THE DIGITIZATION OF CONSTRUCTION SITES

TECHNOLOGICAL INNOVATION AT THE SERVICE OF SAFETY

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ABSTRACT

he DM 560 of 1 December 2017, defines the methods and times for introducing the mandatory nature of electronic modeling methods and tools for construction and infrastructure in contracting stations.
This methodology, named BIM, "Building Information Modeling" and defined by the National Institutes of Building Science as the "digital representation of physical and functional characteristics of an object", has the role, in the construction industry, of supporting communication, cooperation, simulation and optimal improvement of a project along the complete life cycle of the built work, thanks to the participation of all the main actors.
The obligation to use the building information model became mandatory from 1 January 2019 for contracts with an amount equal to or greater than 100 million euro, and then had a 'progressive' adjustment for works of lesser value, up to the mandatory implementation of BIM also for contracts of less than 1 million from 2025.
At the same time, in recent years, the advent of new technologies are exposing the world of work to profound changes; the Internet of Things, artificial intelligence, robotics, have upset the world of work and the management of worker safety. The EU-osha, the European Agency for Health and Safety at work, in this regard, is examining the consequences of the use of these technologies, to provide information on their impact on the nature and organization of work and to provide information on challenges that may affect Occupational Health and Safety.
This technological innovation and digitalization of services has transformed a legal obligation into a natural orientation, a need that the various stackeholders, involved in the construction activity, feel in order to optimize the work activity, leading transformation of the traditional construction site into a digital construction site.
All this must also be able to be projected on small realities, on construction sites not belonging to major works, and therefore not born digital, in order to create a smart construction site able to make the most of technological resources to obtain timely and safe management of building site.
In this context, we want to pay particular attention to how the safety management, provided for by Legislative Decree 81/2008 - Title IV Temporary or mobile construction sites, has been influenced in recent years by the advent of digital systems on construction sites.
Digital technologies can advance the safety management efforts in a number of ways. However, depending on the method of designing and implementing the technologies, the organizational context and the professional position, digitization can affect safety management by also making new risks emerge for the workers involved.
Therefore, starting from a comparison of the different methodologies available today, and the different approaches adopted, also based on the type of construction site to be monitored, the goal is to evaluate the results of the experiences gained in recent years and the expectations of the stackeholders.
With the aid of a questionnaire formulated specifically for the survey and administered online to the selected sample of users, we want to monitor the interviews for the level of integration of technologies and digital processes, particularly with reference to the management of safety at work, on construction sites in the province of Avellino.

INTRODUCTION

BIM, acronym for Building Information Modeling, is a method of approach to the planning, construction and management of a building that is gaining ground in the world in recent years.
The highly innovative element of the methodology is the possibility to allow the various professional fi - ures involved in the project to collaborate in the creation of the virtual model of the work, each contributing, on the basis of their skills and responsibilities, with the information that concern.
Collaboration, accessibility and interoperability are an important part of the application of this operational methodology. BIM allows to identify in advance any critical issues and errors, and to intervene promptly already in the design phase.

Even if the digitization process has reached the construction sector with a certain delay compared to the other economic sectors, this phenomenon is now inevitable given the spread of digitization techniques that now affect every area of life.
To understand the incidence of this phenomenon in the construction field, it makes no sense to think about the construction site as a generic entity, since there are large, medium, small and micro construction and infrastructure sites, but it is necessary to identify what are the structural invariants on which to reason in order to highlight the integration of information technology in the industry.
In the collective imagination it is easy to associate the digital construction site with places with high levels of automation and robotization, for the increasingly constant presence of SARP Systems (Sistema Aer-

omobile a Pilotaggio Remoto) for monitoring the progress of the work, sensors for the management of worker safety, smartphones that allow stakeholders to exchange and share information on the construction site. But the true heart of the fourth industrial revolution in the construction sector lies in the "invisible", that is, in the synchronization of production and decision-making processes, in the ability to digitally manage flows, share the "data" to generate decision-making processes.

Consequently, even the simplest realities can point to high levels of digitization, accelerating a process that has had a slow evolution, perhaps also due to mistrust and cultural blocks typical of the building sector.

The management of the construction site has always been based on a mostly static and documentary approach, however it is evident that the construction site evolves and transforms according to the work to be carried out, leading to the onset of different risks and therefore different prevention measures and protection to be adopted.

Therefore, as regards the aspects of safety management on the construction site, tools that can respond to the dynamism of the activities that follow one another are particularly useful; this goal was achieved by BIM as it introduced another dimension: time. Using this methodology, it is possible to focus attention on particularly sensitive moments, analyze them and understand what the risk factors may be, even more easily evaluating the progress of the work in relation to the programming carried out.

