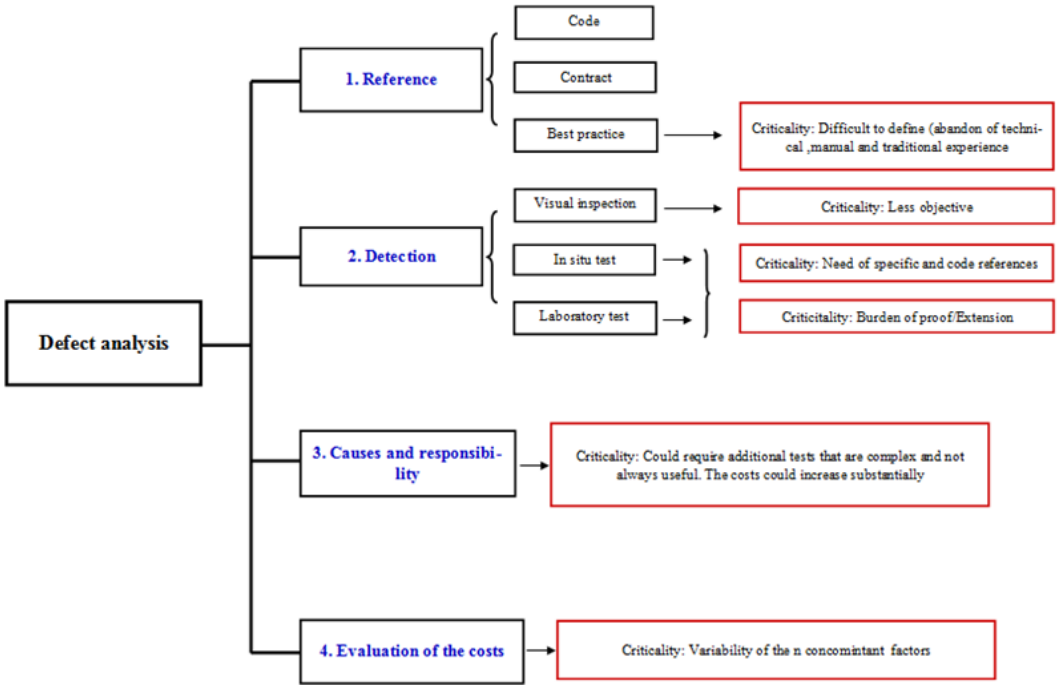


Figure 4.1 Graphical scheme reported the main activities and criticalities of the investigation process.

4.5 Thematic focus: The relevant defect

The Civil Code makes a definitely distinction between "dissimilarity and faults" and "relevant defects". The principal distinction concerns in the timing for the denunciation and the prescription period.

The article 1667 of the Civil Code [4] regulates the cases in which the buildings shows dissimilarities or faults. The dissimilarity is the disagreement of the work from the contract; The fault is the lack of quality or an execution that is not in accordance with the best practice. Independently form the agreement the seller or the constructor must deliver the work completed and realized in accordance with the best practice.

The relevant defect, instead, is defined by the article 1669 of the Civil Code [4] that asserts:

> *"in the case of building or other property, intended for their nature to have a long life, the contractor is responsible toward the client if during the first ten years from the finishing the work shows, entirely or in part, safety problem or relevant defect. The charge must be done within an year from the discovery. The right of the client is expired in one year from the denunciation."*

The technical consultant should join the technical and the juridical knowledge. The aim of this paper is to define a connection between these different field to help the technician in the definition of which defect could be considered relevant, from a technical and juridical point of view.

The "Norme Tecniche di Costruzione 2008 (NTC2008), at chapter II, first paragraph, establish Principles and requirements for the safety, serviceability and durability of structures, describe the basis for their design and verification and gives guidelines for related aspects of structural reliability.

> *"The safety and the performances of a structure are evaluated considering the limit state that could be appear during its intended life. The limit state is the condition s beyond which the structure no longer fulfils the relevant design criteria. In particular , as defined in specific chapters, the different type of constructions should have the following requirements:*
> - *Safety in confrontation of the ultimate limit state (ULS): ability to avoid collapse or loss of equilibrium of the structure or any part of it, that could preclude the safety of people, the loss of goods or cause relevant environmental or social damages;*
> - *Safety in confrontation of the servisability limit state (SLS)): ability to ensure the functioning of the structure or structural members under normal use. [9]*

Overcoming only one of these limit state, prescribed by the code, implies a relevant defect in accordance with the art. 1669 c.c. .

The NTC 08 regulate the design and the verification only of the structural members, more complicated is the definition of relevant defect for the non-structural elements like sealing, finishing, plants or any other architectural element. For these element is possible to refer at the regulation UNI 8289 "Building – Functional requirement of final users – classification". The rule defines the need of the final users that identify the requirement that each technological unit of the building system must satisfy [13]

1. Safety: set of the conditions concerning the integrity of the users, as well as the defense and the prevention from the damages due to accidental factor during the service of the building system.
2. Wellness: set of the conditions concerning the state of the building system adequate to the life, the healthy and to the pursuance of the users' activities.
3. Usability: set of the conditions concerning the aptitude of the building system to be adequate used for the users in pursuance of their activities.
4. Appearance: set of the conditions concerning the way of looking the building system by the users.
5. Management: set of the conditions concerning the ability of the building system to be used sparingly.
6. Integrality: set of the conditions concerning the aptitude of the technological unit of the building system to work together in a functional way.
7. Environmental safeguard: set of the conditions concerning maintenance and the improvement of the environment in which the building system is located.

The requirements defined in the first three points (Safety, wellness and usability) are the same prescribed by the limit state defined in the NTC08. The absence of only one of these could be considered as a relevant defect. Instead the lack of the requirements defined in the remaining point (Appearance, management, integrality and environmental safeguard) does not imply a relevant defect. This classification could be applied both structural and architectural elements. The validation of this could be found in some sentences of the Court of Cassation:

> *" The relevant defect are also the phenomena that do not influence the static of the constructions but produce the alteration, in consequence of unsatisfactory works, of non-structural elements prominently diminishing their enjoyment or their value."(cfr. Trib. di Bologna sent. del 20.06.2011; Cass. n. 11740/2003; n. 117/2000; n. 4692/1999).*

Once again could be considered relevant defect:

> *"the construction deficiency that restrict in a considerably way the enjoyment or the usability of the building system. They refer to the works in which the material used are not suitable or not realized following the rules given by the best practice, also if involves secondary elements (as waterproofing, flooring, sealing, plant, etc.) as long as they influence negatively the serviceability and are eliminable only with maintenance works" (Cass. civ., Sez. II, sent. n. 8140 del 28-04-2004).*

> The Court of Cassation clarifies that :

> *"The prescription of the art. 1669 c.c. regulate the damaging consequences of the building defect that affect the structural element and the functionality of the work. Instead the prescription of the art. 1667 c.c regulate the cases in which the structure is not consistent with the project or with the contract, this means that the work is not in accordance with the best practice." (Cass. Civ. n. 3002/2001).*

A further references, regarding the definition of relevant defect, is present in literature. In the publishing of [10] is reported an illustrative list of the defects that are been considered relevant on not from a Juridical point of view.
Are been classified as small defect:

a) The detachment of a part of the flooring (Trib. Cagliari 21.04.1995);
b) Defect of a false ceiling and the lightning system with the detachment of a chandelier (Cass. Civ. 1396/99);
c) Poor execution of plasterworks and the arrangement of the shingles on a roof (C. App. Napoli 12.11.1998);
d) Defects in the remaking of the electrical system and in the installation of inner and outer frames. (Trib. Milano 26.02.1998)

e) Execution of a flooring in discordance with the best practice (Cass. Civ. n. 682/2006);
f) Defective execution of the waterproofing on the roofing of an outer garage (Cass. Civ. n. 7651/1994).

Are been classified as small defect:

a) Deficiency of the waterproofing with consequent infiltration of water inside the property (Cass. Civ. n.117/2000; Cass. Civ. 3366/1995)
b) Presence of dampness due to the lack of insulation (Cass. Civ. 3146/1998);
c) Crack of the structure, imperfections and dissimilarities that diminuish the market value of the property without any hazard (Cass. Civ.2977/1998);
d) Wrong slope of the balcony with consequent infiltration and water stagnation in the infill walls (Cass. Civ. 3301/1996);
e) Inadequate capacity of biological tank and sewer system (Cass. Civ. 13106/95; Cass. Civ. 2775/1997);
f) Defect in the heating plant leading to the malfunctioning (Cass. Civ. 1081/1995);
g) Defects in the flue that lead to the malfunctioning of the heating plant avoiding the normal enjoyment of the property (Cass. Civ. 2763/1984).

Some example, taken from the analysis of the Technical advice on the Court of Bologna, are reported to better clarify the concept.

Small defect

Cracks

N° R.G 15547/2012

On the wall are been detected crack pattern not ascribable to structural failure. The defect involves only the plasterwork, without any problem for the safety or the usability of the property.

Figure 4.2 Cracks on the plasterwork

Dampness and water infiltration

N° R.G 16783/2012

Small water stain are been detected. During the rainfall event occurs in the day of the inspection, no evidence of the defects are been displayed. The phenomenon is occasional and not implies any reduction for the usability and the functionality of the place.

Figure 4.3 Dampness patches on the intrados of the slab

N° R.G 16783/2012

There are dampness patches on the wall, however the defect do not impair the usability and the healthiness of the place.


Figure 4.4 Evidence of dampness on the walls

N° R.G 8593/2012

On the ceiling of a garage are been detected water infiltration due to errors in the installation of the waterproofing. The dampness patch are visible indifferent portion but considering their extension and the category of use of the room they do no reduce the usability.

Figure 4.5 Water infiltration evidence on a ceiling

Damages

N° R.G 10064/2012

The majority of the window sills and the thresholds show cement stains producing an aesthetical damage of the elements.

Figure 4.6 Cement stains on the windows sills and thresholds

N° R.G 13710/2012

The painting shows swellings and scattered detachment. These defects are located on a balcony and are not able to impair its usability producing only aesthetical damages.

Figure 4.7 Detachment and swelling of the painting

N° R.G 13710/2012

The roofing shows cleavages, the shingles are decayed and cracked. Despite the deterioration there is no danger for the safety of the people furthermore within the structure are not detected damages.

Figure 4.8 Deterioration of the shingles

Flooring detachment

N° R.G 10064/2012

There is a detachment between the flooring and the sealing of the wall. The cause of the defect is a defective execution. The usability of the flooring is not compromised.

Figure 4.9 Detachment between the flooring and sealing of the wall

Relevant defect

Cracks

N° R.G 16577/2008

A scattered crack pattern is visible on the wall. The crack are quite wide (6/7 mm) and are due to an excessive deformation of the slab. The dimensions of the cracks are bigger with respect to the one reported in previous documentation. This means that the phenomenon represent an increasing instability that impair the static and the functionality of the work.

Figure 4.10 Large crack on the wall

N° R.G 8593/2012

The masonry enclosure shows small cracks due to an excessive deformation. The code limits the deformation of the structure. The measurement prove that the serviceability limit state is not verified.

Figure 4.11 Cracks on a masonry enclosure

Dampness and water infiltration

N° R.G 17868/2012

The water infiltration cause the deterioration and the detachment of a large portion of the plasterwork surface making impossible the usage of the property.

Figure 4.12 Deterioration of the surface due to infiltration of water

N° R.G 8337/2012

The deterioration of the roof coverage and the lifting of the waterproofing are the causes of water infiltration inside a storage. Despite the phenomenon is quite limited, the presence of stored materials, expensive equipment and electric cables lead to a danger situation and reduce considerably the usability.

Figure 4.13 Lifting of the water proofing **and consequent infiltration of water**

N° R.G 8551/2012

On the wall is possible to see stains due to water infiltrations. Moreover extreme rainfalls event cause the flood of the rooms preventing the regular usage. In this case the water infiltration could not be considered only as an aesthetical damage but impart the serviceability of the good.

Figure 4.14 Stain on the flooring due tp water stagnation

Water stagnation

N° R.G 16783/2012

The slope of the balcony is not been realized in the proper way. During the rainfalls event the balcony are completely flood and could not be used for several day. This defect reduce the their usability.

Figure 4.15 Water stagnation on a balcony

N° R.G 10064/2012

The measurements made by using the bubble level show the lack of flatness of the flooring of the balcony causing water stagnation that prevent the regola usage beyond the formation of unpleasant stains.

Figure 4.16 Water stagnation due to inadequate slope

Damages

N° R.G 10064/2012

The shutters of the French- window are not aligned. This kind of defect is not only aesthetical but reduce the usability since leads to losses of insulation.

Figure 4.17 Misalignment of the shutter of a French-window

N° R.G 8551/2012

The railing of the building, made by pre-fabricated elements in pre-stressed reinforced concrete, are decayed, disjoint and inclined. The cause is an insufficient anchorage. Between the panels and the case structure of reinforced concrete cast in situ. This situation is dangerous for the integrity of the people. The panel, inclined only for the action of their self-weight, are not able to resist to the lateral forces defined by the code. The defect impairs the static of the elements.

Figure 4.18Instability of the railing of the building

Detachment of the flooring

N° R.G 10049/2012

The baseboard is detached form the flooring. The cause of the defect is an excessive deformation of the slab. Beyond the undeniable aesthetical damage this defect reduce the functionality of the good since the requirement prescribed by the serviceability limit state in the code are not fulfilled.

Figure 4.19 Detachment of the base board

4.6 Thematic focus: Etiology of the events

The analysis and the study of the reasons for which some events or processes happened (from the Greek language *aitia*=cause and *logos*= word/speech), or the reason that are behind specified occurrences, is an integrant part of the technical advice. The reconstruction of the contingency relationship, that is the connection throughout which is possible to ascertain that a given event is the consequence of a certain action, has a very relevant role.

The word "cause" indicates each single condition of the event without which the event would not occur. It is important, in every analysis following an event, distinguish between the two etiological category that identify the temporal and casual progression of the episode involved in the same event, that are:

- Predisposing causes: the subsequent phenomenology;
- Triggering causes: in the strict sense the event.

The distinction in these two groups is essential for the technical consultant in order to establish, for the juridical authority, exact responsibility profiles at the different levels. [1]

A very practical but exhaustive example is the following:

Considering a tank having an height is equal to 3 m. The level of the water contained in it is equal to 2,99 m. At a certain point starts to rain. In two hours the depth of rainfall fallen is equal 2 mm. Obviously the tank would be saturated and the water overflows. The triggering cause of the flood is the rainfall event, but the predisposing cause is the fact that the tank was already full. If the level of the fluid inside it was properly controlled, there would be not the flood.

Another illustrative example, found during the analysis of the real cases at the Court of Bologna, is reported.

N ° R.G 5695/2012

After the copious snowfalls of the January and February 2012 on Bologna, the detachment and the collapse of a wall covering of a building, used as a school, occurred causing the closure of the facility. The fault affected an embossed

portion of the external wall, characterized by the absence of sealing structures on the side.

Figure 4.20 Collapse of the top part of the front and detachment of the wall covering

In order to define the causes and the responsibility some investigation method are been used:

- Altimetry reading of the façade
- In situ survey

Figure 4.21 Connection element near the windows and in the jambs between the windows

Figure 4.22 Anchorage of the wall covering to the frame

- Thermography survey

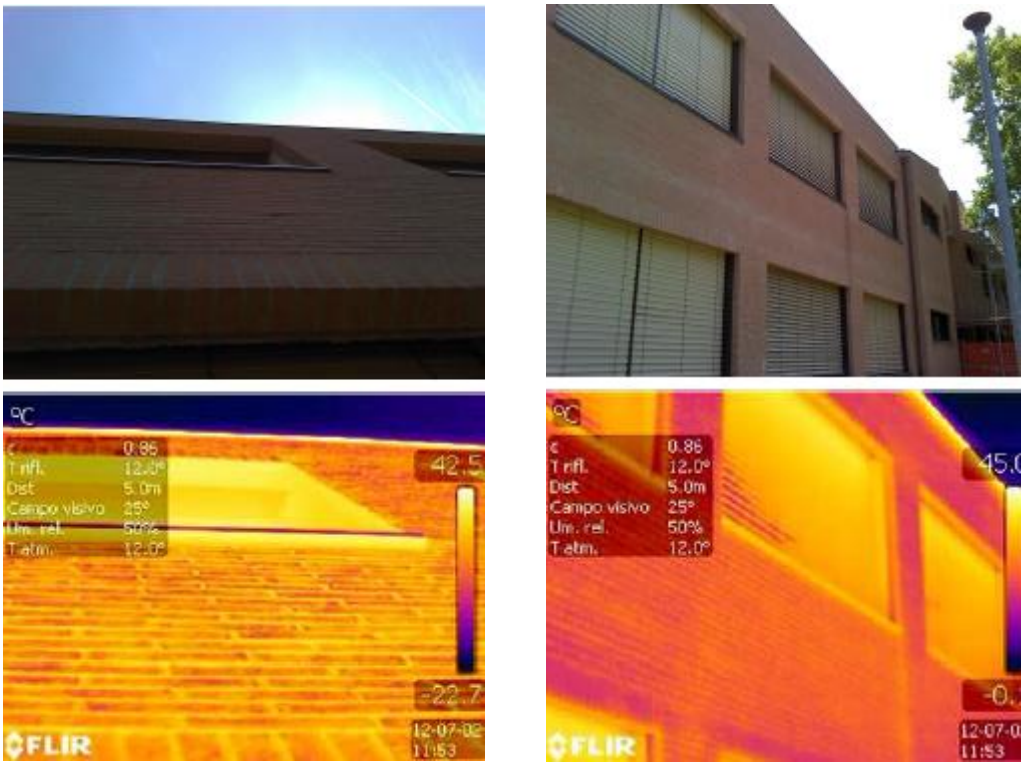


Figure 4.23 Result of thermography

- Overturning verification

The altimetry readings show displacements of the wall with respect to the vertical plane up to 62 mm. These values indicate the presence of a strain state that could be considered dangerous in absence of specific information concerning the realization of the anchorages.

The in situ and thermography surveys show that the number of connection, between the wall covering and the behind structure is insufficient. Furthermore the typology of anchorage used is not able to between create an efficient constrain to the horizontal displacements

For the top part was performed an overturning verification with respect to the horizontal action of the wind. The calculation are performed by following the prescription given by the NTC 08 in the paragraph 3.3.. The overturning of the top part occurs for wind pressures smaller than the values defined by the code.