It is possible to cite numerous examples of applications of the technologies for a more efficient management of safety on construction sites:

- The use of high-precision sensors that measure the pollutants in the air, the noise level and other standard environmental parameters to provide data to artificial intelligence systems capable of offering efficient monitoring of environmental risk in the workplace.
- The use of sensors and software to control access and monitor worker safety, automate the tracking processes of machines and materials, thus obtaining information automatically.
- The digitization of information, web platforms and cloud storage that allow the operator on site, through the use of a tablet or smartphone, to quickly connect to the database with the necessary information.
- The same training and information activity provided for D. Lgs 81/2008 can derive numerous benefits from the application of the Information Tecnology. In this case virtual reality can allow to overcome the limit of a theoretical training that does not contextualize the worker in the space designated for him in relation to his role and therefore to the risks actually present. Training using virtual reality is intended to help workers and technicians familiarize themselves with particularly dangerous areas and situations, since it is carried out within the same construction site where they will work later or for which they will be responsible as personnel for health and safety at work.

From these considerations it is natural to ask at what point is the digitization process of Italian shipyards. Numerous surveys conducted by major associations and organizations highlight the state of the art at national and international level through annual reports; in this work, on the other hand, we wanted to conduct a survey on the local situation, interviewing employers in the province of Avellino.

The legislation governing BIM

In the European scenario, the regulatory cornerstone for the introduction of Building Information Modeling is Directive 2014/24 /EU of the European Parliament and the Council. Introduced in 2014, the legislation obliges EU member states to promote and adapt to BIM for public works by 2016.

Pursuing a strategy aimed at "smart, sustainable and inclusive growth" of the public contracts sector, the Directive considers technology as a necessary tool to achieve this goal.

In Italy, this Directive was implemented with Legislative Decree 50 of 2016, Code of Public Contracts.

With the entry into force of the Code of Contracts and Public Procurement, the BIM methodology also becomes a determining evaluation parameter of the requirements.

The Ministerial Decree n.560 of 2017 (BIM Decree) subsequently sanctions the introduction and mandatory nature of BIM in the public procurement sector, defining the methods, introduction times, methods and specific electronic tools and extending their use to all phases of a work, from planning to management and verification

Furthermore, a series of definitions are introduced, partly already contained in the Code of public contracts, partly unpublished; in particular, the concept of the data sharing environment is introduced to pursue the objectives of transparency, sharing and traceability. Using digital systems, an environment must be created where all data is produced, collected and shared. These measures are accompanied by an intense standardization activity that plays an important role in defining the guidelines to be followed in the adoption of this methodology: the UNI 11337 standard.

UNI 11337 regulates the aspects related to the digital management of construction information processes. Specificall , it deals with models, documents and information objects for the development of digitized products and processes. Divided into ten parts each dedicated to specific aspects to be regulated, it is constantly evolving to follow the changes in the process.

The survey at the national level

In recent years, the phenomenon of the digitization of construction sites is a topic of great interest to the scientific community, as the introduction of the BIM methodology in the infrastructure sector has led to a very important cultural change.

To understand the opinion regarding BIM, at national level, it is interesting to analyze the 2020 ASSOBIM report, the association created to promote the dissemination of Building Information Modeling and support the activity of the entire BIM technological chain in Italy and the " annual survey on the sector of Italian engineering companies, final balance 2020-budget 2021 "of the OICE (Associazione delle Organizzazioni di Ingegneria e Consulenza Tecnico Economica).

The starting point of the 2020 edition of the ASSOBIM BIM Report was the analysis of the degree of knowledge and use of Building Information Mode-