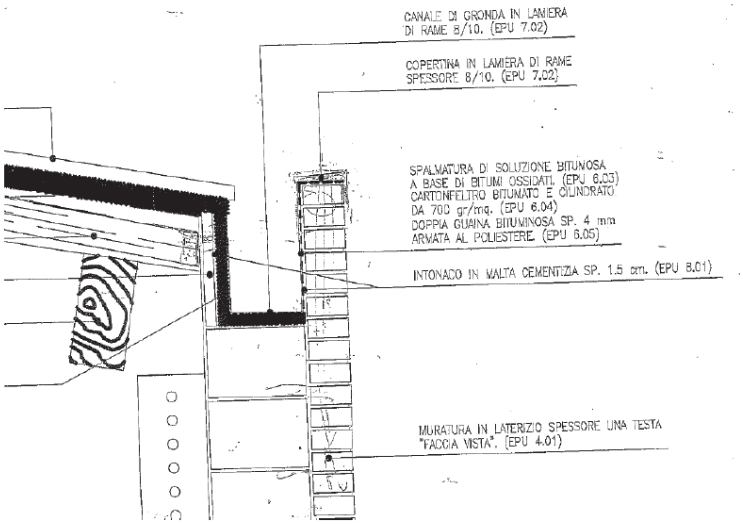


Figure 4.24 Wall covering detailing

The wind is considered as a horizontal pressure evaluated as (eq 3.3.2 par 3.3.4 NTC08):

The coefficient values changes depending on the surface that is considered, it being windward, leeward and depending on the type of the roof, they can be determined by looking at the "Istruzioni per l'applicazione delle 'Norme Tecniche per le Costruzioni' di cui al D.M. 14 gennaio 2008".

Finally has been obtained:

Windward:

$$\mathbf{P(0,8)= 658,7\ N/m^2 = 0,67kN/m^2}$$

Leeward:

$$\mathbf{P(-0,4)= -329,4\ N/m = -0,33\ kN/m^2}$$

The verification are performed by considering the rules given by the code and the action calculated before. The model used are representative of the behavior of the structures or the conservative limit case with respect to it. The overturning resistance is evaluated only for the top part. The actions are schematized in figure 26.

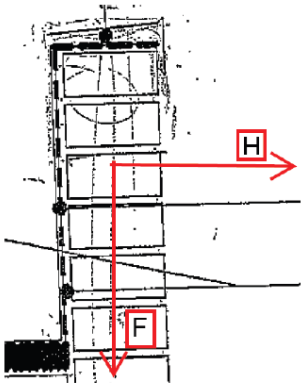


Figure 4.25 Schematization of the action acting on the wall covering

The overturning force, due to the wind pressure, can be evaluated imposing that the stabilized and overturning moment, calculate with respect to the rotation point, are equal.

The rotation of the panel occurs for value of wind pressure ($p = 68,6\ kg/m^2$) close to the ones defined by the code ($p = 67\ kg/m^2$) .

Considering as limit condition the one in which there is the partialization structure of the cross section or in absence of connection between the wall covering and the behind structure, the minimum values are much smaller with respect to the one prescribed by the code.

A first cause of the defects is ascrivanle to the snow accumulation on the roofing of the building. A contributory caise is the lack of maintenance and in particulare the immediate removal of the snow considering also the possibility of freezing. However the causes could be entirly ascribed to the lack of an adequate system of connection between the wall covering and the framework and the absence of an efficient constraind system for the horizontal displacement. No responsibility could be assigned to the copious snowfall. In fact this situation could not be considered in the design and in the construction phases. Despite an immediate

removal of the snow near the eaves channel could limitat the damages is not acceptable the the designer and the construction firm had not adopted solutins able to reduce the thrust of the snow avoiding the detachment and the collaps of the walls. From the results of the analysis could be defined:

Predisposing causes:

- Lack of an efficient constraind system for the horizontal displacement;
- Lack of an adequate system of connection between the wall covering and the framework;

Triggering causes:

- Copious snowfalls;
- Late removal of the snow on the roofing.

In this case the technical consultant ascribes the responsibilities only to the professional figure involved in the building process for the absence of a correct design, verification and execution of a structure able to withstand to the loads due to the meteoric events.

4.7 Thematic focus: The expected behaviour

The people are more familiar with the management of the consumables with respect the properties (it is easy estimate the shelf life of a mobile phone, complicated is the estimation of the shelf life of the painting of the houses). For this reason sometime the effects of the normal evolution of a building system could be considered as defects or faults. It is important to define the concept of "expected behavior" that could help the technical consultant in the individuation of causes and responsibility of the defects on the building elements. Give a definition clear and unambiguous from a technical and juridical point of view is not easy. In fact in the Italian Civil Code there are not background materials that could help in this task.

The sentences of the judge *Liccardo* in the civil lawsuit number 11428/2003 R.G., sets a precedent:

> *" the state of the building works is ascribable to the notion – common in the building technic – of expected behavior, that is the common state of wear due to the timing, so it is not attributable to the sellers or the construction firm "*

From a technical point of view the expected behavior of a structure is strictly related to the concept of long term behavior. The ageing and the decay of the materials and the technological elements of the building system, especially in absence of an adequate maintenance or due to an improper uses, are common phenomena that should be taken into account. When the negative performance are shown in unexpected time there is a defect or a fault.

The old building tradition and manual are fallen in disuse leading to the abandoned of the past knowledge. It is necessary to arrange an adequate activity of bibliographic research to recompose the set of technical knowledge regarding the normal behavior of the different kind of building units.

Different example were found in the technical advice of the Court of Bologna. In the following are reported the most significant that could be a reference for the technical that deal with this kind of issues.

Expected behavior due to lack of maintenance

All the elements of the building system are subjected to climatic and environment factors and situation of common use that lead to the physical degradation. The periodic maintenance works or the substitution of elements or parties, have the goal to eliminate or delay the natural degradation, avoiding bad influences on the entire building system.

N° R.G 16783/2012: Decay of timer elements due to the atmospheric agent

The defect involves the element of an inclined pitched roof having a structure made in layered wood with a covering of Canadian shingles. In particular is

claimed that after few years form the construction these elements show an high level of deterioration.

Figure 4.26: Degradation of a wood roofing

In the contract is specified that the layered rood would be soaked with a protective treatment described in the technical documents. The product is used for surface that are not in continuous contact with the soil or water, so not adequate for sealing, balconies and roofing. The producer recommend to check the state of the painting within two years from the application and make a renovation if necessary.

The first treatment was made in October 2006, only in the 2001 the Condominium accomplished a second protective treatment on the wood structure exposed to atmospheric agents. It is obvious that the specification contained in the technical documents are not be fulfilled.

The wood structure on the outside are inevitably subjected to dampness, rainfalls, temperature variation, UV rays. The precautionary measures could only delay the inevitable degradation process. In conclusion the claimed defect is considered as an expected behavior of the materials used.

Expected behavior due to improper use

The design solution and the material are selected in function of the service condition and the environment in which the structure will be used. An improper

use of the property, especially in aggressive condition do not considered in the design phase could lead to unpleasant effects.

N° R.G 6314/2012: Crumbling of a yard flooring

The concrete flooring is realized on an external area of an industrial hanger, used for the loading and unloading of goods.

For these kind of flooring some behavior, within certain limits, could not be consider as defects but as expected behavior due to the properties of the concrete. The characteristics and requirements should be defined before the installation considering the loading condition and the environment in which it is placed.

The crumbling is a loss of cohesion between the cement and the aggregates contained in the concrete. In the figures 6.70 is possible to see as this phenomenon involve all the flooring, in particular it is evident in correspondence of the gallipots of the service area.

Figure 4.27 Crumbling of and industrial flooring

Two core of concrete were taken in correspondence of intact and degraded areas. The sample were exposed to freezing and thawing cycles. The results show that the combined action of water and salts produces on the surface a deterioration ten time greater with respect to the effect due to use of only water (without thawing

salt). There are no evidence of a unusual sensitivity of the concrete to the freeze while it is sensitive (as expected) to the salt attacks used as defrosted products.
It is possible to conclude that the crumbling is due to an erroneous usage and management of the service area. In the technical documents, included in the contract, there are no evidences of required performance for this particular usage. The claimed defect is ascribable to an expected behaviour of the material used.

Expected behavior due to extraordinary action

As mentioned in the § 2.3 "Valutazione della Sicurezza" of the D.M. 14 gennaio 2008, for the evaluation of the safety of the structure must be used probabilistic criterion that are scientifically proved. In the majority of the case is possible to use the semi-probabilistic criterion. In the method are compared the resistance of the structure and the effect of the actions that minimize the structural safety (conservative method).
Basing on this approach there is a small probability for which the actions are greater than the ones for which the structure is designed. In this particular cases, if all the verification are fulfilled, it is no possible to talk of construction defect.

N° R.G 6950/2012 : Fire

The case is related to the collapse of a structure after a fire.
As known the reinforced structure are not characterized from a good fire resistance if not properly designed (following the prescription given in § 3.6.1 of the NTC 2008). In the case of pre-fabricated elements in which the steel member are in a coactive state (pre-tensioned or post-tensioned) the sensitivity to the fire is even greater.
The structure is made of: 13 cast in situ columns on pre-fabricated plinths, 5 reticular truss, wall covering of pre-fabricated panels and a concrete flooring.

Figure 4.28 Partial collapse of a building due to a fire

The majority of reinforced concrete elements show a porous surface. The phenomenon is due to an irreversible dehydration, with consequent destruction of the crystalline structure of the cement that leads to the decline of the mechanical property of the concrete. This is an evidence of the fact that during the fire the temperature was around 600/650° C, if not even higher.

Considering that the thermal conductivity of the reinforcement is substantial, the exposure to temperature greater than 500/500° C provokes the alteration of the structure leading to the loss of its elastic property up to become plastic.

The fire burns up in the structure reached temperature much greater of the one normally considered in the design. For this reason, considering the characteristics of the steel and the concrete, he collapse could be considered as expected behavior.

Expected behavior according to the best practice

The different elements of the building systems, especially the finishing, are design in order to ensure adequate performances, established by the regulation, the best practice or the need of the users.

Depending on the type of elements and the materials used are available regulation and “best practice material” that define the requirement that they have to fulfilled.

N° R.G 3556/2012: Noisy flooring

The defect involves the tiles of a flooring. It is placed in rooms used as office and it is made of porcelain having a thickness of 9 mm and dimension 30 x 30 cm. An elastic joint is placed each 3 m. The presence of these element is recommended when the dimension of the flooring are quite big and able to produce high stress in the drain mortar. Walking on the flooring is possible to hear that the tiles are noisy Three in situ test were performed. The results show that the concrete screed has a thickness of 6 cm and on it is placed a soundproofing mat. From the screed were taken a sample, then thinly pulverized and by using the hygrometer were measured the level of dampness that is of 2,5 %.

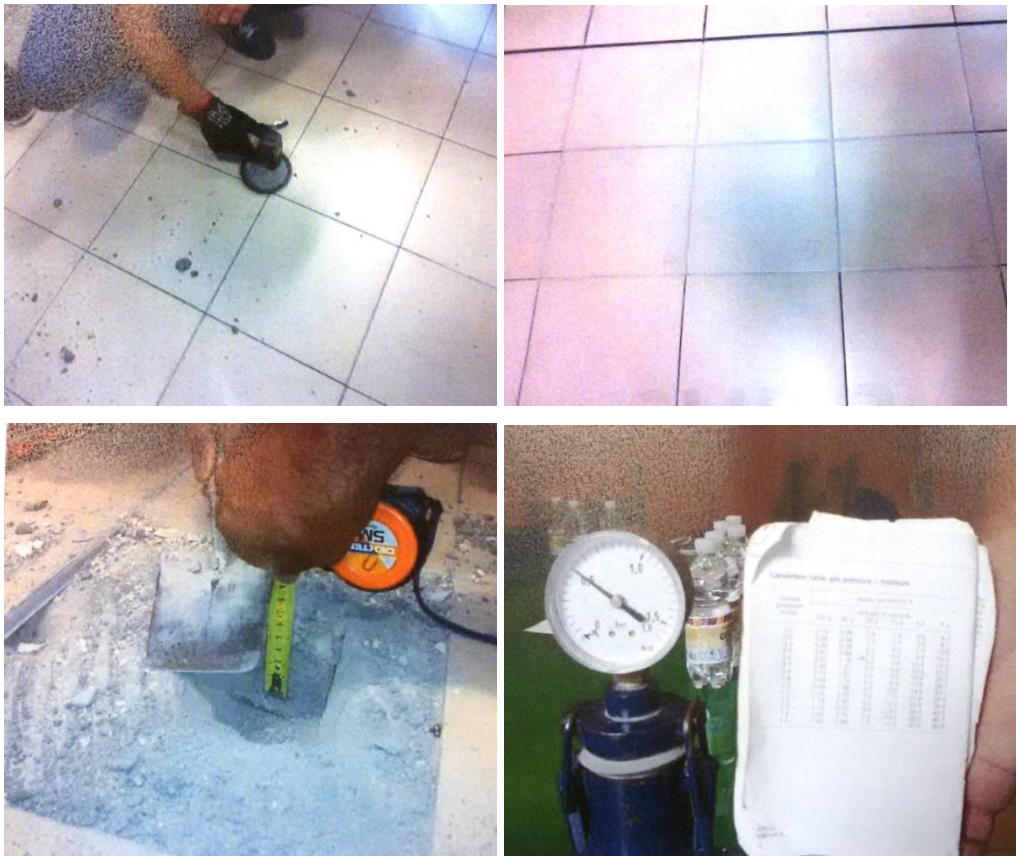


Figure 4.29 Tests on the flooring

The flooring was beat throughout a small rubber mallet to identify the number of the noisy tiles. The result shows that total number is 1490 of which: 553 (49,68 m^2) at the ground floor, 729 (65,65 m^2) at the first floor and 209 (18,81 m^2) at the second floor.

Considering the dimension of a tile equal to 0,09 m^2 the noisy surface is equal to 134,1 m^2. The surface of each floor is equal to

- Ground floor 173,41 m^2
- First floor 203,85 m^2
- Second floor 219,96 m^2

The total surface is equal to 597,22 m^2. The percentage of noisy tiles is 22,45%.

The tests show that: there are not defects on the structure, the concrete screed was realized in accordance with the best practice. The cause of the noisy could be ascribable to the imperfect adhesion between the tiles and the screed. However it is no possible identify the causes with certainty because the installation was made a lot of time ago. The claimed defect not deacrease the usability of the floor. It is important to notice that this issues could be considered, within certain limit, as physiological phenomenon. The rule CEN/TR 13548 – "Regole generali per la progettazione e l'esecuzione delle piastrelle ceramiche"- accounts as consistent a bonding of the porcelain tiles not lower than 75 % . If the noise is produced from a portion smaller than 25% , as in the present case, the flooring is considered functional and well realized. The noise of the tile is ascribable as an expected behavior.

4.8 Technical focus: The industrial flooring

The concrete flooring are generally used for the realization of the finishing in the industrial area. For this reason they are known as "industrial flooring". Their characteristic as high strength, wear resistance, continuity (lack of leaks), versatility (installation on different kind of support), high realization speed, relative low costs. They do not need much maintenance so are particular used for this application in industrial areas. Together with resin or superficial treatments could be used for the flooring of houses, showrooms and commercial spaces, being a good meeting point between design, quality and price. However the

innumerable qualities, this solution has a lot of issue related to the intrinsic characteristic of the concrete and the environmental condition during the usage.

The flooring is made of a concrete slab having big dimensions. The latters are responsible of a great numbers of relevant defects. The wide surface in contact with the air causes the evaporation of big quantity of water during the setting and the hardening of the concrete. In this case the shrinkage is much greater with respect to the ordinary structure. The consequences are the formation of cracks, the lack of flatness due to the curling and differential shrinkage between the upper and the lower part of the slabs. To reduce this kind of problems are chosen concrete with low value of hygrometric shrinkage and sometime are used fluidizing permitting the reduction of the quantify of water without diminishing the workability.

The slab generally has a hard wearing coating. The layer is realized applying on the fresh concrete an anhydrous mixture or a pre-mixed mortar made with water, cement and aggregates resistant to the abrasion. This sealing increase the resistance to the abrasion but also reduce the bleeding effect. The latter phenomenon is due to excessive setting time of the concrete that lead to the formation of water is some zone creating superficial defects.

Pay attention to the setting time of both concrete and coating is important. If the coating is placed too late the two material do not mix homogenously with the formation of overlapping layers that easily separated one from each other. This effect is called delamination. Instead if the coating is applied too soon, the water due to the bleeding is stopped on the surface because the impermeable coating prevent its evaporation. The water contained in this portion, is absorbed by the concrete with the consequent formation of voids. With the application of the loading the presence of empty cavities cause deep delamination.

The phenomenon of the delamination it is not due only to timing problems. A wrong usage of fluidizing additive, that require anti-foam agents, can form bobble of air in the concrete. The air returns to the surface and is catch form the coting layer with the consequent formation of deep delamination.

The selection of the aggregate used for the concrete is important. The alkali contained especially in the coating layer can react with amorphous silica minerals

contained in the aggregate. The consequence of the chemical reaction is the expulsion of portion of material, having a conical shape, called pop-out.

The variation of temperature and the shrinkage of concrete create stress and deformation in the flooring with the consequent formation of cracks. To reduce this physiological and unavoidable phenomenon it is necessary to adopt continuous solution so the dimensions of the slab are reduced. The flooring need joints able to absorb the natural dimension variation guarantee, at the same time, the transmission of the loads acting on the slab. Not only the selection of the concrete is fundamental but also the sizing, the design and the technical expedient of the slab and the support.

Detailing regarding all this aspect could be found in the "Good Practice Code CONPAVIPER [6]".

The above mentioned code gives information for the design of the structure and the support, the choice of the materials and products, the installation methods according with the rule prescribed by the regulation UNI.

The characteristics and requirements for these kind of flooring should be defined before the installation considering the loading condition and the environment in which it is placed.

From the previous discussion is emerged that some behavior, within certain limits, could not be consider as defects but as expected behavior due to the properties of the concrete. The code [6] furnishes a list of the principal:

- Curling: the designer should indicates the tolerances in order to adpot the right solution to reduce the pathology.
- Cracks in the elevation corners due to high stresses bigger than the ones intrinsic to the concrete. The designer and the client have to agree with on it and decide the limitations.
- Chipped in the corners of the joints: the aggregate in that point are wrap up in an insufficient way from the cement. The designer should specify the solution to improve the behavior in time.
- Small web cervices: all the cement structure show thus defect that do not compromised the long term behavior.

- Efflorescence: anesthetically phenomenon, shown in presence of dampness, that is unavoidable for concrete. It do not compromised the durability of the flooring.
- Finishing: along the wall, the basements and columns and other area do not reachable form manual instrument, it is possible to have not uniform textual structures.
- Chromatically differences: the concrete is not an homogeneous materials. The color difference is due to different causes going from the instrument used to the humidity level.

Other references regarding the industrial flooring are the technical regulation, also if they are mandatory only if insert in the contracts. The more important regulation is the UNI 11146 - "Pavimenti di calcestruzzo ad uso industriale. Criteri per la progettazione, la costruzione ed il collaudo" September 2005, that defines the functional requirements for the system:

- Typical defects of these kind of structures;
- Fundamental requirements to fulfilled;
- In-depth analysis of the construction phase.

The analysis of the cases analyzed on the Court of Bologna show the following issues.

Photographic reports

Cracks and curling

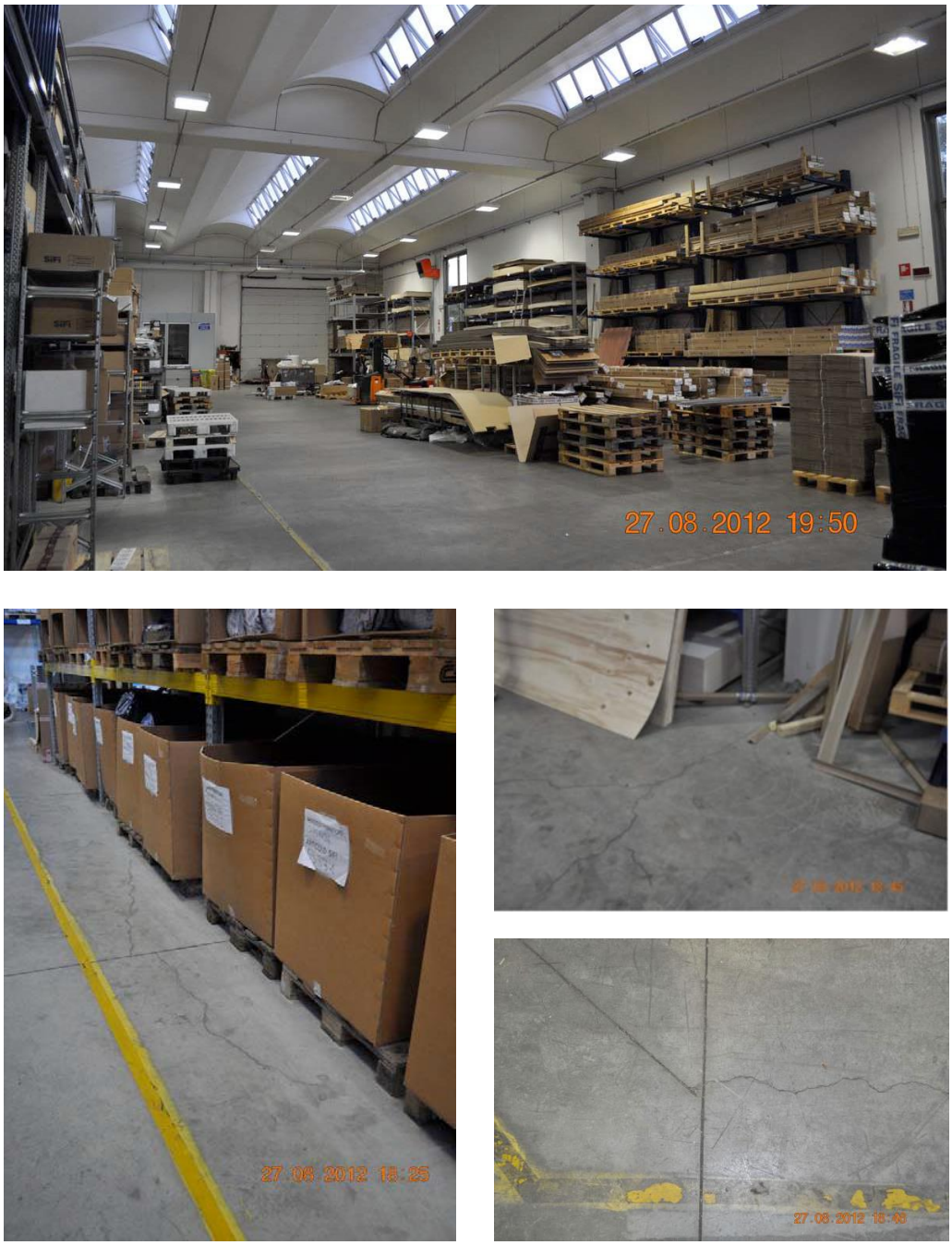


Figure 4.30 N° R.G. 10141 Crack on the flooring of an industrial hanger

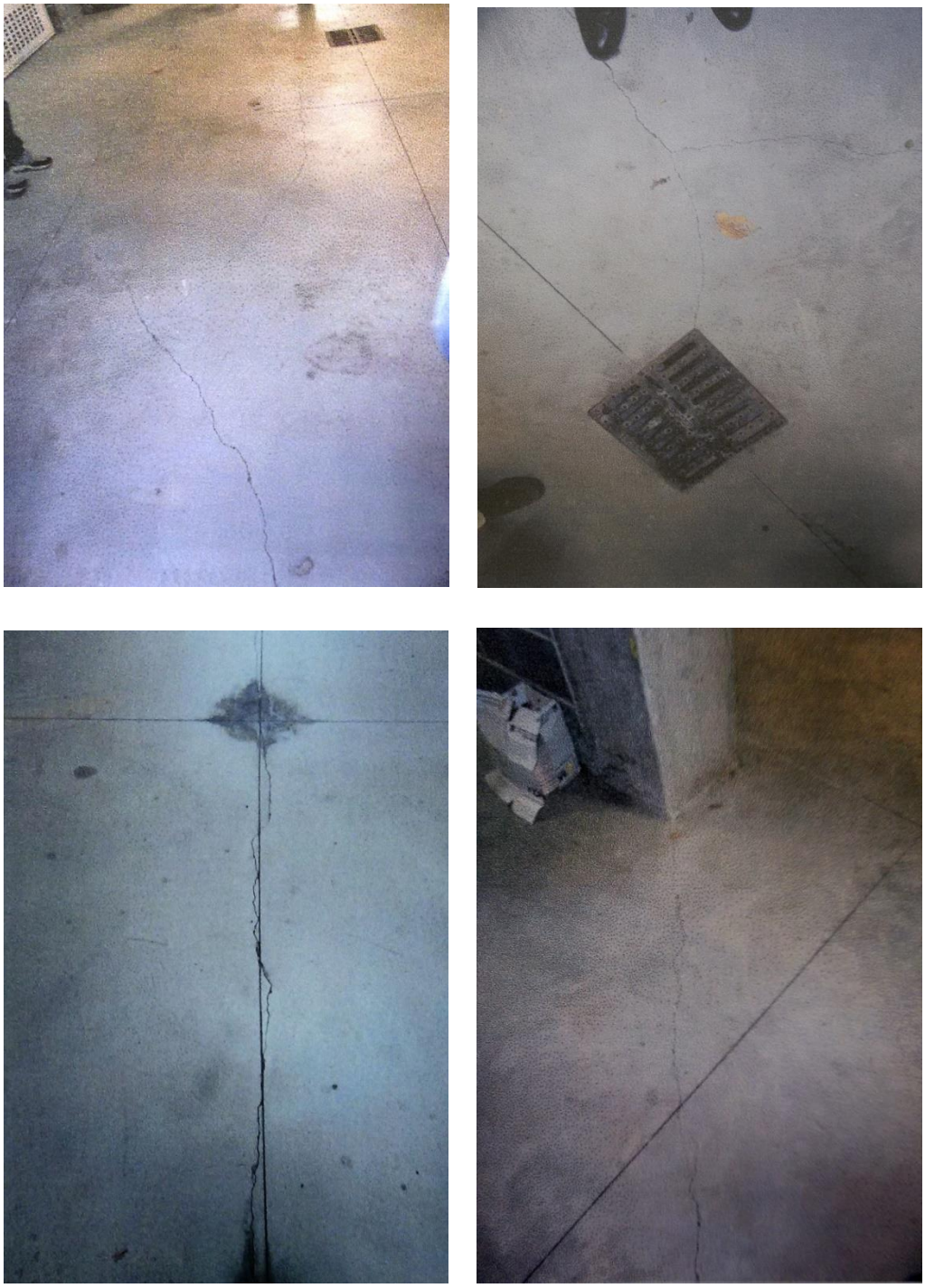


Figure 4.31 N° R.G. 10155/2012 Crack on the concrete flooring of a garage

Figure 4.32 N° R.G. 2188/2012 Crack on the concrete flooring of a garage

Figure 4.33 N° R.G. 10141/2012 Curling of a concrete slab

Delamination and crumbling

Figure 4.34 Crumbling of an external industral flooring

Figure 4.35 N° R.G. 6314 Delamination of an internal concrete flooring

Swelling and chromatic discoloration

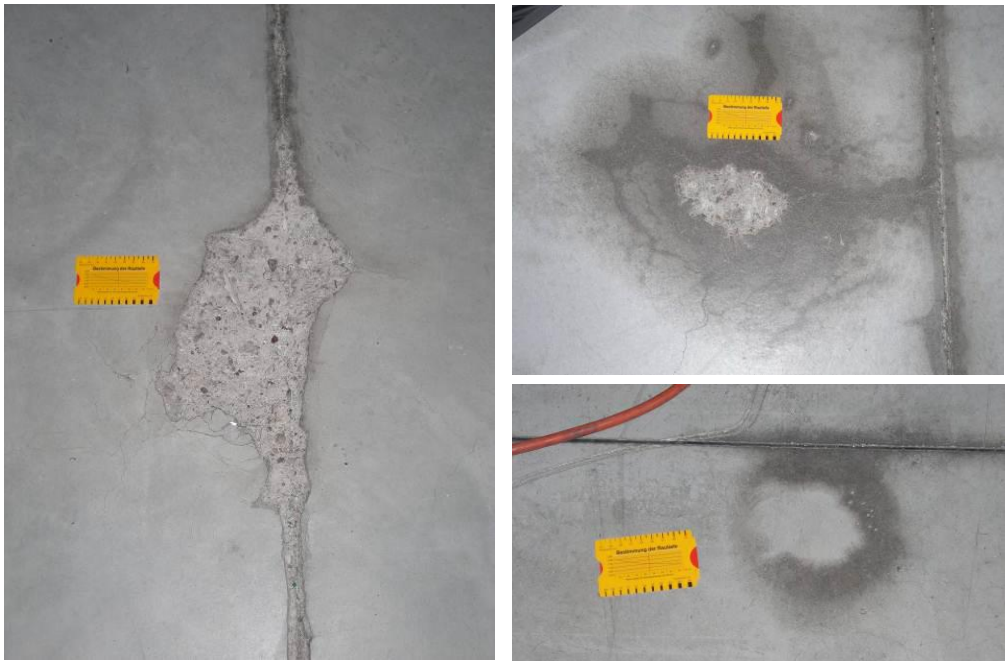


Figure 4.36 N° R.G. 6314 Swelling of the concrete

Figure 4.37 N° R.G. 6314 Chromatic non homogeneous due to the presence of oil

Reference regulations

- Regulation UNI 11146 - *"Pavimenti di calcestruzzo ad uso industriale. Criteri per la progettazione, la costruzione ed il collaudo"* del settembre 2005 [16]
- Best practice code made by CONPAVIPER [6]
- Guideline on the structural concrete made by "Consiglio Superiore dei Lavori Pubblici [5]
- DM 96 – "*Norme Tecniche per il calcolo, l'esecuzione ed il collaudo delle strutture in cemento armato".* [9]
-

Investigation methods

Concrete characteristics

- Sampling

The analysis o9f the sampling allow the evaluation of the compactness and the grain size of the concrete. Furthermore permit to ascertain the presence of eventual cracks, their direction and deepness..

Figure 4.38 N° R.G. 6314 sampling of the inner concrete flooring

Figure 4.39 N° R.G. 6314 sampling of the outer concrete flooring

- Mechanical resistance test (according with rule UNI EN 12504-1 [21] and UNI EN 12390-3[19])

The extracted samples, if properly prepared throughout, could be used for compression tests.

Carota (sigla)	diametro ø, mm	Rapporto h/d	Resistenza cilindrica f_c, N/mm²	Resistenza cubica R_c, N/mm²
2	94	1,05	26,75	26,75
3	94	1,05	37,90	37,90
4	94	1,07	32,42	32,42
5	94	1,09	33,43	33,43
6	94	1,09	31,12	31,12
media:			**32,32**	**32,32**
A	94	1,88	32,13	38,56
C	94	1,87	38,19	45,82
media:			**35,16**	**42,19**

Figure 4.40 N° R.G. 6314 Results of a compression test

The concrete should have a sufficient mechanical resistence and a failure mode consistent with the prescription of the rule UNI EN 12390-3 [19]

- Optical analysis to the polarizing microscope (according with the rule UNI EN 12407 [20])

This kind of analysis is used to verify the presence of detachment phenomena between the cement and the aggregate of the concrete, that lead to the formation of hairline network going toward the outside or the formation of air layers. These defects are ascribable to concrete defect as the bleeding in the initial phase of installation.

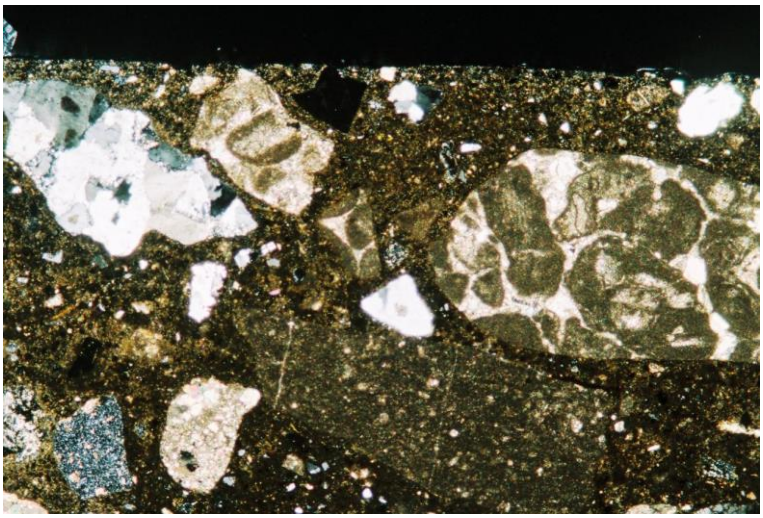


Figure 4.41 N° R.G. 6314 image of a portion of concrete taken from the microscope

Cracks and delamination

- In situ surveys

Are cuts of the concrete slab, that could have different dimensions, realized in portion affected by the crack phenomenon. With this test is possible to evaluate:

The width of the craks, that could involve only the surface or the entire concrete layer.

The stratification of the layer and the amount of reinforcement present and compare them with the indication given in technical documents.

Figure 4.42 N° R.G. 10141 Example of in-situ survey

- Crack opening

The crack are a physiological defect of the concrete flooring but their presence should not influence the functionality. To evaluate if the cracks are purely an aesthetical defect could be evaluated the limit state related to the crack opening defined by the DM 96' – Norme Tecniche per il calcolo, l'esecuzione ed il collaudo delle strutture in cemento armato. Considering the exposure class of the structure and according to EC, the width of the cracks wk has to be smaller than a fixed value. The best practice code edited by CON.PAVI.PER. specified at § 8.3 that The limit state for the crakcs must be defined in the contract considering the serviceability condition and the environment in which the flooring will be installed.

- Ultrasound investigations (according with the rule UNI 9524 [14])

The tests are conduct on different section of the flooring. The presence of defects produce a reduction of the propagation speed of the waves that are measured.

PUNTO	tempo µs	distanza, cm	velocità m/s	media t µs	media v m/s
E1	62,91	20	3179,1		
	60,7	20	3294,9	65,62	3068,26
	73,24	20	2730,77		
E2	61	20	3278,7		
	68,4	20	2924	65,23	3073,10
	66,3	20	3016,6		
E3	68,54	20	2917,81		
	66,67	20	3000	64,79	3099,59
	59,15	20	3380,95		
E4	68,8	20	2907		
	66,67	20	3000	67,72	2953,73
	67,7	20	2954,2		
E5	73	20	2739,7		
	61,03	20	3276,92	68,68	2931,47
	72	20	2777,8		
E6	80,8	20	2475,2		
	89,2	20	2242,2	83,58	2398,05
	80,75	20	2476,74		
E7	62,1	20	3220,6		
	64,6	20	3096	63,27	3162,07
	63,1	20	3169,6		
E8	67,4	20	2967,4		
	78	20	2564,1	78,57	2582,10
	90,3	20	2214,8		

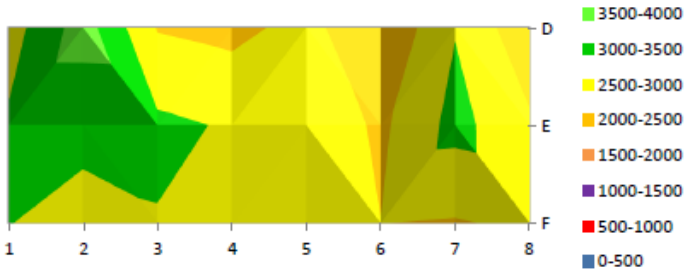


Figure 4.43 N° R.G. 6314 results of an ultrasound test

- Ultrasound propagation speed on the sample (according with the rule UNI 9524 [14])

The test are conduct with an impulse generator having a frequency of 50 Hz and recurrence equal to 6 Hz, by using the transparency method (direct method) between the inner and outer parts of the sample

CAROTA	*distanza tra le sonde, mm*	*tempo di propagazione ultrasuoni, microsec (valore medio)*	*velocità di propagazione ultrasuoni, m/s*
2 (*)	170	52,96	3109,93
3 (*)	170	49,09	3462,74
4	170	48,90	3476,41
5	105	28,62	3668,50
6	170	46,50	3656,08

(*) spolvero superficiale non presente.

Figure 4.44 N° R.G. 6314 results of an ultrasound test on samples

Crumbling

- Evaluation of the resistance to freezing and thawing cycles in presence of salt (UNI EN 1338:2004 – ANNEX D [18])

The sample of concrete is subjected to freezing and thawing cycles. The content of soluble chloride is measured on concrete fragment, prior pulverization according with the rule UNI 9944 [15].

The test are performed considering both the action of the only water and the combined action with the salt. If the results of the latter experiment show evident sign of degradation greater than ten times the effect produce only by the action of the water is possible to ascertain the the coating layer do not protect the concrete by the chloride attack.

Figure 4.45 N° R.G. 6314 sample subjected to freezing and thawing cycles

Carota B1	*SU SPOLVERO*	*CON SALE*
Carota B2	*SU CALCESTRUZZO*	*CON SALE*
Carota D1	*SU SPOLVERO*	*SENZA SALE*
Carota D2	*SU CALCESTRUZZO*	*SENZA SALE*

sigla CAROTA	perdita di massa per unità di superficie, kg/m^2	massa di materiale sfaldato dopo 28 cicli, mg	area della superficie di prova, mm^2
B1	5,61	38700	4149
B2	5,17	21700	4149
D1	0,55	2300	4149
D2	0,71	3000	4149

Figure 4.46 N° R.G.6314 Results of the freezing and thawing cycles

Swelling and chromatic discoloration

- Chemical and physical analysis

These kind of analysis are performed to verify the reactivity of the concrete to determined substances contained in the environment in which the flooring is placed. The surface and an inner portion of the slab are put in contact with the substance in certain temperature and dampness conditions for a fixed time.
At the end of the cycle is evaluated the state of the samples. In particular if they show alteration, fractures or detachments.