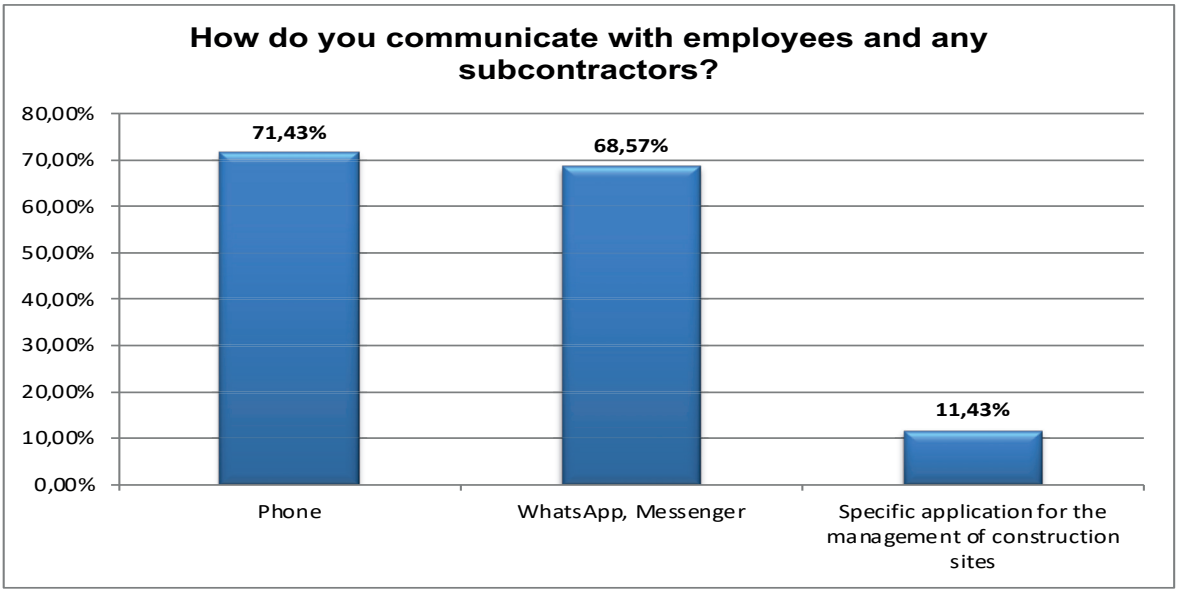

Fig. 1 - *Question 5 - how to communicate with employees*

ling and its potential among industry operators. The interviewed sample - largely made up of design firms (over 52% of the sample) and engineering companies (17.1%) - knows and uses the BIM methodology, while a further 40% know it but do not use it or makes partial use of it, and only a marginal number of operators (just over 10%) are unaware of it. The growth in knowledge, skills and use was matched by the data on the degree of awareness of the benefits deriving from the adoption of the BIM methodology in professional practice. Over 80% of the sample - 10% more than in 2019 - are convinced that the adoption of BIM is able to contribute strongly (up to a third less) to the reduction of the initial construction cost and costs relating to the entire life cycle of the building, as well as the reduction (up to 50% less) of the overall time for carrying out the work, from start to completion of the works.

The survey conducted by the OICE, on the other hand, shows that:

86.4% of companies declare that they have made investments in BIM (Building Information Modeling). Investments in BIM were mainly aimed at training (87.4%) and the purchase of software (76.4%).

31.3% of larger companies believe the usefulness of investments in BIM is high, while this percentage drops to 16.3% for smaller companies. At the same time, only 6.3% of larger companies consider the effectiveness of these investments insufficient, while the percentage rises to 20.7% for smaller companies.

Survey methodology in the province of Avellino

The survey on the Avellino area was carried out by integrating the study of the reference framework with the analysis of a questionnaire developed ad hoc to understand the approach to the digitization process of companies in the area.

The questionnaire

The questionnaire was developed in order to provide an overview both on the real integration of technologies and digital processes within construction companies and on the perception of employers towards innovative technologies.

The questionnaire proposes a series of questions, a total of 18 questions, with multiple choice that provide control tools to assess the actual match between the perception of technologies and their effective integration into the company.

The questions can be grouped into five macro sections:

- A. Understanding of the type of company, its size and its cultural approach to IT
- B. Familiarity with new communication technologies and information sharing
- C. Surveys on the state of use of the software in the company
- D. Surveys on the status of worker safety management using IT techniques
- E. Prospects for technological development in the company.

How do you communicate with technicians?

	Regularly	Occasionally	Rarely
Phone	85.71%	8.57%	5.71%
Email	76.47%	20.59%	2.94%
WhatsApp, Messenger	64.71%	32.35%	2.94%
Sharing tools (Dropbox, OneDrive) **Collaboration tools** (Microsoft teams, Google Hangouts, Trello)	29.03%	38.71%	32.26%