Figure 4.47 N° R.G. 6314 sample subjected to chemical analysis

Reparation works

Swelling

The works consist in localized staking of the flooring in order to remove the ingurgitated objects and the creation of an adequate location for the reconstruction materials.

Delamination

To repair this kind of the defects is necessary the removal the damaged superficial layers. The intervention consists in the milling of the surface up to the untouched concrete. Then the superficial layer is remade

Crumbling

The repairing works for the crumbling of the concrete due to salt attack are the following:

- Removal of the damaged layers up to the untouched concrete throughout milling.
- Dusting of the surface and application of a primer increasing the adhesion.
- Application of a concrete coating adequate for the serviceability conditions.
- Water proof treatment of the finishing layer to reduce the absorption of meteoric water. It is recommended a regular maintenance of the surface.

Cracks and delamination

The repairing works for these defects are the following:

- Removal of the portion of slab subjected to cracks and curling.
- Remake of the flooring according with the best practice including the realization of the necessary joints.
- Creation of a joint able to separate the flooring with the structural elements.
- Remake of the coating layer.

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Chapter V

Analysis of the matrices' efficiency

In the previous chapter the database and the matrices were described and the analysis of the data related to the year 2011 and 2012 reported.

The first step for the editing of the present thesis was the collection of the data related to the cases of the year 2012 on the Court of Bologna. The aim of this activity is not just to increase the knowledge of the defects in building construction, but also understand the efficiency of the developed system. The data entry shows different issues regarding the database and, in particular, the matrices.

In this chapter, the attention is focused on all the difficulties encountered during the compilation of the database and the significant improvements that can be made to obtain an efficient system of collection and analysis of the data.

5.1 Critique analysis of the matrix

The effectiveness of the matrices is done by the evaluation of the statistic of the year 2011. Thanks to this evaluation the main issues related to matrices can be discussed and proper alternatives can be found for their solution. In this chapter, differently from the previous one, the main point is not to analyze just the main data of the chart, but dig into the specific data connected to the detailed information.

In this chapter, working hypothesis of how to change the matrix will be proposed, whereas the ultimate solution will be discussed in the next chapter.

The enhancement could be done in different ways:

- Punctual improvement: increasing or decreasing the number of entries related to the item in consideration;
- Global improvement: changing the rationale behind the items;
- Improvement of the classification: make reference to the codes in order to avoid misunderstanding .
-

MATRIX A

d. Temporal detection	1. In service	88%
	2. Under construction	12%

Table 5.1 Inquiry on the matrix A: Temporal detection

No issues are revealed in the cage above, the entries are able to collect and show all the possible cases.

e. Category of use	1. Residential area	79%
	2. Commercial area	6%
	3. Industrial area	10%
	99. Other	6%

Table 5.2 Inquiry on the matrix A: Category of use

Analyzing a large number of lawsuits, it's shown that the number of possible alternatives increased.

Some lawsuits' goals are to use buildings as offices and schools, some other regarded the defect on street or parking, in this case the entries are not adequate.

The solution of this problem is simple: the addition of new entries at the list is enough to solve it.

f. Type of construction	1. Reinforced concrete	21%
	2. Steel	9%
	3. Masonry	40%
	4. Timber	0%
	5. Mixed	28%
	99. Other	2%

Table 5.3 Inquiry on the matrix A: Type of construction

Different issues can be found for this entry, in particular

- Lack of a precise references in order to classify the different structural type. Since the insertion of the data should be the least possible arbitrary it is necessary to refers to the code for the definition of the structural type
- From the experience is appeared that in the majority of the cases ,the technical advice of this information, is not reported by the technical consultant. This kind of information is not strictly necessary for the analysis of the defect and is not requested by the judge either. In this situation, the addition of a new entry is necessary in order to avoid wrong interpretation of the results.

g. Property	1. Public	2%
	2. Private	94%
	99. Other	4%

Table 5.4 Inquiry on the matrix A: Property

This item does not present particular problems, is enough to show and collect the different cases that is possible to face in the civil lawsuit.

g. Property	2. Private	1. Citizen	68%
		2. Society	17%
		99. Other	9%

Table 5.5 Inquiry on the matrix A: Property - Private

Most of the time, in the lawsuit the claiming party is the "Condominium". The civil law is not completely clear about the definition of this party and its right, so

its classification could create uncertainty. An easy and feasible solution is to insert into it new entries.

MATRIX B

Looking at the results of the year 2011 the defects claimed in the civil lawsuits are various and can be of different types.

c. Kind of defect	1.Water infiltrations	13%
	2. Dampness/Mold	11%
	3. Crack/Small crevices	8%
	4. Poor workmanship	22%
	5. Impact	7%
	6. Incomplete work	11%
	7. Deformation	6%
	8. Deterioration/Damage	3%
	9. Code violation	9%
	10. Agreement violation	1%
	11. Unexpected behaviour	5%
	99. Other	5%

Table 5.6 Inquiry on the matrix B: Kind of defects

Any case can contain inconsistencies. First, the number of possible choices is quite high leading to the inefficient analysis of the results. Second, values used to classify a specific defect are too generic, and don't follow a defined explanation, creating misjudgment issues. To better understand the problems mentioned above, common problems emerged during the analysis of the lawsuit in the Court will be presented.

- Often, in the claim, the infiltration and dampness are reported together, because most of the time, for example, the dampness patch and presence of molds are due to the infiltration of water. Identify which one is the main problem is difficult to understand , because the explanation of those defects is not well- defined. In order to avoid these kind of problems is important to consider the relation between the defects and the voice could be jointed.
- A entry that appears meaningless is "Impact". An impact cannot be listed under the voice "defect" but can been seen as the cause of a partial or

total collapse. It could be erased and replaced by another parameter that is more clear and specific to the situation.

- The presence of a defect implies that the behavior of the component is not consistent with the expectation otherwise it not would be considered like that. The unexpected behavior is not a real defect, it is included in each entry of the list. For example: a customer commissions a firm for the installation of a flooring, after a while the flooring shows signs of deformation or misalignment of the tiles. Obviously the client does not expect this kind of malfunctioning, and the claim in the lawsuit, probably, will bet the flooring not planted properly.
- In some case the choice to insert an additional entry in the chart is due by the lack of a better alternatives. In some lawsuits, the claim is the generic malfunctioning of the plants, this kind of defect could be interpreted as damages of the plants, and the creation of a new entry could be useful for a proper classification.

c. Kind of defect	1.Water infiltrations	0. General	31%
		1. Rainwater leakage	50%
		2. Groundwater infiltration	6%
		3. Leakage due to inner plant disease	6%
		4. Leakage due to outer plant disease	6%
		99. Other	0%

Table 5.7 Inquiry on the matrix B: Kind of defect - Water infiltration

Looking at the data above, regarding the water infiltrations, the voices in the cages reflect the real issues we face in the reality.

Looking at the percentage related to the water losses due to plants disease, and considering the low influence, they could be joint, in fact whether the rapture of an inner plant or outer plant lead to the same consequences.

c. Kind of defect	2. Dampness/Mold	0. General	0%
		4. Dampness patches/Plasterwork degradation	62%
		2. Mold growth	38%
		99. Other	0%

Table 5.8 Inquiry on the matrix B: Kind of defect - dampness/mold

From the statistic and the cases analyzed, the entries present list is able to collect the possible situations that could be found in reality. The percentage related to "General" and to "other" are equal to zero, meaning that in the analyzed real cases are not present different situations.

c. Kind of defect	3. Crack/Small crevices	0. General	18%
		1. Crack greater than 3 mm	36%
		2. Small crevices	36%
		99. Other	9%

Table 5.9 Inquiry on the matrix B: kind of defect - Cracks

The data of this kind of defect are various, the General 's cage percentage is quite high. It is not a surprise since, from the experience, in the greater amount of the technical advice, the crack opening is not measured.

c. Kind of defect	4. Poor workmanship	0. General	75%
		1. Flooring and covering joint	0%
		2. Plasterwork not flat	7%
		3. Irregular joint in outer skirting-board	0%
		4. Erroneous sewers	0%
		5. Not-vibrated asphalt	0%
		99. Other	18%

Table 5.10 Inquiry on the matrix B: Kind of defect - Poor maintenance

Particular meaningful are the results shown in this list. As it is possible to see from the statistic, in nearly every case the defect is listed in "general" or in "other". This means that the classification is useless. From the experience, it is evident that the kind of defects related to execution error are a lot and could involve every kind of element. List all the possible cases entail the creation of an infinite list where the numbers of entries become uncountable. The only possibility is to avoid any specification.

c. Kind of defect	5. Impact	0. General	56%
		1. Total collapse	0%
		2. Partial collapse	22%
		3. Sliding	11%
		4. Crack	11%
		99. Other	0%

Table 5.11 Inquiry on the matrix B: Kind of defect - Impact

As mentioned before " impact " cannot be considered as a real and effective defect. It is seen as a cause so any of this has no meaning.

c. Kind of defect	7. Deformation	0. General	43%
		1. Sidewalk deformation	0%
		2. Flooring deformation	57%
		3. Deformation of inspection manhole	0%
		4. Deformation of grid/ inspection manhole covering	0%
		99. Other	0%

Table 5.12 Inquiry on the matrix B: Kind of defect - Deformations

Before we mentioned the defects caused by the poor workmanship, this is a detailed list which shows that a lot of named cases are missing, and each case of the defect is collected in "general". In this chart a classification is not possible without the addition of multiple entries, it is preferable to avoid any specification.

c. Kind of defect	6. Incomplete work	0. General	100%
		1. Finishing	0%
		2. Plant	0%
		99. Other	0%

Table 5.13 Inquiry on the matrix B: Kind of defect - Incomplete works

The specification related to the incomplete work are redundant in fact the element on which the defect claimed is described in another macro-voice of the matrix. The solution of the problem of redundancy could be solved or, at least, reduced by changing the order of how the information are given.

If in the first step is described the location and the kind of element where the defect is located, in the latter it is possible to avoid some specification that are already mentioned as reported in the example below.

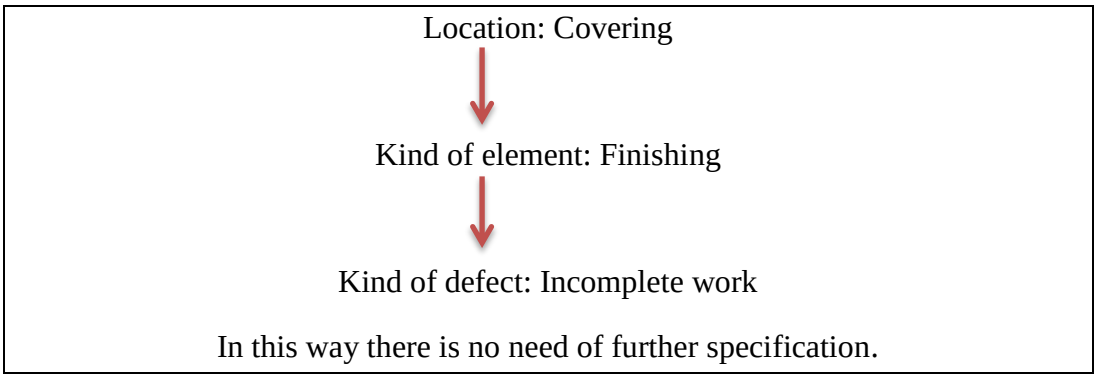

Figure 5.1 Example on a possible improvement for the matrix B

d. Location in the building	1. Basement	11%
	2. Elevation (excluding roofing)	76%
	3. Roofing	10%
	99. Other	2%

Table 5.14 Inquiry on the matrix B: Location in the building

The civil lawsuit could involve not just any single element of the building but any civil work. In the cases, a road or any other accessory construction, the classification results inadequate. Some entries to indicate external location should be added.

e. Kind of element	1. Framework	31%
	2. Finishing	49%
	3. Plant	20%

Table 5.15 Inquiry on the matrix B: Kind of element

As before the classification is not able to describe the elements of any civil work but only the elements of a building. Another problem is the violation of the " Urban Building Code" where the defect involves the entire structure, problems related to the useful surface or volumetric incongruence, none of the entries is correct.

e. Kind of element	1. Framework	0. General	35%
		1. Foundation element	0%
		2. Vertical structural element	35%
		3. Horizontal structural element	28%
		99. Other	3%

Table 5.16 Inquiry on the matrix B: Kind of element - Framework

e. Kind of element	2. Finishing	0. General	50%
		1. Outer (Covering, coating, ecc)	27%
		2. Inner (Plasterwork, flooring, fixture, etc)	16%
		99. Other	6%

Table 5.17 Inquiry on the matrix B: Kind of element- Finishing

e. Kind of element	3. Plant	0. General	68%
		1. Plumbing/Gas plant	20%
		2. Electrical system	4%
		99. Other	8%

Table 5.18 Inquiry on the matrix B: Kind of element - Plant

The specifications related to the type of element are too general, and more important, there are no references to classify them univocally. For this reason this list should be organized and developed according to the indication of the rule UNI for the classification of the technological system of the building.

MATRIX C

b. Inspection method	1. Visual inspection	87%
	2. In situ test	2%
	3. Specific test	3%
	4. Drawing check	0%
	99. Other	8%

Table 5.19 Inquiry on the matrix C: Inspection method

No description of the inspection method is provided, so the choice depends on how the technicians interpret the different entries. Another problem comes up when more than one method is used even where it is not possible.

c. Expected behaviour	1. Yes	0%
	2. No - Relevant defect according with art. 1669 cc	3%
	3. No - Poor ordinary/extraordinary Maintenance	15%
	4. No - Code violation	73%
	5. No - Agreement violation	9%

Table 5.20 Inquiry on the matrix C: Expected behavior

The definition of relevant defect and expected behavior are one of the most common issues in the lawsuits since neither the jurisprudence nor the technical code define them properly. For this reason classify the defect in just one specific

category is not easy and often the final place in a certain category is based on the interpretation of a technical consultant.

Some important issues are underlined:

- The expected behavior is related to a long-term which may or not result in a degrading behavior. The degradation of an element due to a lack of maintenance, therefore not ascribable to the seller and the construction firm, could be considered as expected behavior, this aspect is not clear in the classification used in the database;
- There are some other defects that cannot be classifies as "relevant" either be ascribable to code or agreement violation. The classification in this case results completely insufficient since the "small" defect is not considered at all.

d. Level of impairment	1. Structural safety/stability	12%
	2. Functionality/Usability	47%
	3. Appearance	35%
	99. Other	7%

Table 5.21 Inquiry on the matrix C: Level of impairment

There are not particular problems related to this classification, but a well-defined classification with reference to the UNI classification would be better.

MATRIX D

a. Cause of the defect	1. Poor materials	8%
	2. Poor execution	56%
	3. Design errors	3%
	4. Site manager errors	0%
	5. Negligence	5%
	6. Collision	6%
	7. Incomplete works	12%
	99. Other	9%

Table 5.22 Inquiry on the matrix D: Cause of the defect

The classification of the causes of the defect seems to be pretty clear. There is just one aspect omitted; sometimes the causes which create a specific defect are not indicated in technical advice. The reasons can be different:

- It is impossible to determine;
- The judge does not require the identification of the causes in the question;
- The technical consultant omits this information.

The addition of an entry for this specific situation would improve the effectiveness of the matrix. Another problem is related to the specifications of the cause of the defect that are too general and, more important there are no references which classifies them univocally. For this reason this list should be organized following the indication of the rule UNI for the classification of the technological system of the building.

a. Cause of the defect	1. Poor materials	1. Concrete	13%
		2. Steel	13%
		3. Bituminous sheath	50%
		4. Paperwork	0%
		5. Flooring	13%
		6. Covering	13%
		7. Tinsmithery	0%
		8. Glass	0%
		9. Plywood	0%
		10. Wood	0%
		11. Reinforcement	0%
		12. PVC tubing	0%
		99. Other	0%

Table 5.23 Inquiry on the matrix D: Cause of the defect –Poor materials

The percentage of cases where the defect is caused by poor material is quite small, this explains the reason of many empty entries. Except for some voice which belongs to a certain category, there are other elements such the plywood which is too much specific and can be cataloged to the wood, but for a better and well done evaluation of this particular item is necessary to collect more data.

a. Cause of the defect	2. Poor execution	1. Concrete installation	11%
		2. Concrete supply	4%
		3. Reinforcement installation	0%
		4. Plasterwork installation	7%
		5. Bituminous sheath installation	15%
		6. Flooring/Covering installation	13%
		7. Window installation	2%
		8. Door installation	4%
		9. Sheet pile installation	0%
		10. Excavation	4%
		11. Drainage of water	0%
		12. Vibration	0%
		13. Screed coat adjustment	2%
		14. Exhaust pipe installation	0%
		15. Heating plant	2%
		16. Absence of spigot for cold/hot water	0%
		17. Wrong location of the valve	0%
		99. Other	38%

Table 5.24 Inquiry on the matrix D: Cause of the defect –Poor execution

Looking at the statistic is evident that the greater number of data in contained in the entry "other" underlining that the matrix is not efficient. The entries are too specific, the possible cases are too much and it is impossible to list all of them. The solution is to make a more generic classification avoiding any specification.

a. Cause of the defect	3. Design errors	1. Geological/geotechnical relation	0%
		2. Structure calculation	67%
		3. Executive design	0%
		4. Lack of detailing	0%
		5. Urban restriction violation	33%
		99. Other	33%

Table 5.25 Inquiry on the matrix D: Cause of the defect – Design errors

There are not particular problems related to this classification.

a. Cause of the defect	5. Negligence	1. Poor ordinary maintenance	64%
		99. Other	36%

Table 5.26 Inquiry on the matrix D: Cause of the defect – Negligence

a. Cause of the defect	6. Collision	1. Impact with a vehicle	45%
		99. Other	55%

Table 5.27 Inquiry on the matrix D: Cause of the defect – Collision

Negligence and Collision cages are too generic, that's understandable looking at the percentage of data included in "others".

MATRIX E

a. Responsibility	1. Designer	5%
	2. Site manager	3%
	3. Construction firm	51%
	4. Tenant	15%
	5. Condominium	10%
	6. Seller	2%
	7. Adjacent property	3%
	99. Other	12%

Table 5.28 Inquiry on the matrix E: Responsibility

The definition of the responsibility is a delicate aspect. The first problem that comes to light is the lack of reference in order to attribute it. Another aspect that should be considered as main factor is that, often, the responsibility are not clearly attributed to a subject or to another, the reason could be different:

- It is impossible to determine it;
- The judge does not require the identification of the responsibility in the question;
- The technical consultant does not put this information.

The addition of an entry to evaluate this specific case would improve considerably the effectiveness of the matrix, in fact in the compilation of the database the data should be not interpreted or deduced.

a. Responsibility	1. Designer	1. Geological	0%
		2. Geotechnical	0%
		3. Foundation	0%
		4. Structural	50%
		5. Architectural	13%
		6. Finishing	38%
		7. General	0%

Table 5.29 Inquiry on the matrix E: Responsibility – Designer

a. Responsibility	2. Site manager	1. Structural site manager	100%
		2. Architectural site manager	0%
		3. General site manager	0%

Table 5.30 Inquiry on the matrix E: Responsibility – Site manager

a. Responsibility	3. Construction firm	0. General	0%
		1. Contractor firm	89%
		2. Subcontractor firm	9%
		3. a.t.i Firm	2%
		99. Other	0%

Table 5.31 Inquiry on the matrix E: Responsibility- Construction firm

There are not particular problems related to the specification of the responsibility, they collect and explain well all the possible classification.

Looking into the statistic some entries related to the responsibility of the designer or site management, maybe, could be joint together, since the collection of the data is only at the beginning and the lawsuits are a significant small number, this could be avoided.

5.2 The new matrices

The matrix are a dynamic tools in the sense that, on the bases of the experience and the increase of the knowledge in this field, they could be modified in order to collect information in a more efficient way.

The new matrix, created for the solution of the above mentioned issues, are presented in this paragraph and discussed in the detail in the following chapter.

Matrix A: General information on the construction where the defect is located		
a. General Rule	*1. ATP*	
	2. Civil lawsuit	
b. Description		
c. Address		
d. City		
e. Structure condition	*1. In construction*	
	2. In service	
f. Category of use	*1. Residential areas*	
	2. Commercial area	
	3. Industrial areas	
	4. Economical areas	
	5. Recreational areas	
	6. Traffic and parking areas	
	99. Others	
g. Type of construction	*1. Reinforced concrete*	
	2 .Steel	
	3. Masonry	
	4. Timber	
	5.Mixed	
	99. Others	
h. Property	*1.Pubblic*	
	2. Private	*1. Citizen*
		2. Society
		3. Condominium
		99. Other
	99. Others	
i. Indirect damage	*1. Yes*	
	2. No	

Matrix B: General information on the defect			
a. Progressive number			
b. General location in the building	*1. Basement*		
	2. Elevation (No roofing)		
	3. Roofing		
	4. Outside		
	99. Other		
c. Kind of element	*0. General*		
	1. Framework	*1. Foundation structure*	*1.Shallow foundation*
			2. Deep foundation
		2. Elevation structure	*1. Vertical*
			2. Horizontal and inclined
			3. Spatial
		3. Retaining structure	*1. Vertical*
			2. Horizontal
	2. Clousure element	*1. Vertical closure*	*1. Perimeter walls*
			2. Outer window frames
		2. Horizontal closure	*1. Ground slabs*
			2. Covering
	3. Partition	*1 Vertical partition*	*1. Walls*
			2. Window frames
		2 Horizontal partition	*1. Slabs*
			2. Mezzanine
			3. Windows frame
			4. Balconies or loggias
		3. Inclined partition	*1. Stairs*
			2. Flight
	4. Plant	*1 Supply of services plant*	*1. Air-conditioning plant*
			2. Water and sanitary system
			3. Waste disposal plant
			4. Gas supply plant
			5. Electrical system
			6. Solar panels
			7. Rainwater removal system
		2 Security plant	*1. Fire system*
			2. Grounding system
			3. Circuit breaker lines
	5. Finishing	*0. General*	
		1. Flooring	
		2. Covering	
		3. Shingles/Roof tiles	
		4. Waterproofing	
		5. Fiber/Membranes	
		6. Insulation	
		99. Other	

	6 Street/Pertinance work	*1. Streets*	
		2. Sidewalks	
		3. Enclosure/Barriers	
		4. Meteoric water regulation	
		5. Other	
	7. Urban elements	*1. Surface*	*1. Territorial surface*
			2. Landed area
			3. Covered surface
			4. Useful gross surface
			5. Useful surface
			6. Accessory surface
		2. Volume	*1. Planivolumetric shape*
			2. Total Volume
			3. Useful Volume
		3. Height	*1. Chamber height*
			2. Building front height
		99. Other	
	99.Other		
c. Kind of defect	*1. Water infiltration/Dampness*	*0. General*	
		1. Rainwater leakage	
		2. Groundwater infiltration	
		3. Leakage due to plant disease	
		4. Dampness patch	
		5. Plasterwork degradation	
		6. Mold growth/ efflorescence	
		7. Water stagnation	
		99. Other	
	2. Crack	*0. General*	
		1. Small crack	
		2. Small cervices	
		3. Diffused cracks	
		99. Other	
	3. Damage/Deterioration	*0. General*	
		1. Rapture/Fracture	
		2. Separation	
		3. Discoloration	
		4. Stain	
		99. Other	
	4. Deformation	*1. Flexion*	
		2. Traction	
		3. Slump/swelling	
		4. Sliding	
		99. Other	
	5. Collapse	*1. Partial*	
		2. Total	
		99. Other	
	6. Malfunctioning		

	7. Defective workmanship		
	8. Code violation	*1. Technical regulation*	
		2. Building Urban Code	
		3. Territorial/Environmental plan	
		99. Other	
	9. Agreement violation	*1. Incomplete work*	
		2. Supply of construction material	
		3. Dissimilarity with the project	
		99. Other	
	99. Other		

Matrix C: Detection and quantification of the damages		
a. Progressive number		
b. Confirmation	*1. Yes*	
	2. No	
c. Insection method	*1. Structural safety*	
	2. Wellness	
	2. Usability	
	3. Appearance	
	99. Other	
d. Expected behaviour	*1. Si*	
	2. No	
e. Level of impairment	*1. Structural safety*	
	2. Wellness	
	2. Usability	
	3. Appearance	
	99. Other	
f. Repairing time	*1. Free text*	
	2. Not reported	*1. Not request in the question*
		2. Not evaluated
	3. Already evaluated in another matrix	
	4. Null	
	5. Incomputable	
	99. Other	
g. Repairing costs	*1. Price or insurance value*	
	2. Not reported	*1. Not request in the question*
		2. Not evaluated
	3. Already evaluated in another matrix	
	4. Null	
	5. Incomputable	
	6. Decrease in value	
	99. Other	
h. Agreement before sentence	*1. Yes*	
	2. No	
i. Compensation method	*1. Remedial work by the guilty party*	
	2. Monetary compensation	
	99. Other	

Matrix D: Cause of the defect		
a. Progressive number		
b. Cause of the defect	*1. Poor materials*	*1. Concrete*
		2. Steel
		3. Wood
		4. Aluminum and other metals
		5. PVC and other plastic
		6. Glass
		7. Masonry/Bricks
		8. Tiles/Shingles
		9. Paints/Covering
		10. Backfill
		11. Protective membranes/fibers
		12. Resins/Foams
		99. Other
	2. Poor execution	*1. Not consistent with the best practice*
		2. Not consistent with the agreement
		3. Not consistent with detailing specification
		4. Not consistent with the project
		5. Incomplete work
		99. Other
	3. Design errors	*1. Geotechnical calculation*
		2. Structural calculation
		3. Executive design
		4. Lack of detailing
		99. Other
	4. Code violation	*1. Not consistent with the technical prescription*
		2. Not consistent with Urban Regulation
		3. Not consistent with other regional planning
		99. Other
	5. Lack of site manager supervision	
	5. Negligence	*1. Lack of ordinary maintenance*
		2. Improper use
		99. Other
	7. Human causes	*0. General*
		1. Collision
		2. Tampering
		3. Explosion/Fires
		99. Other

	8. Natural Causes	*0. General*
		1. Earthquake
		2. Landslide/Land movement
		3. Flooding
		99. Other
	9. Impossible to determine	
	99. Other	

Matrix E: Responsibility		
a. Progressive number		
b. Responsibility	*1. Designer*	*1. General*
		2. Geotechnical
		4. Structural
		5. Architectural
		6. Services
		99. Others
	2. Site manager	*1. General site manager*
		2. Structural site manager
		3. Geotechnical site manager
	2. Inspector	*1. Static inspector*
		2. Technical-administrative inspector
	3. Construction firm	*0. General*
		1. Contractor firm
		2. Subcontractor firm
		3. a.t.i Firm
		99. Other
	4. Costumer	
	5. Condominium	
	6. Seller	
	7. Adjacent property	
	8. Impossible to determine	
	99. Other	

Chapter VI

The new matrices

The analysis of the database and the matrices, discussed in the previous chapter, carries out different problems that can be summarized as follow:

- Lack of references to code and regulation;
- Redundant information;
- Insufficient alternatives for the description of the possible cases;
- List of alternatives too much detailed.

These problems can been solved creating new matrices.

The new matrices arise from a long process of critical analysis of the previous matrices together with the collection of the data coming from the lawsuits of the 2012 of the Court of Bologna. They are yet at the beginning stage and a database able to converted the data already collected is not available. The new matrices will be the basis for the collection of the data of the future years

In the present chapter will be provide a guideline containing all the information, definitions and references helpful for the insertion of the data.

6.1 Guideline

The guidelines presented in the following paragraph describe in a detailed way, according to the definitions provided by the code, regulation or other references, all the entries of the matrices. In this way the information used by the technical consultant are clear enough there are no misunderstandings.

6.1.1 Matrix A

The matrix A, unique for each " technical consultancy ", contains the general information about the construction work, where one or more defects are reported.
As defined in the paragraph 1.5 of the EN 1990, the construction work is everything that is constructed or it is the result from construction operations. The term includes both: building and civil engineering works. It refers to the complete construction works including structural, non-structural and geotechnical elements.
The list is made up by the following entries:

a- General Roll (in Italian "Ruolo Generale, RG")

It is the code number the identifies the case in the archive of the court.
In jurisprudence the proceedings that require a technical advice are many. Their identification as their typology are provided by many different information.

1. ATP

It is referred to a Precautionary inquiry prosecution that is the collection of evidences before the establishment of the arbitration.

2. Civil lawsuit

It is referred to the Evidentiary inquiry prosecution that is the phase of a civil lawsuit where all the evidence necessary for the solution of the trail are collected.

Example:


TRIBUNALE CIVILE DI BOLOGNA

Relazione di Accertamento Tecnico Preventivo

N. R.G. 10141/12

Accertamento Tecnico Preventivo

Figure 6.48 Example of General roll of court file

b- Description

Contains a short illustration of the case under inspection. No changes had been done between the previous and the new matrices.

c- Address

The exact address where the construction site is located. No changes had been done between the previous and the new matrices.

d- City

"Istat code[1]" of the city where the construction site is located. No changes had been done between the previous and the new matrices.

e- Structure condition

Indicates the state of the construction when the defect has been noticed for the really first time . No changes had been done between the previous and the new matrices.

1. Under construction

The Italian legislation defines the "building intervention" as:

> *" Any work that modifies an existing building or that leads to the realization of a new construction"*

[1]The "Istat" (National Institute of Statistic) ascribes to each existing municipality a code made of

As better specified in the art. 3 of the D.P.R n380/2001 (known as "Testo Unico dell'edilizia) belong to this category:

- Ordinary maintenance work;
- Extraordinary maintenance work;
- Preservative restoration and reconditioning work;
- Property renovation work; (Ristrutturazione edilizia)
- New construction;
- Urban renewal work.

2. In service

At this category belongs the construction where no building intervention have been done, but in which the defect appears during the "working life".

f- Category of use

It indicates the specific uses of the construction works. This entry has been enlarged because the possible choices in the previous matrix were insufficient .The classification is made considering the category of use according to the definitions in the Urban Building Code of Bologna (Regolamento Urbano Edilizio di Bologna [16]).

1. Residential areas

Single dwelling, permanent and temporary, included residences, bed and breakfast, home for holidays; shared house like boarding schools and cloisters.

2. Commercial areas

Small and medium shops and business for the people as beauty and hair shops, bakeries, restoration services, stations, etc…; Big commercial structures as super-markets, shopping centers, etc….

3. Industrial areas

Industrial and hand-crafted production of goods, including activities like research and probationary labs, technical and administrative offices, stocks.

4. Economical areas

Small activities, conduct in single real estate, placed in building having many different activities like professional offices, banks, insurance companies etc…; Managerial activities in complex structures as office buildings, centers for tertiary activity, public and private agencies, congressional and exhibition centers, etc… .

5. Recreational area

In this category belonged schools, cafés, restaurants, churches, theatres or cinemas, hospital, etc…

6. Traffic and parking areas

In this category belonged roads, garages, parking areas, parking halls, access routes, delivery zones, etc…

g- Type of construction

The type of construction, according with the paragraph 1.5 of the EN 1990, indicates the principal structural materials with the structure is made up by. No changes had been done between the previous and the new matrices.

The "NTC 08" defines the following type of structure:

1. Reinforced concrete

In this category are included:

- Traditional Reinforced concrete structure;
- Pre-stressed reinforced concrete structure;
- Concrete with a low percentage of reinforcement or without it.

Figure 6.49 Example Reinforced concrete structure

2. Steel

In this category are included all the works where the bearing structure (beam and columns) is made of structural steel.

Figure 6.50 Example steel structure

3. Timber

In this category are included all the works in which the bearing structure (beam and columns) is made of structural timber as the hardwood or with wooden structural element like plywood, wooden panels.

Figure 6.51 Example of timber structure

4. Masonry

In this category are included all the works in which the vertical elements are made of masonry connected by slabs, that could be of different tipe.

Figure 6.52 Example of masonry structure

5. Mixed.

In this category are included all the works in which the bearing structure is made of different material.

Figure 6.53 Example of mixed structure

h- Property

In jurisprudence, the property is a real right[2] that ensures the opportunity to benefit and exert direct influence on the things in an exclusive and full manner within and in accordance with the obligations provided for by law (art. 832 Italian Civil Code). Depending on who is the legal subject owner of the title it is possible to distinguish private and public properties. In many lawsuits, condominiums denounce some defects, so it is revealed the classification problem of this particular kind of property. For this reason the entry is extended.

1. Private property

Owned by an individual person or artificial entities that represent the financial interests of people.

In this category it is possible to identify different legal subject:

- Citizen
- Society
- Condominium

About the last one, a clear explanation has to be done since the Civil Code does not define it clearly.

A condominium, is the form of housing tenure and other real property where a specified part of a piece of real estate (usually of an apartment house) is owned

[2] In Civil law, real right refers to a right that is attached to a thing rather than a person. Real rights include ownership, use, pledge, usufruct, mortgage, habitation and predial servitude.

by a single person. Common entrances to the facilitie such as hallways, heating system, elevators, and exterior areas are executed under legal rights associated with the individual ownership. These rights are controlled by the association of owners that jointly represent ownership of the whole piece. (Wikipedia)

The correct explanation puts the light on that private property, when it's not exclusive, belong to more than one people.

Condominiums have conditions, covenants, and restrictions, and often extra rules are made to govern and regulate the individual unit owners, when they have to share the common space.

2. Public property

It is a property for the public use. It is a subset of state property. The term is also used to describe the right use of each property, the character of its ownership (owned collectively by the population of a state).

i- Connection with other cases

Indicate a lawsuits, if any, that is connected with the case objected of the study.

6.1.2 Matrix B

The matrix B, contains the general description of the defect denounced by the claimant. If there is not a single defect but more than one, it is possible to have many matrix B for each lawsuit. For this reason in the General Roll is also reported a progressive number that identifies any single defect.

The list is comprised of the following entries:

a- Progressive number

It is used to identify the defect claimed in the proceeding. It contains the number of the general roll followed by a number.

b- General location in the building

It contains a general location of the place where the defect is located in order to have an overview of the situation.

1. Basement

In reference to ex art. 48 D.P.R[3] n° 303/1956 "Linee-guida per la notifica relativa a costruzione, ampliamento o adattamento di locali e di ambienti lavoro" basement is defined as the portion of a building where the gap between the ground level (Point A) and the horizontal plane containing the intrados of the slab (Point B) is lower than one third of the height (h) as reported in the figure 6.7.

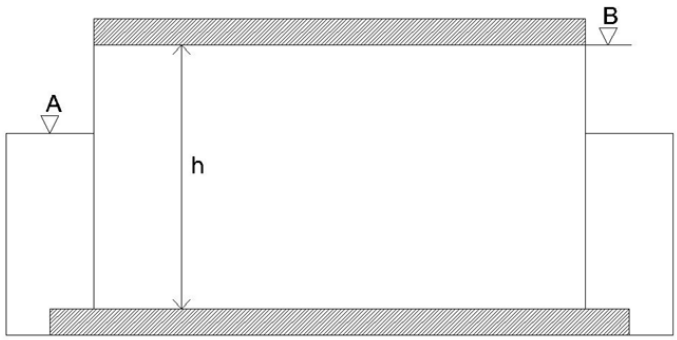

Figure 6.54 Scheme for the evaluation of basement

2. Exterior part

It is the portion of building which is not included in the previous definition.

3. Roofing

According with the definition of the rule UNI 8088 and the DPGR 23 novembre 2005, n. 62/R the roofing is defined as the upper edge of the building system aimed to the protection against the atmospheric agents, made of a bearing structure and a surface covering.

4. Outside

In this entry all the elements that are out of the building system as gardens, roads, swimming pools and sidewalks are contained.

c- Kind of element

This section describes the exact location of the defect inside the structure.

The different components of the building system are defined according with the rule UNI 8290 "Edilizia residenziale – Sistema tecnologico, classificazione e

[3] It is a regulation or administrative provision issues by the President of the Italian Republic.

terminologia". The rule gives, in the residential construction field, the classification and the organization of the technological unit and the technical element where the building system is broken down [4].

The aim is to join the terminology used in the different regulation, deign, operational and operational activities. The decomposition is made on three levels and rises to three sets called, according with the rule UNI 7867 part 4th:

- Classes of technological units (I level);
- Technological units (II level);
- Classes of technical elements (III level).

1. Framework

Set of technological units and typical elements belonging to the building system which have the function of carrying the load and statically connect the different parts[5].

The technological units included in this level are:

1.1. Foundation structures

Set of technical elements of the building system having the function of transmitting the load to the soil[5].

The technical elements included in this level are:

1.1.1. Shallow foundation;

In this category are included:

- Pads
- Strip footings
- Rafts

[4] The technological system is defined by the rule 7867 as:
" *The set of the technological units or technical element according to the operational design phase of the building process in consideration".*
[5] Definition given by the rule UNI 8290"Edilizia residenziale – Sistema tecnologico, classificazione e terminologia".