Fig. 2 - *Question 6 - how to communicate with technicians*

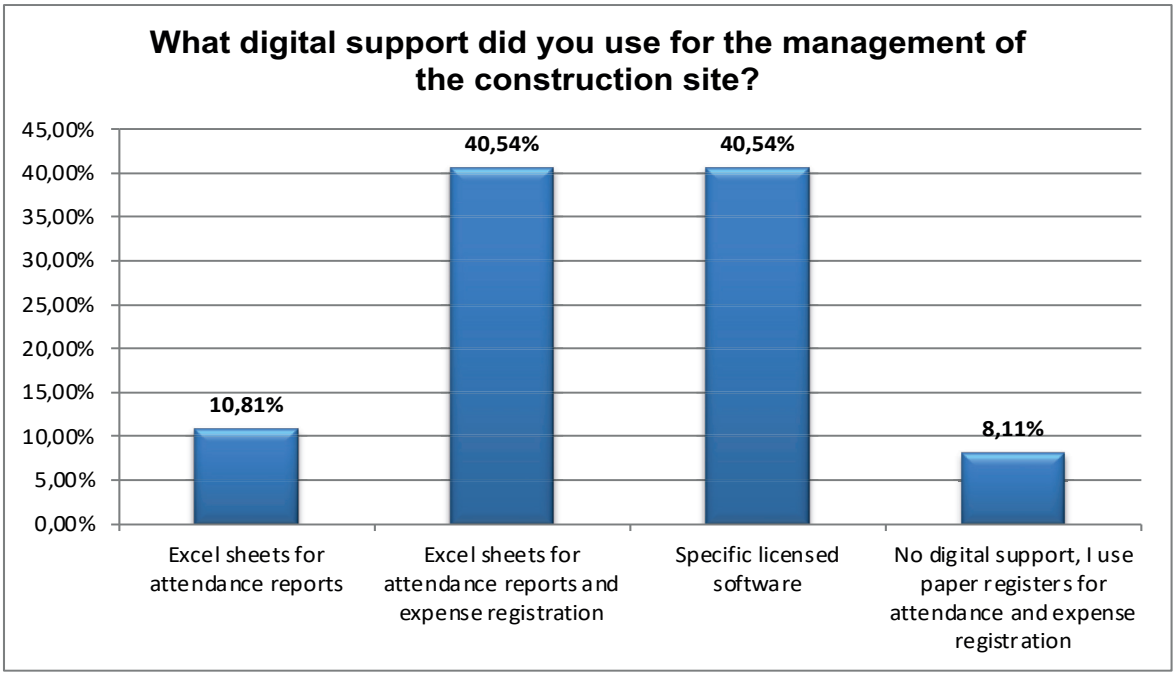

Fig. 3 - *Question 4 - digital medium used for site management*

RESULTS

The results are presented below and divided according to the macro-sections identified in the questionnaire.

A. Understanding of the type of company, its size and its cultural approach to IT

The sample analyzed is made up of a total of 37 companies, mainly small businesses (only one company has a number of employees between 51 and 100).

The analysis of the level of availability for innovation and change aimed at understanding any mistrust and cultural blocks offers a very positive data: 57.67% of the interviewees described themselves as open to innovation while adopting a prudent approach, and declares an average age between 41 and 50 years, with some cases, 18.92%, with an age between 61-70 years.

B. Familiarity with new communication technologies and information sharing

The second section of the questionnaire, after the initial questions regarding the classification of the sample, shows, Figures 1 and 2, that the primary form of communication with employees, but also with other safety figures, is contact telephone and instant messaging systems, while there is little inclination towards the issue of cloud computing and digital interoperability between the figures involved in the activity. Even the use of specific applications appears to have a very low response (only 4 companies).