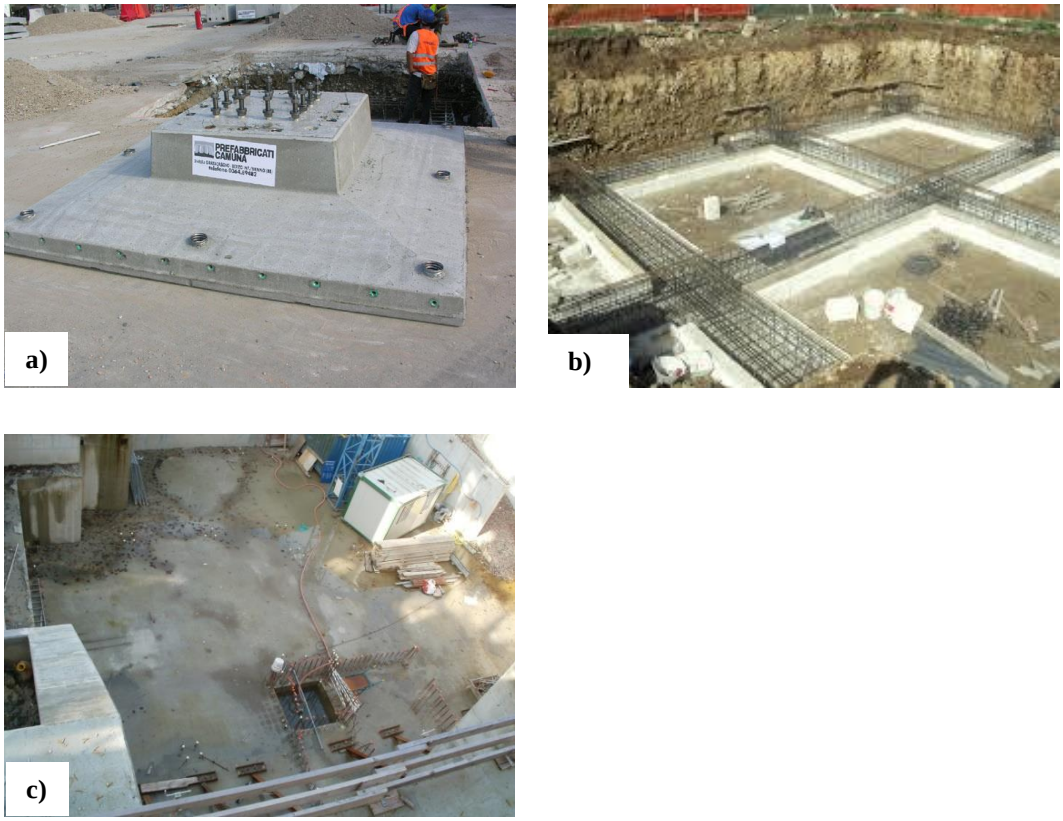

Figure 6.55 Examples of shallow foundations: a) Pad; b) Strip footing; c) Rafts

1.1.2. Deep foundation

In this category are included:

- Piles
- Caissons

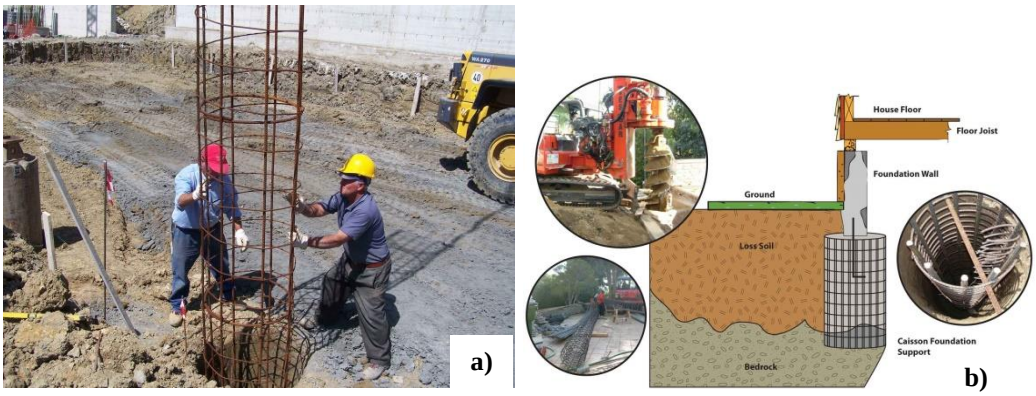

Figure 6.56 Example of deep foundation: a) Pile; b) Caissons

1.2. Elevation structure

Set of technical elements of the building system which have the function of carrying the vertical and/or horizontal loads and transmit them to the foundation[5].

The technical elements included in this level are:

1.2.1. Vertical elevation structures

In this category are included:

- Structural walls
- Column

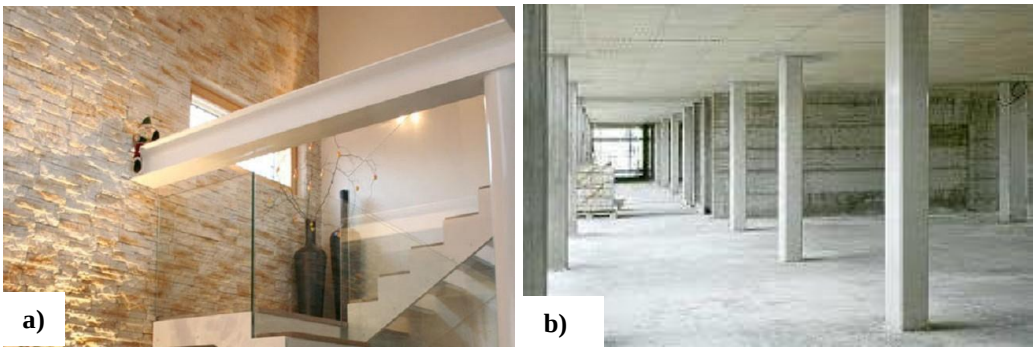

Figure 6.57 Examples of vertical elevation structures: a) Structural walls; b) Columns

1.2.2. Horizontal and inclined elevation structures

In this category are included:

- Beams
- Joists
- Arches

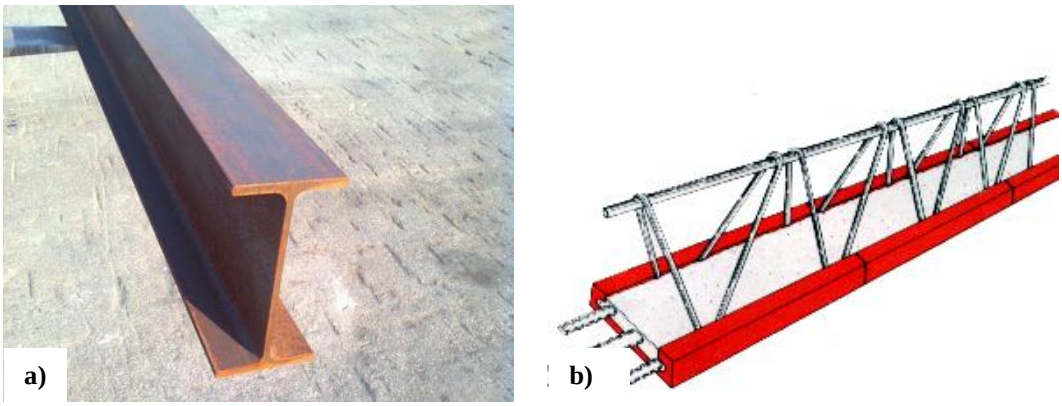

Figure 6.58 Examples of horizontal elevation structure: a) Steel beam; b) Joist.

Figure 6.59 Examples of horizontal elevation structure: Arches.

1.2.3. Spatial elevation structures

In this category are included:

- Vaults
- Shells
- Cupolas

Figure 6.60 Examples of spatial elevation structures: a) Vaults; b) Cupola.

1.3. Retaining structure

Set of technical elements of the building system connected with the its system which have the function of carry the loads coming from the soil[5].

The technical elements included in this level are:

1.3.1. Vertical retaining structure

In this category are included:

- Retained walls
- Sheet piles
- Diaphragm wall panels or barrettes

Figure 6.61 Examples of retaining structures: Sheet piles; b) Diaphragm wall; c) Retaining wall

1.3.2. Horizontal retaining structure

In this category are included:

- Under floor cavities

2. Closure element

Set of technological units and typical elements belonging to the building system having the function of separating and shaping the inner space of the building system respect to the outside [5].

The technological units included in this level are:

2.1 Vertical closure

Set of technical vertical elements of the building system having the function of separating and shaping the inner space of the building system with respect to the outside [5].

The technical elements included in this level are:

2.1.1 Vertical perimeter walls

2.1.2 Outer vertical window frames

In this category are included:

- External windows
- Exit doors

Figure 6.62 Example of vertical closure

2.2 Horizontal closure

Set of technical Horizontal elements of the building system having the function of separating and shaping the inner space of the building system with respect to the outside [5].

The technical elements included in this level are:

2.2.1 Ground slabs

Figure 6.63 Example of ground slab

2.2.2 Covering

Figure 6.64 Examples of covering

2.2.3 Outer horizontal window frame

In this category are included:

- Skylights
- Trapdoors

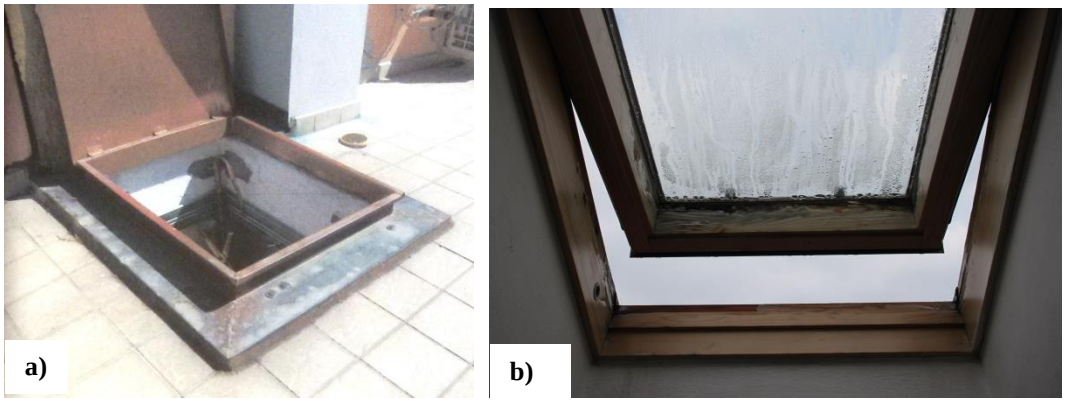

Figure 6.65 Examples of outer horizontal windows frame: a) Trapdoor; b) Skylight

3. Partition

Set of technological units and typical elements belonging to the building system having the function of separating and shaping the inner/outer space of the building system[5].

The technological units included in this level are:

3.1 Vertical partition

Set of technical vertical elements of the building system having the function of separating and shaping the inner/outer space of the building system with respect to the outside [5].

The technical elements included in this level are:

3.1.1 Vertical walls

3.1.2 Vertical window frames;

In this category are included:

- Inner doors;
- Inner windows

Figure 6.66 Examples of vertical partitions: a) Inner doors; b)Vertical wall

3.2 Horizontal partition

Set of technical horizontal elements of the building system having the function of separating and shaping the inner/outer space of the building system with respect to the outside [5]. The technical elements included in this level are:

- 3.2.1 Slabs
- 3.2.2 Mezzanine
- 3.2.3 Horizontal windows frame
- 3.2.4 Balconies or loggias

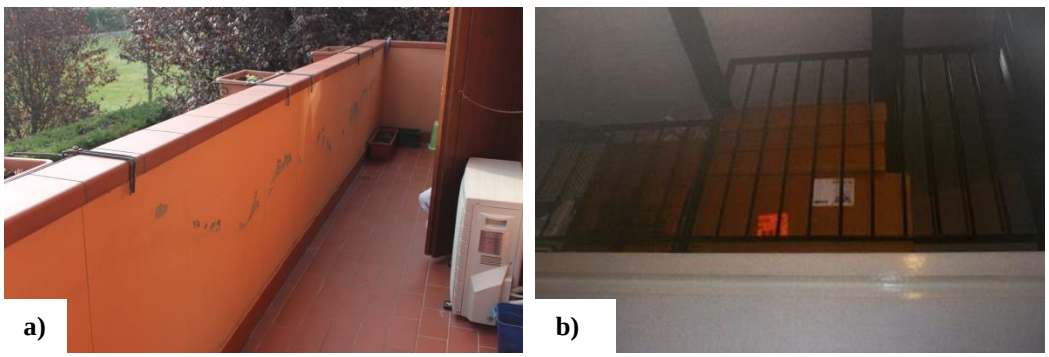

Figure 6.67 Example of horizontal partition: a) Balcony; b) Mezzanine

3.3 Inclined partition

Set of technical elements of the building system having a lying position almost horizontal with the function of separating and shaping the inner/outer space of the building system with respect to the outside [5].

The technical elements included in this level are:

3.3.1 Stairs

3.3.2 Flight

Figure 6.68 Examples of inclined partition

4. Plant

Set of technological units and technical element of the building system having the function of allowing the use of the building system[5].

The technological units included in this level are:

4.1 Supply of services plant

Set of technical elements and technical element of the building system having the function of allowing the use of energetic, information technology and material flows requested by the users and of allowing the consequent removal of discharge products [5].

The technical elements included in this level are:

4.1.1 Air-conditioning plant

4.1.2 Water and sanitary system

4.1.3 Waste disposal plant

4.1.4 Gas supply plant

4.1.5 Electrical system

4.1.6 Solar panels;

4.1.7 Rainwater removal system

In this category are included:

- Drainpipes
- Piping
- Gallipots;
- Manhole

Figure 6.69 Examples of plants: a) Ground heating system; Wayer distribution system; c) Rain water removal system; d) Solar panels; e) gallipot

4.2 Security plant

Set of technical elements and technical element of the building system having the function of protecting the use and the system in case of dangerous situations [5].

The technical elements included in this level are:

4.2.1 Fire system

4.2.2 Grounding system

4.2.3 Circuit breaker lines

5. Finishing

Set of technological units and element that complete the building structure making possible its use. The technological units included in this level are:

5.1 Flooring

In this category are included:

- Tile
- Screed
- Expansion joint
- Baseboard

Figure 6.70 Examples of flooring a) base board; b) Tiles

5.2 Covering

In this category are included:

- Plasterwork;
- Painting;
- Masonry coverage
- Wallpapers

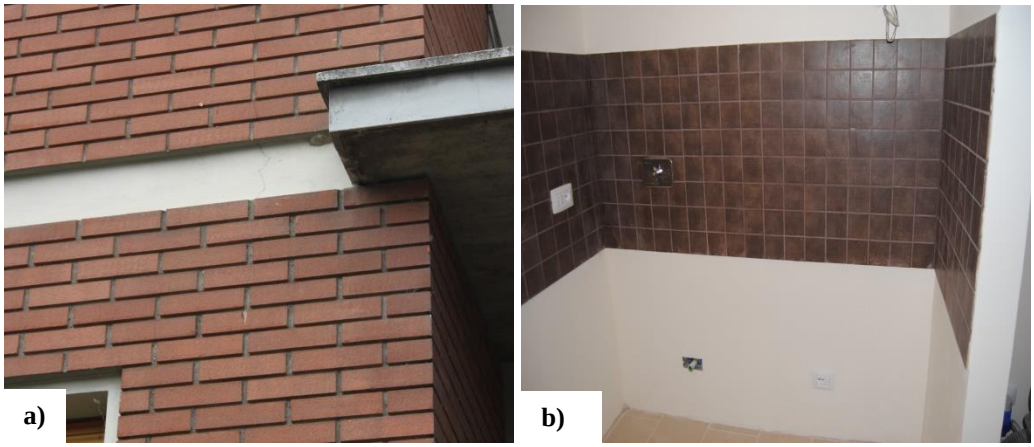

Figure 6.71 Example of covering: a) Masonry coverage; b) Painting with tiles coverage

5.3 Shingles/Roof tiles

5.4 Waterproofing

In this category are included:

- Sheeting
- Membranes
- Flashings
- Grout lines

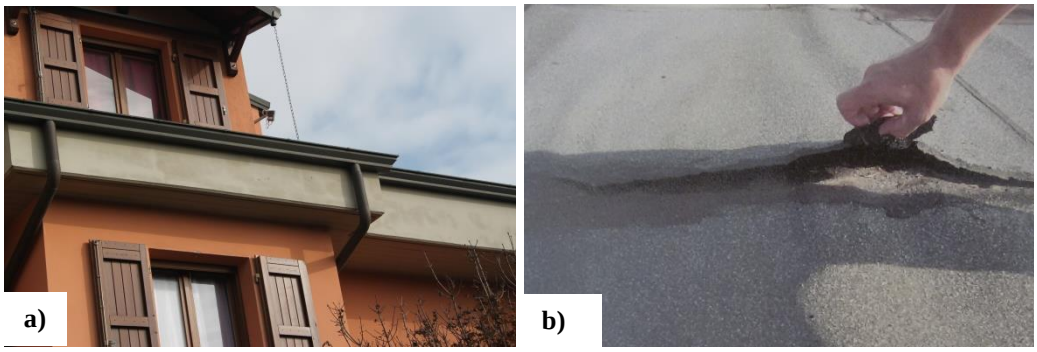

Figure 6.72 Example of waterproofing: a) Grout line; b) Membrane

5.5 Insulation

In this category are included:

- Panels;
- Fiber/Textiles

6. Street/Pertinance work

According with the definition given in the D.L. 30 aprile 1992 n° 285 "Nuovo Codice della

Strada" the street is the area assigned for the circulation of pedestrians, vehicles and animals.

The pertinence is defined as the part of the street permanently destined to the service or functional furniture of it.