C. Surveys on the state of use of the software in the company

The third section, Figures 3, 4 and 5, describes the

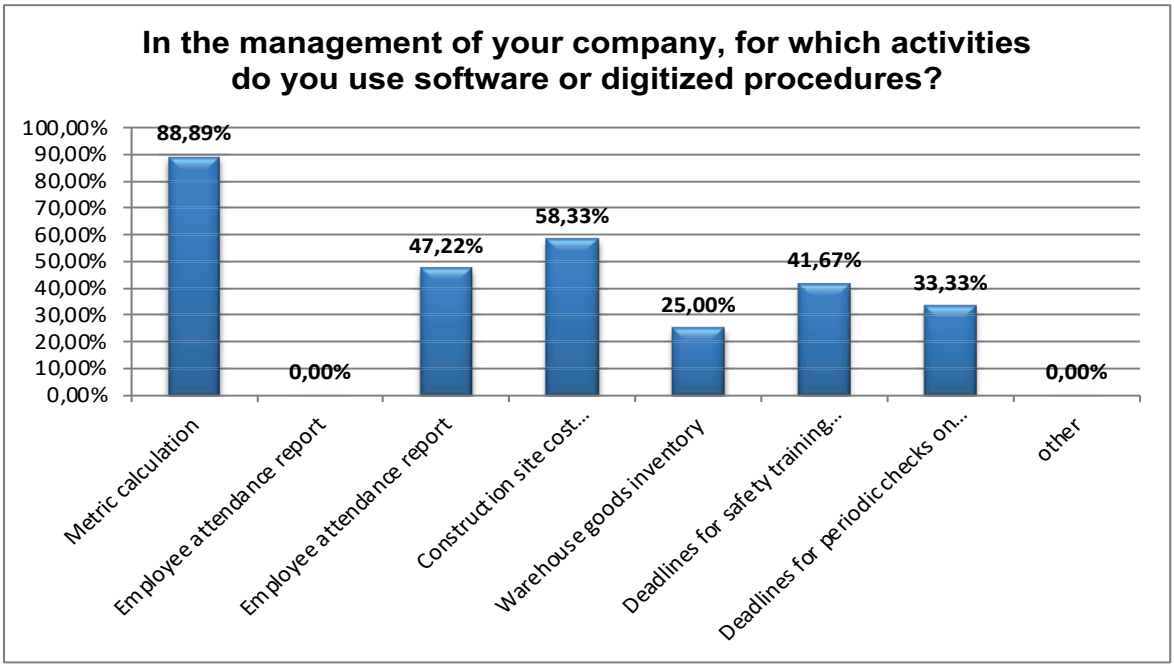

Fig. 4 - *Question 7 - digitally managed activities*

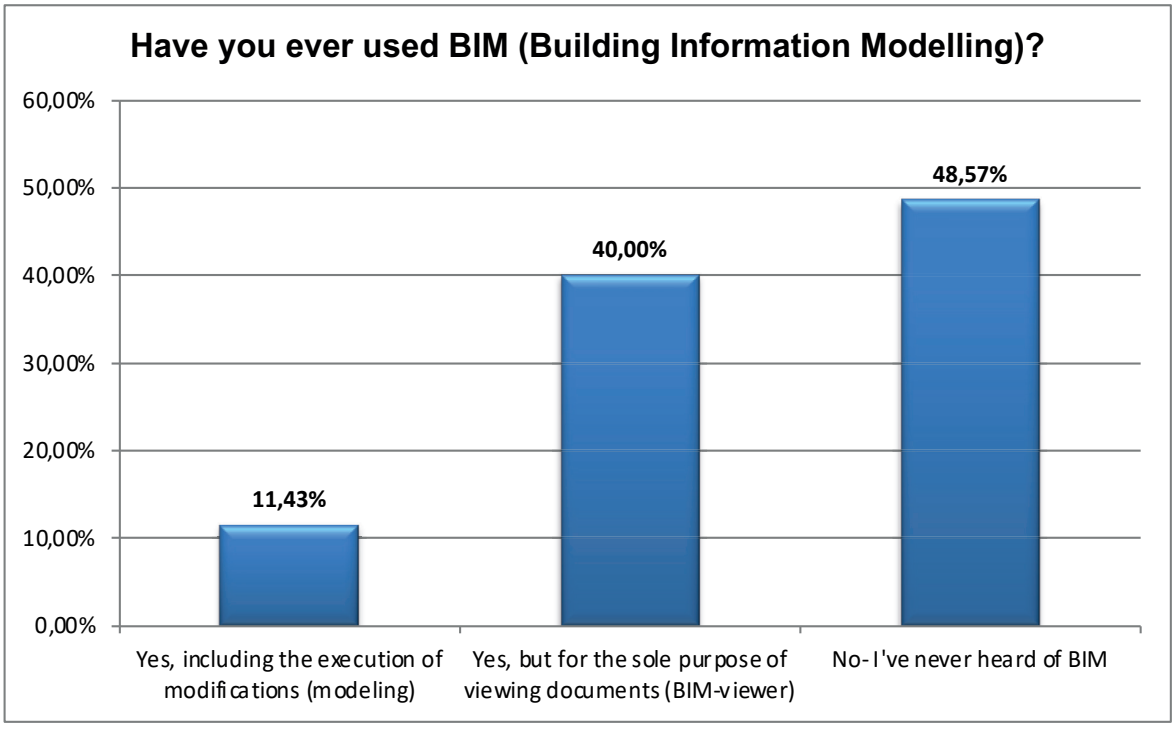

Fig. 5 - *Question 9 - using BIM*

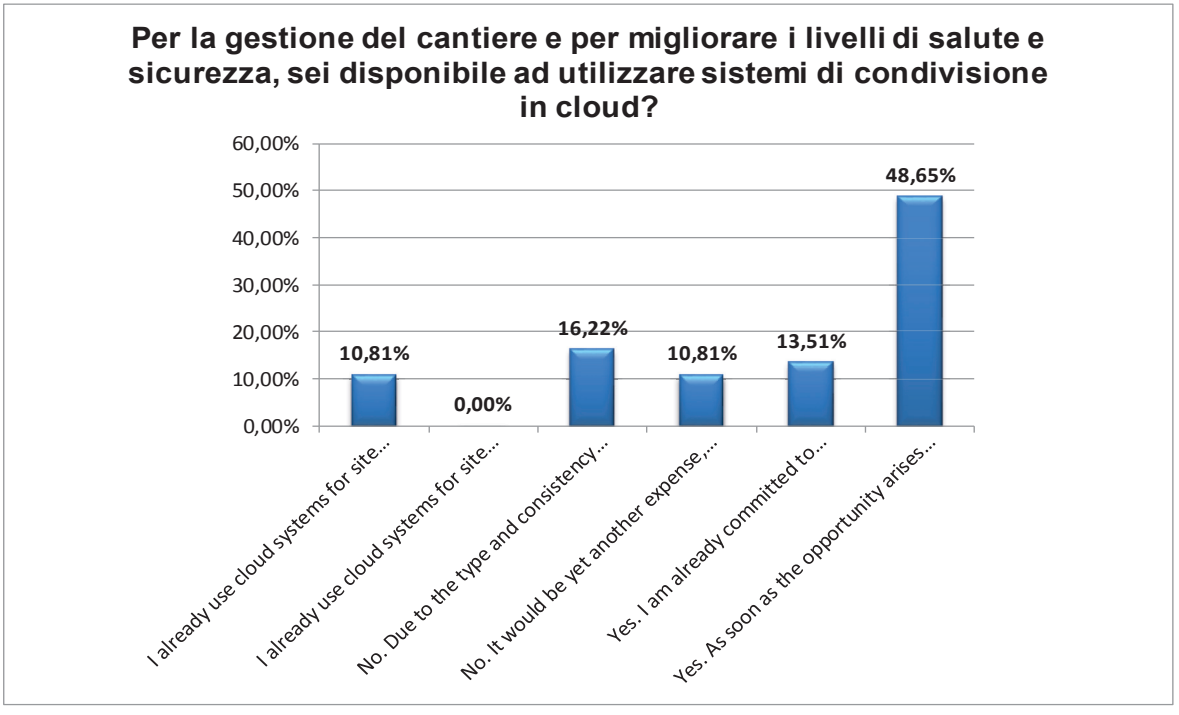

Fig. 6 - *Question 8 - Cloud propensity*

type of software used in the management of the construction site to carry out digitized procedures and understand the level of knowledge of the territory of the BIM methodology. It is interesting to note that 3 companies have declared that they do not use any digital support for the registration of attendance and expenses, but use paper to keep track of the following information.

While it is not surprising that over 88% of the interviewees declare that they use software application for the metric calculation, it is interesting to highlight that almost the 42% keep digital track of the deadlines related to the training of workers in the field of safety at work and 33% of the deadlines of periodic checks of machines and systems.

The data relating to BIM confirm a lack of knowledge and above all use of the BIM methodology; only 4 companies (approximately 12%) used the model in its entirety.

D. Surveys on the status of worker safety management using IT techniques

As regards the management of worker safety with the support of information technologies, the data obtained must be read, probably, taking into account the small working realities that characterize the area. Almost 50% of respondents say they are willing to invest in the

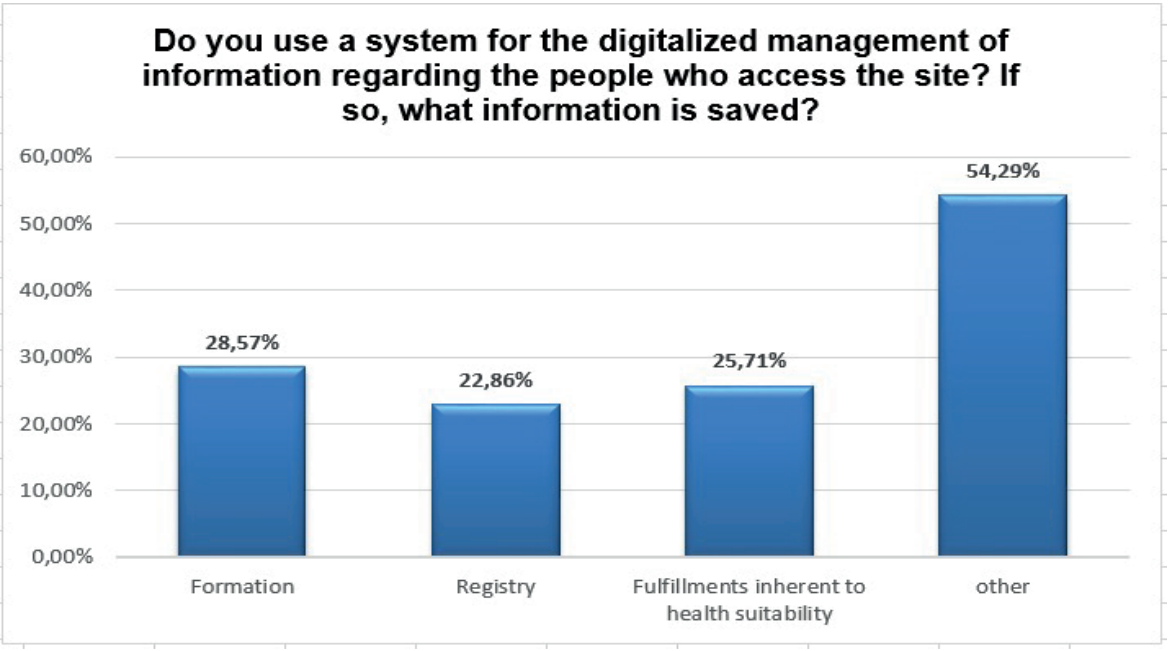

Fig. 7 - *Question 10 - digitalized management of means of transport*

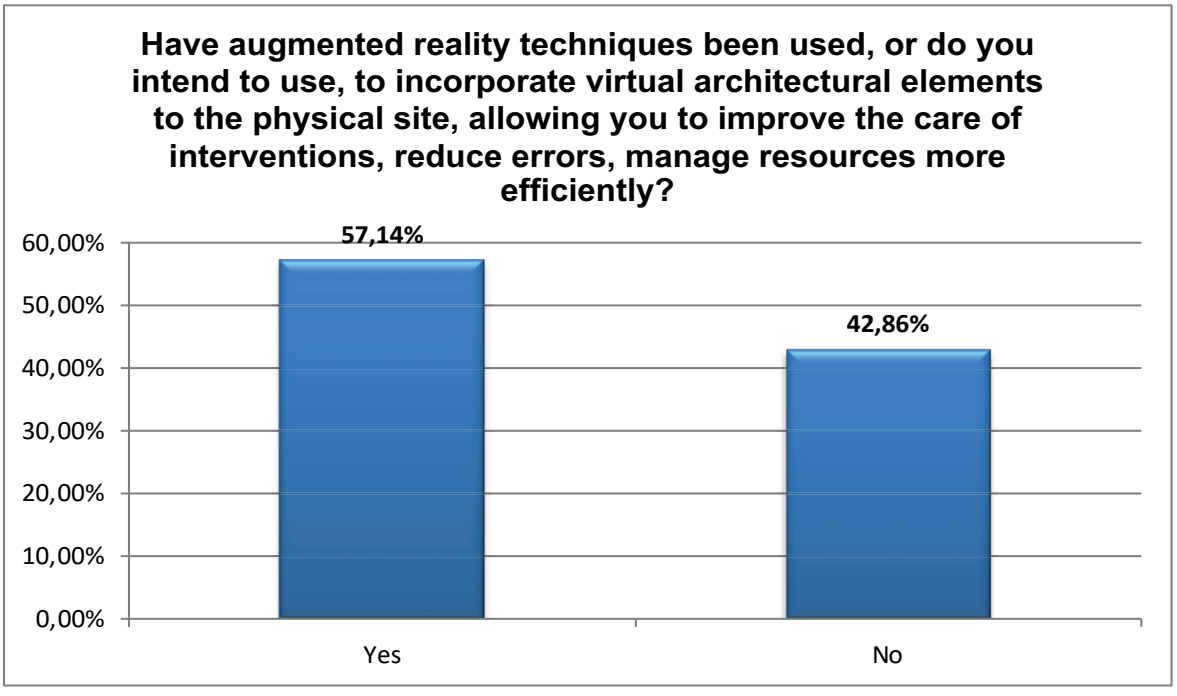

Fig. 8 - *Question 12 - use of augmented reality*

use of the cloud once they have fully understood how it works and the advantages, Figure 6, while the 16,22% of the interviewees declare that no digital support is necessary for the type and size of their business; this information read taking into account the territory also motivates the scarce application of innovative systems of artificial intelligence and augmented reality such as sensors, SARP systems and more.

It is clear that the aspects managed most in digital form are those related to legal obligations, both as regards machines and people.

E. Prospects for technological development in the company

The section on future prospects, however, is heartening; there is an awareness that digital technology can improve work activity according to 65% of respondents, Figure 12, and there is a statement of poor knowledge of the applicability of information technologies in the construction sector, 28.57%, Figure 13, given that it manages to motivate the slow process of digitization in the sector. However, the figure of 25.71%, representing the percentage of interviewees who declares "work culture and deep-rooted traditions" as the greatest impediment to the digitization process, a reason perhaps to be considered taking into account the average age of the employers.

As for the last answer, in which the interviewee was given the opportunity to express their opinion freely, unfortunately there were not many important observations; on the whole, all of them confirm the importance of technology as a tool for improving construc-