The element included in this definition are

6.1 Streets

6.2 Sidewalks

6.3 Enclosure/Barriers

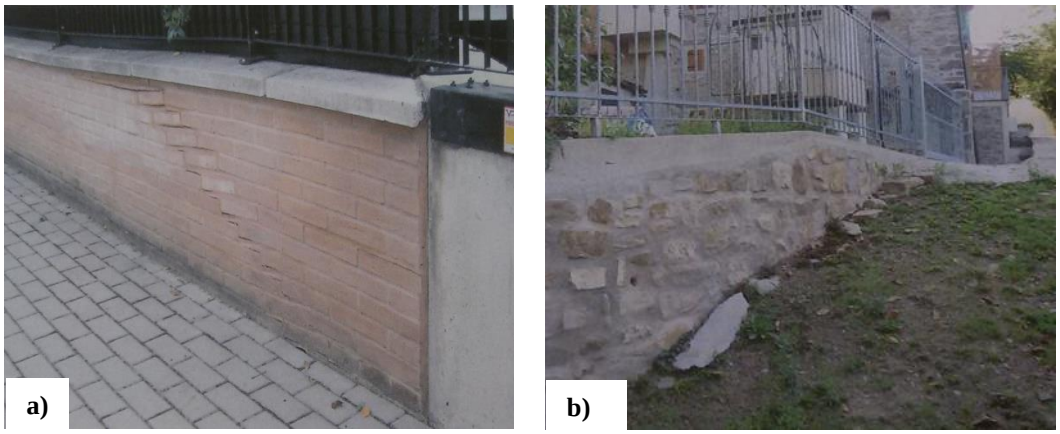

Figure 6.73 Examples of enclosures

7. Urban elements

Urban elements are the fundamental index , quantity and geometrical entity throughout containing in the Building Urban Regulation (Regolamento Urbanistico edilizio) of Bologna.

7.1. Surface

7.1.1. Territorial surface (in Italian Superficie territoriale)

Is the entire surface of an area whose transformation is regulated by an indirect implementation planning.

7.1.2. Landed area (in Italian Superficie fondiaria)

It is the surface used for the direct edification, including the area where the building and the its pertinences are built. The areas occupied by the

infrastructures, the urbanization works and the collective area are not considering as part of the surface.

7.1.3. Covered surface (in Italian Superficie coperta)

It is the projection on the ground of the planivolumetric shape, that is the surface of the figure described on the ground level by the vertical projection of the external element of the building.

7.1.4. Useful gross surface (in Italian Superficie utile lorda)

It is the sum of the useful and accessory surface of the entire elevated floor surrounded by walls.

7.1.5. Useful surface (in Italian Superficie utile)

It is the sum of the flooring areas of all the spaces which form the building unit.

7.1.6. Accessory surface (in Italian Superficie utile)

It is the area of a building unit for the services.

7.2. Volume

7.2.1. Planivolumetric shape (in Italian Sagoma planivolumetrica)

It is the envelope figure described by the intersection of the planes containing the surfaces of the external walls with the ground.

7.2.2. Total Volume (in Italian Volume totale)

It is the measure in cubic meters of the elevation structure defined by the planivolumetric shape.

7.2.3. Useful Volume (in Italian Volume utile)

It is the volume obtained by the multiplication of the useful surface for the useful height.

7.3. Height

7.3.1. Chamber height (in Italian Altezza utile del vano)

It is the height measured from the ground surface to the intrados of the slab.

7.3.2. Building front height (in Italian Altezza delle fronti dell'edificio)

It is the height of any single part om the front where the building could be spread, measured from the ground line to the coverage line.

The ground line is draft by the intersection of the front of the building with the plane of the existing ground, as documented in the actual condition .

For building having a plane roof, the coverage line is draft by the intersection of the front external wall with the intrados of the last slab. For roof having an inclination smaller than 45° the line is determined by the intersection of the front external wall with the plane containing the intrados of the coverage structure. For roofing having an inclination greater than 45°, the height is measured by the roof peak or, anyway, by the highest point of the building.

d- Kind of defect

Defect is defined as the inappropriateness of one or more constituent elements of the building system; it is a factor of interference capable to produce a malfunction or a decay whose causes can be various.

1. Water infiltration/Dampness

The water is present in the building in different forms and located in different places. its effect could be various.

The consequences due to dampness can be various depending from the nature and the time they will be repaired

1.1. Rainwater leakage
1.2. Groundwater infiltration
1.3. Leakage due to plant disease
1.4. Dampness patch
1.5. Plasterwork degradation
1.6. Mold growth/ efflorescence
1.7. Water stagnation

Figure 6.74 Examples of defects due to water infiltration: a) Ground water infiltration; b) Mold growth; c) Infiltration due to plants diesis; d) Dampness patch; e) Plasterwork degradation; f) Water stagnation

2. Crack

In this category are included all the defects related to the presence of cracks and their propagation. The appearance of crack could be linked to different factors. A further specification is made on their extension.

2.1. Small cervices

2.2. Large cracks

2.3. Diffused cracks pattern

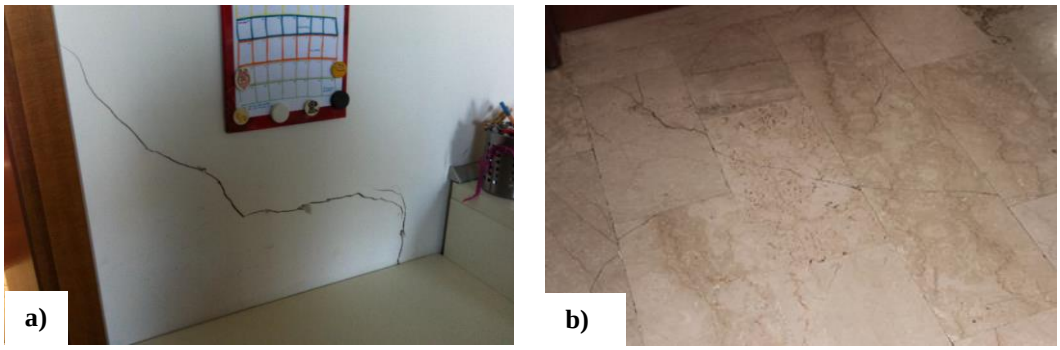

Figure 6.75 Example of cracks: a) large crack on a vertical wall; b)Diffused crack pattern on a flooring

3. Damage/Deterioration

Damage and deterioration are the consequence of an action or an event that cause the reduction in terms of integrity and functionality of a an element of the building system[6].

3.1. Decay

3.2. Detachment

3.3. Surface disintegration

3.4. Discoloration/Stain

Figure 6.76 Examples of damage/deterioration: a) Shingles deterioration; b) Covering detachment

[6] Commissione CIB W86 ("Building Pathology")

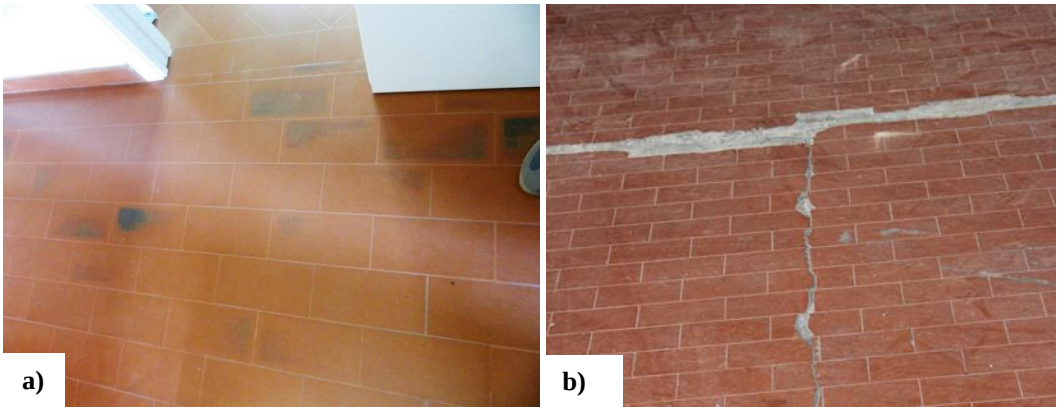

Figure 6.77 Examples of damages: a) Stains on a flooring; b) Detachment of the flooring tiles

4. Deformation

Change in the shape, dimension or position of the element.

4.1. Rotation

4.2. Deflection

4.3. Sliding

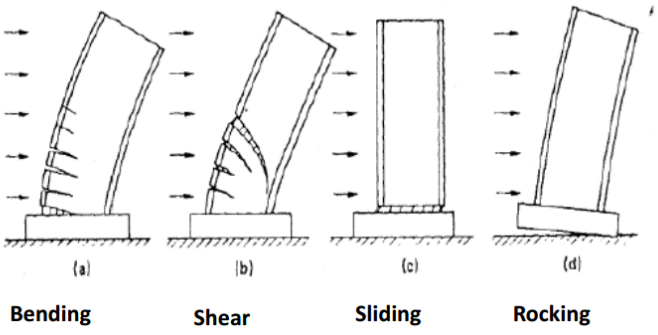

Figure 6.78 Example of deformations

5. Defective workmanship

The work is not realized following the best practice rule.

6. Code violation

The work is not realized following the prescription or the rule given by the different Code.

6.1. Technical regulation

6.2. Building Urban Code

6.3. Territorial/Environmental plan

7. Agreement violation

The work is not realized according to the points stipulated in the contract and signed by the parties.

7.1. Incomplete work

7.2. Supply of construction material

7.3. Dissimilarity with the project

8. Collapse

The entire structure or its part fall down.

8.1. Partial

8.2. Total

Figure 6.79 Examples of collapse: a) Collapse of a roofing due to a fire; b) Collapse of a enclosure wall due to a fall of a tree

9. Malfunctioning

It is a deterioration where an element is worn-out or it is not able to perform anymore.

6.1.3 Matrix C

The matrix C contains information regarding the inspection method used for the detection of the defect, describes the level of compromising caused by the defect, if its detected, it quantifies the time and the costs need for its reparation. This matrix is related to a matrix B that describes the defect claimed.

The list is comprised of the following entries:

a- Progressive number

In this section should be indicated the number of the matrix B to which the matric is connected.

b- Confirmation

Must be indicated if the claimed defect has been detected.

c- Inspection method

The diagnosis of the defect is an important and crucial phase of the technical advice. The variety of circumstances and causes that can be responsible of the defect are wide and could confront the investigator. During the detection process is important to follow certain procedures and adopt a systematic approach. Depending on the circumstances there are different ways the information can be collected.

1. Visual inspection

The inspection of the affected area is an important and fundamental phase that cannot be ignored by the technical consultant. The typical procedures made in the visual inspection are:

- Photographs
- Graphical schemes

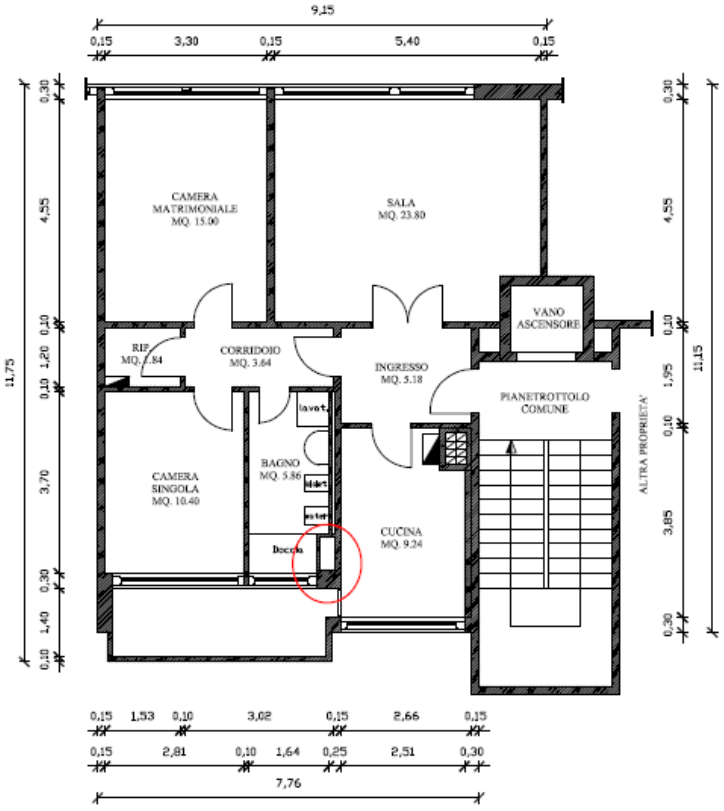

Figure 6.80 Scheme reporting the measurement made during the inspection

- Videos

Figure 6.81 Instruments for the video ispection of a drainage system

- Metric and land survey

Figure 6. 82 Metric survey: a) Inclination of the balcony; b) Measure of the distance between the stud axis and the flooring

2. <u>In situ test</u>

The in situ test are simple procedures that could be easily performed during an inspection. Example of typical in situ tests are:

- Sampling or excavation in order to establish the layers of an element

Figure 6.83 Examples of in situ test: a) Excavation of a beam b) Sampling of an external flooring; c) inspection hole for an exhaust pipe; d) Survey on a wall

- Water-tightness tests

Figure 6.84 Water-tightness tests

- Moisture measurement to evaluate the level of dampness

Figure 6.85 Examples of measurement of the moisture

3. Specific test

Are tests, generally more complex than the in situ ones, that are requested by the technical consultant in accordance with the parties or with the permission of the judge.

The typology of tests depends obviously on the kind of the test.

- Loading test

- Laboratory test

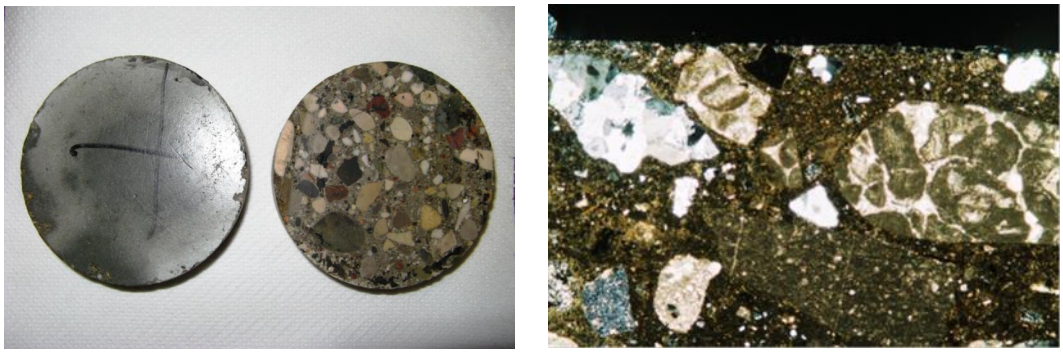

Figure 6.86 Laboratory tests: a) Chemical analysis; o a concrete sample b) Analysis of the concrete with a polarizing microscope

- Acoustic test

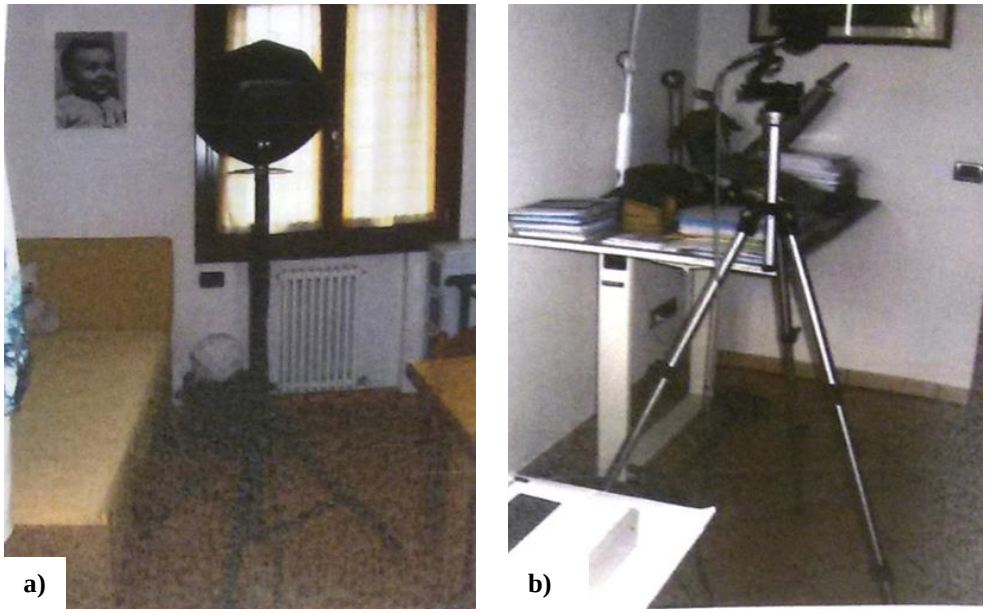

Figure 6.87 Acoustic test: a) sources b) receiver

- Term Thermography

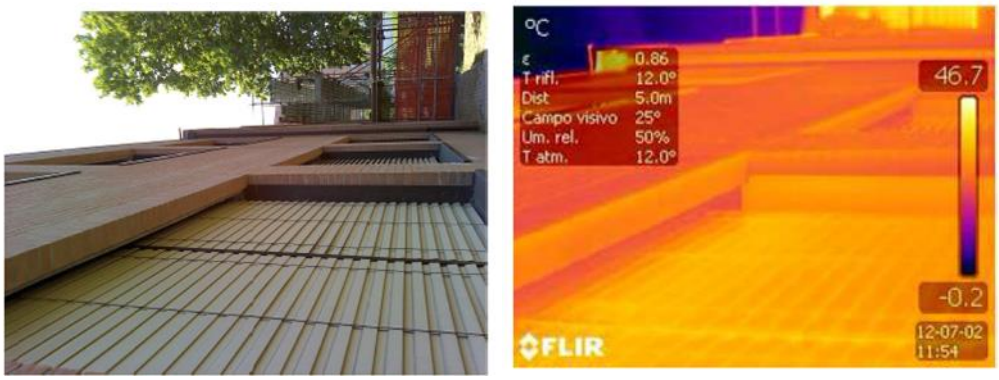

Figure 6.88 Test for the evaluation of the temperature

4. Design check

These kind of methods include:

- The analysis of the structural response and the comparison with the calculation made during the design.

		UNITA'	PROGETTO		BACK 1		BACK 2		NON DRENATO	
			Φ' [°]	c' [kPa]	Φ' [°]	c' [kPa]	Φ' [°]	c' [kPa]	Φ [°]	Cu [kPa]
		1	25	-	25	-	25	-	-	60
		2	25	40	25	10	25	5	-	85
		3	30	60	25	25	25	20	-	120
		4	35	100	25	50	25	50	-	200
			w [mm]	M_{max} [kNm/m]	w [mm]	M_{max} [kNm/m]	w [mm]	M_{max} [kNm/m]	w [mm]	M_{max} [kNm/m]
attrito struttura-terreno 2/3tanφ	CONDIZIONE DI VINCOLO	TIPO 1	37	173	82	310	89	336	19	154
		TIPO 2	78	214	188	362	221	401	26	135
		TIPO 3	91	219	191	332	217	367	39	168
		TIPO 4	146	255	306	397	367	458	64	181

Figure 6.89 Comparison between the design parameter (first column) and the result obtained with a numerical calculation

- The analysis of the drawing in order to reveal detailing on the constructions. This kind of verification is generally made when it is necessary a comparison between the actual and the design situation.

d- Expected behavior

It indicates the identified defect as a consequence of the normal behavior of the structure in the service conditions.

The expected behavior is something difficult to define. From a technical point of view is related to the state of common aging of the building structure and materials, therefore not ascribable to a design or construction error. In the definition are also included behaviors connected to an extraordinary event.

For example, it has been established that for roofing made of shingles, its necessary an ordinary maintenance about every 10 years in order to avoid the slipping of the tiles. In absence of maintenance after 15 years, also if the detachment of the shingle has been detected, it cannot be considered as a defect but it is a expected behavior.

A better and more exhaustive explanation of this aspect will be provided in the next chapter.

e- Level of impairment

It indicates the effect of the presence of the defect has done the building system behaviour.

According to the specification of the rule UNI 8289 the following compromising level are been considered

1. Structural safety

Set of conditions related to the safety of the users, as well as the defense and protection from the damages related to fortuitous factors, during the operational life of the building system[7].

2. Wellness

Set of conditions related to the condition of the building system properly adequate to the life, the healthy and the carrying out the activities of the users[7].

3. Usability

Set of conditions related to the aptitude of the building system to be adequately used by the users during their standard activities[7].

4. Appearance

Set of conditions related to the building perceptual usability of the system by the users [7].

f- Repairing time

The time necessary to eliminated the defect correspondent to the duration of the remedial work.

[7] UNI 8289 "Building – Functional requirement of final users – classification".

1. Free text

Insert the estimated repairing time

2. Not reported

In some cases the repairing time is not reported in the technical advice.

2.1 Not request in the question

The task of the technical consultant pose by the judge. In some cases the estimation of the repairing time is not requested.

2.2 Not evaluates

In few cases the answer to the question could be incomplete and the repairing time is not calculated by the consultant.

3. Already evaluated in another matrix

The estimation of the remedial work could be general, if so the consultant could evaluate the repairing time necessary for the removal of all the defects. In other case two or more defects could be eliminated proceeding the same operation. In these situations, in order to avoid erroneous evaluation related to a lawsuit and reported redundant information, the repairing time is reported just ones.

4. Null

The repairing time is null when there is no need of remedial work, as in the case of building permit violations where is enough to pay a penalty.

5. Incomputable

The technical consultant has to provide a general solution for the elimination of the defect without draw an effective project. In the case of very complicated situation an estimation is impossible.

g- Repairing cost

Estimation of the cost due to the elimination of the defect.

1. Price or insurance value

Insert the estimated repairing cost that should be evaluated through a bill of quantities based on the official price list provided by the Region.

2. Not reported

In some cases the repairing costs are not reported in the technical advice.

2.1 Not request in the question

The task of the technical consultant pose by the judge. In some cases the estimation of the repairing costs is not requested.

2.2 Not evaluates

In few cases the answer to the question could be incomplete and the repairing costs are not calculated by the consultant.

3. Already evaluated in another matrix

The estimation of the remedial work could be general and the consultant could evaluate the repairing costs necessary for the removal of all the defects. In other case two or more defect could be eliminated with the same operation. In these situations, in order to avoid erroneous evaluation related to a lawsuit and reported redundant information, the repairing costs are reported just ones.

4. Null

The repairing cost is null when there is no need remedial work.

5. Incomputable

The technical consultant has to provide a general solution for the elimination of the defect without draw an effective project. In the case of very complicated situation an estimation is impossible.

6. Decreasing value

In this item is quantified the loss in the economic value of the building system due to the presence of the claimed defects.

h- Agreement before sentence

The technical consultant carries out an appraisal in the presence of the court experts signed by the parties, in this stage it has also the responsibility of trying a reconciliation between the parties in order to avoid a civil trial.

i- Compensation method

For removal method is meant the way the dispute is solved, while the description of the remedial work necessary for the elimination of the defects is not necessary.

1. Remedial work by the guilty party

The responsible provides for the solution of the problem carrying out the remedial work. This solution is common in the cases of agreement between the parties.

2. Monetary compensation

The responsible has to pay out the claimant which provides to the remedial work.

6.1.4 Matrix D

The matrix D contains information regarding the causes that lead to the appearance of the defect. This matrix is related to a matrix B that describes the defect claimed.

Since the causes of the defect could be various it is possible to create more than one matrix for each defect.

The list is comprised of the following entries:

a- Progressive number

In this section should be indicated the number of the matrix B to which the matric is connected.

b- Cause of the defect

In this section should be indicated the causes of the claimed defect.

1. Poor material

According with the UNI 8402 the quality is "the set of property and characteristic of an entity that give to it the capability to satisfy the required and implicit needs.

The regulations define the reception criteria of the materials (any product crated in order to be used in the building works) including the description of the objective features and which qualities they should have.

The requirement for the products are contained in the Legislation 2006/42/CE. The legislation defines the essential requirement of the construction and all the materials and products referred during the installation, in particular:

- Mechanical strength and stability (RE n.1);
- Fire resistance (RE n.2);
- Cleanliness, healthy and environment (RE n.3);
- Safety in operational (RE n.4);
- Protection against noises (RE n.5);
- Energy conservation (RE n.6).

The products should be equipped with CE mark8 that certify the adequacy of the construction process.

The materials included in the list are the following:

1.1 Concrete
1.2 Steel
1.3 Wood
1.4 Aluminum and other metals
1.5 PVC and other plastic
1.6 Glass
1.7 Masonry/Bricks
1.8 Tiles/Shingles
1.9 Paints/Covering
1.10 Backfill
1.11 Protective membranes/fibers
1.12 Resins/Foams

2. Poor execution

The causes related to errors committed during the construction stage are contained in this section. The execution is the longest and most delicate stage in the building process and the factors that could lead to the presence of defects are various.

2.1. Not consistent with the best practice

A civil work is not consistent with the best practice if it is not built following the general criteria provided by the technique for each kind of manufacturing.

[8] The CE mark or formally is a mandatory conformity marking for certain products sold within the European Economic Area(EEA) since 1985.[1] The CE marking is also found on products sold outside the EEA that are manufactured in, or designed to be sold in, the EEA.

According with the rule UNI 10839 the building quality could be defined as the set of properties and features of the building organism or its parts that give to it the ability to satisfy through the performances the required and implicit needs.
According with the legislation 2006/42/CE and CE mark the products should be applied, installed and mounted is such a way to satisfy, if properly design, the essential requirement provided by the rules.
The regulations provide the definition of the behavior that the component should have in order to fulfill the requirement. The also provide rule for the installation and the check of the different building elements..

2.2. Not consistent with the agreement

The quality of the production the building process is related not only to the best practice but also on the requirement chosen and defined in the contact.

2.3. Not consistent with detailing specification

During the construction the technical documents provided by the designer or the costumers are not be respected.

2.4. Not consistent with the project

The current condition in not consistent with the design situation provided in the design documents. Building is not constructed in accordance with the design.

2.5. Incomplete work

Is the case in which the construction is not be completed or are not be realized all the works indicated in the contract.

3. Design errors

The design is the process that starting from technical rule, calculation, specification and drawing achieve to the construction of a product.
The goal of the design is, according with the definition provide in the Titolo III, Capo II, D.P.R. 554/1999, the realization of a good intervention that is technically efficient obeying the cost-benefits ratio, inspired to the principle of nonrenewable resources minimization and maximum reuse of natural resources.

In this section are considered as design error the one connected to the conceptual design, in particular the selection of an adequate models and parameter in the calculation.

3.1. Geotechnical calculation

In this section are reported errors connected with the design of the foundation or retaining structures.

An example of these kind of errors could be the selection of wrong parameter for the definition of the soil characteristic as the friction angle, the shear modulus, cohesion etc… .

3.2. Structural calculation

In this section are reported errors connected with the design of the elements carryind the horizontal or vertical load.

An example of these kind of errors could be the selection of model that are not able to represent the real behavior of the structure.

3.3. Executive design

The construction design defines every architectural, structural and plant detail of the building work to realize.

An example of these kind of errors could be the absence of a sufficient system for the anchorage of the covering.

3.4. Lack of detailing

In this section are reported errors related in which the detailing for the construction phase are insufficient in order to describe properly the intervention.

4. Code violation

The different codes identify different condition that should be respected during the reduction of the project and the construction of the building system.

4.1. Not consistent with the technical prescription

The "Norme Tecniche per le Costruzioni 2008" establishes Principles for the design, the execution and the testing in accordance with requirements for the safety, serviceability and durability of structures. It defines the general criteria for

the structural safety, defining the design action to use in the project, the features of material and products. It represent the basis for the design and verification of the structure and gives guidelines for related aspects of structural reliability.
All the civil work must be design, built and tested in such a way the can be used for the purpose for which they are intended to in accordance with the safety level prescribed by the code.
An example of these kind of errors could be the absence of the minimum amount of reinforcement, excessive deflection or inter-story drift.

4.2. Not consistent with Building Urban Regulation

The "Codice Civile - Titolo II - Capo II - Della proprietà fondiaria Sezione I - Disposizioni generali" in the art 869 prescribes that the construction or the modification of a structure where is present an urbanistic instrument as to be realized in accordance with the prescription provided by them.
The Building Urban Regulation define the building-urbanistic quantities and the relative calculation method, builging-urbanistic procedures and also the design criteria for the materials, the open and built space. Any violation of one the prescription represent a building permit violation (in Italian abuso edilizio) .

4.3. Not consistent with other Regional planning Regulation (in Italian Piani Urbanistico Territoriali)

The regional planning govern the management processes of the territory. They represent ones of the instrument for the analysis and the evaluation of the effects that specified design action could have on the area. The prescription given by these regulation are mandatory and their violation is an building permit violation.

5. Lack of site manager supervision

The control of the building properly is not been performed correctly during the duration of the works.

6. Negligence

Conduct that falls below the standard of behavior for the protection of the building system.

6.1. Lack of ordinary maintenance

6.2. Improper use

7. Human causes

Related to the human activity

7.1. Collision

7.2. Tampering

7.3. Explosion/Fires

8. Natural causes

Related to extraordinary event depending on the natural phenomena

8.1. Earthquake

8.2. Landslide/Land movement

8.3. Flooding

9. Impossible to determine

In the case in which it is impossible to determine with certainty the causes of the defect.

In this kind of proceeding there is no space for the probability, the causes are attributed only with there is no doubt.

6.1.5 Matrix E

The matrix E contains information regarding the responsibility that lead to the appearance of the defect. This matrix is related to the previous matrices (B and D) that describe the defect and its causes

The list is comprised of the following entries:

a- Progressive number

In this section should be indicated the number of the matrix B to which the matric is connected.

b- Responsibility

In this section should be indicated the responsibility the claimed defect

1. Designer

The designer has to define in advance all the elements that have to be realized. The project must be consistent with the expectation of the costumers and with technical and juridical regulation.

In the Civil Code, with respect to the relevant defect, responsibilities are ascribed to the designer also in the absence of a contract with the costumer, since he has to guarantee the stability of the building or other civil structure that has a long nominal life and the safety of the citizen.

1.1. General

The designer could be general if he has to manage a project team and his function is to coordinate and define the design phase.

1.2. Geotechnical

The designer could be structural if has the assigned task of defining the foundation elements.

1.3. Structural

The designer could be structural if has the specific task of defining the structural elements.

1.4. Architectural

The designer could be architectural if has the specific task of defining the architectural elements.

1.5. Services

The designer could be architectural if has the specific task of defining the services

2. Site manager

The site manager has different responsibilities defined by the articles of the 29 DPR 380/2001:

- Pay attention to the correspondence of the works with the project authorized by the Public Administration (art.) contesting, immediately, any contingent violation to the costumers and builder

- Pay attention that the works are correspondent to the project, to technical specification and to the contract.
- Control the quality of the material (acceptation) and the installation of the elements
- Write the preliminary rand the final reports that are deposited at the public office
- Communicate the end of the work after the testing.

2.1. General

The site manager could be the same designer. Generally there is only one site manager, but if he does not have particular skills in a certain field it is possible to have more than one.

2.2. Structural

The site manager could be structural if has the specific task of controlling the realization of the structural works.

2.3. Geotechnical

The site manager could be structural if has the specific task of controlling the realization of the foundation works.

3. Inspector

The inspector is a technician nominated by the costumers that as the task of verify and certify the civil work. The obligation and responsibility are defined in the Art. 67 Of DPR 380/2011 – Testo Unico dell'edilizia. It is possible to define two kind of inspectors.

3.1. Static inspector

He Has the task of verifying the correspondence that a building is built respecting the project attached to the contract. After the execution of test on the material to certify the quality and quantity, the verification of the dimension and the shape He can states the validity of the structure.

3.2. Technical-administrative inspector

Has the task to verify that the works are realized in accordance with the best practice, following the established technical prescription and in compliance with the contract, the modification and the approved documentation. The inspector must also carries out all the technical verification prescribed by regulation basing also on the documentation provided by the builder.

4. Construction firm

The construction firm must be able to realized the works, organizing and managing the capital, the machineries and the workers, according to the rules of the best practice and in observance of the project and the contract stipulated with the costumers

The firm has the obligation of provide a warranty with respect to defects and dissimilarities of the works in the modality described in the art 1667 and 1669 of the Codice civile , Libro IV, Titolo III, Capo VII.

The costumers could request the elimination of the above mentioned defects or dissimilarities or a reduction in the price, expect for the compensation of the damage in the case that the fault are of the firm

Depending on the type of contract it is possible to classify the firm as follow

4.1. Contractor firm

4.2. Subcontractor firm

4.3. a.t.i Firm

5. Costumers

The costumer is the subject that has the put money, and for this reason has decision-making power, to realize a building intervention. The costumer could be public or private entity, a natural person (as the owner of a property) or legal person (as a Condominium).

The costumer commit to a firm a work through a contract.

The obligation of the costumer are reported in the " Codice civile , Libro IV, Titolo III, Capo VII" and are the following:

- Responsibility for the agreement containing in the contract with particular attention to the economic aspects;

- Accept the work at the end of the construction operation. If the costumers does not carry out the verification or does not communicate the results in a reasonable time, the work is considered accepted and the contractor is responsible only of hided defects.
- Make an appropriate use of the structure and manage it appropriately (maintenance)

6. Condominium

The "Codice Civile - Titolo VII - Della Comunione-CAPO II. - del Condominio degli edifici" defines the common parts of the building and the responsibility of the Condominium. In particular are considered common parts of the building the soil where the structure is built, the external wall, the roofing, the flat roofs, the stairs, the arcades, the courtyards and in general call the part of the building necessary for the common use. Also the plants for the supply of services and the elevetors are included in this category.

The Condominium cannot realize works that could causes damage of the part of the building for common or personal usage.

7. Seller

The art 1490 C.C sanctions in general term the obligation of the seller. The building system should not present any defects that reduce the usability, for the use it is intended to, or that diminish in an appreciable way the value. The regulation define also the case in which this article is not applicable and the seller is not forced to respect the above mentioned obligation for example in the case in which the buyer know the existence of the defects at the moment of the signature of the contract.

8. Adjacent property

The owner of a property that realized civil works are responsible , considering the art. 840 comma 1 c.c., of the damage caused on adjacent properties independently from the responsibility of the contractor that execute the works, in general , under the art. 2043.

9. Impossible to determine

In the case it is impossible to determine with certainty the responsibility of the defect. In this kind of proceeding there is no space for the probability, the responsibility are attributed only when there are no doubts.

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Conclusion

Thanks to the agreement with the Court of Bologna and the Department of Civil, Environmental and Material Engineering (DICAM) of the Faculty of Engineering at the University of Bologna it has been possible to analyze and study the real cases of litigations concerning building. The link between the Court, that provides the Documentation from technical advice in lawsuits and the Department, that provides the technical knowledge is the research center "Observatory Claudio Ceccoli". The center is entirely devoted to the identification ant the analysis of the defects on building structure in order to increase the preparation and the culture of the technicians. The first years of activities of the center focused on the collection and the examination of the real cases available in the archive of the Court of Bologna, regarding the civil proceeding of the year 2011.

This is the starting point of the thesis. During the present work are been collected the data related to the civil proceeding of the 2012 in order to increase the information already available and conducts more in depth analysis. The data entries operation has put in evidence some issues related to the structure and the efficiency of the matrices, that constitutes the structure of the database. In particular, inquiring the different sections of the matrices, is been shown:

- Lack of references to code and regulation;
- Redundant information;
- Insufficient alternatives for the description of the possible cases;
- List of alternatives too much detailed.

Thanks to this evaluation the main issues related to matrices are been discussed and proper alternatives can be found for their solution. The enhancement are of different type:

- Punctual improvement: increasing or decreasing the number of entries related to the item in consideration;
- Global improvement: changing the rationale behind the items;

- Improvement of the classification: make reference to the codes in order to avoid misunderstanding.

The analyses led to the definition of new matrices for the database. For them is been created a guideline guidelines that describes in a detailed way, according to the definitions provided by the code, regulation or other references, all the entries of the matrices. In this way the information used by the technical consultant are clear enough there are no misunderstandings.

Despite the above mentioned problem the data collected until the 2012 are anyway important and descriptive of the most commons defect occurring in the civil works.
The largest part of defects is detected in residential building belonging to private citizen and are detected during the service life. In particular they are caused by an erroneous execution, that does not respect the best practice role, and involved in the majority of the case the finishing.
The analysis of the costs was more complicated and only general information are been obtained. In one half of the case the costs are smaller than 25.000€. In this half the number of technical advice having a cost smaller than 2.500 € is the highest.

From the analysis of the real cases emerged some critical aspects. For this reason are been developed some documents called "Focus" that, in the context of the Technical Advices, are in-depth analysis regarding topics that are useful for the activities of the various actors involved in the field. These documents have different nature, they could analyzed recurrent issue encountered during the investigation of the real lawsuit or could clarified some aspects related to the investigation process. It is possible to identify two main typologies:

- Thematic focus: help the Technical Consultant, that has the task to joint technical knowledge and juridical notions, in the creation of a common language that unify the overall view regarding the main and frequent issues.

- Methodological focus: have as topic the activity of the technical consultant. The goal is to help the management of the investigative operations and the relationships with the other professional figure involved in the process.
- Technical focus: establish, following an univocally tendency, specific technical information and references for the analysis of the common defects.

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The lack of references put under the light the need to share information, knowledge and experiences in these wide field in which many aspects are still unknown. The studies conduct on the defects in the civil structure, at national or international level, are very rare. Only few academic publication are available, particularly noteworthy are:

- Documents of the conferences IF CRASC, organized by the Italian Association of Forensic Engineering;
- "Bullettin des erreurs" a document publisced by the French society SOCOTEC;
- "Why buildings fall down?" a famous text of Mario Salvadori.

Anyway the tendency is to analyzed collapse or catastrophic failure. The university of Bologna is one of the few university that dedicates attention to these particular problem. The idea is to continue the collection and the analysis of the real cases with the creation of a database and focus that could be used by all the technical consultant. In this way is possible to share the big amount of data available and create a common language that is able to merge the juridical and technical references, increasing the awareness of the people involved in the building process, as contractor, costumers and exerts, on the risks that are intrinsic of these kind of activities.

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