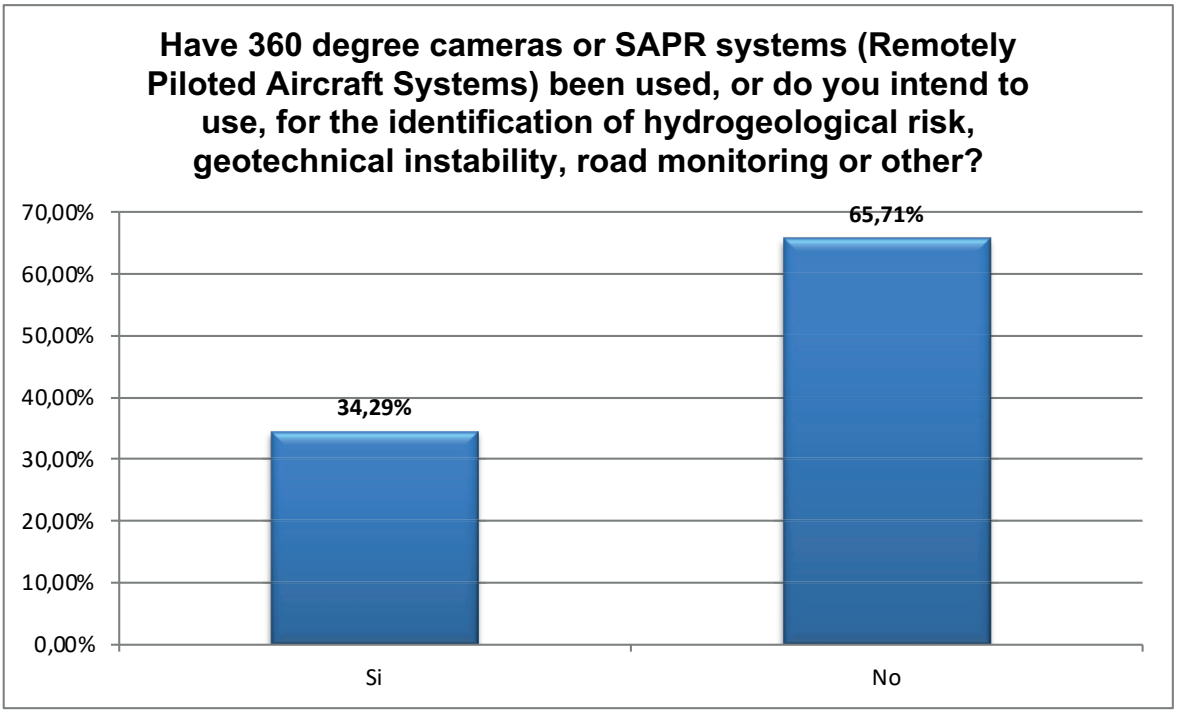

Fig. 9 - *Question 13 - use of 360 degree cameras and SAPR systems*

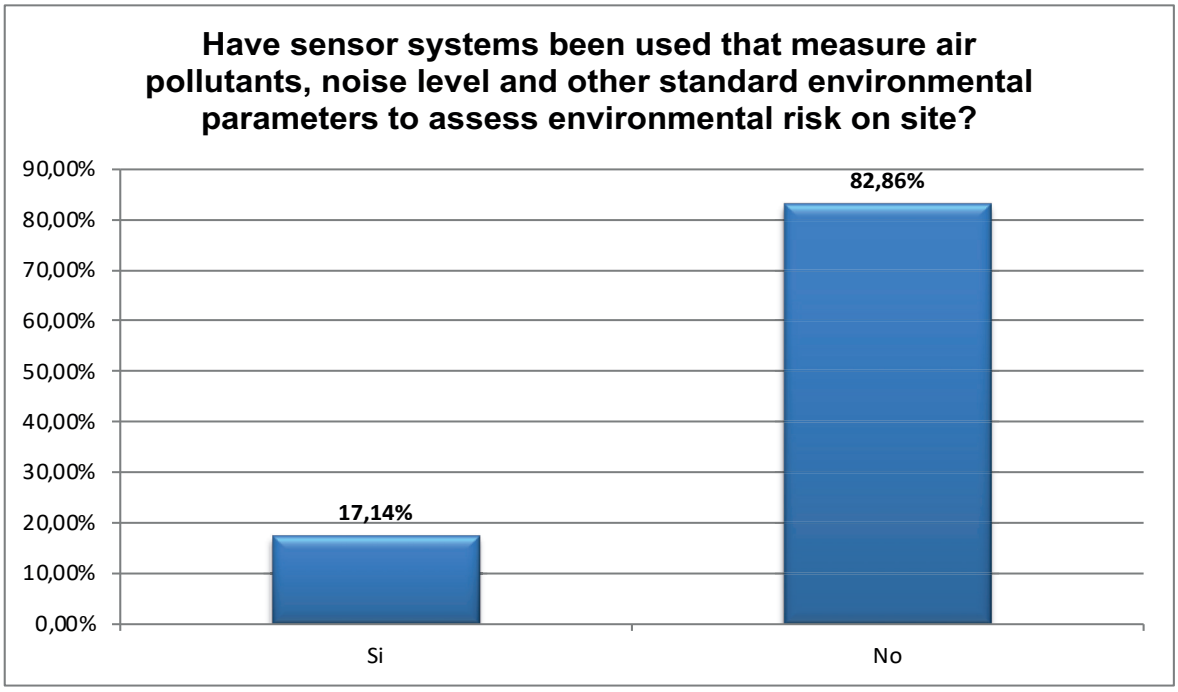

Fig. 10 - *Question 14 - use of sensors for environmental risk assessment*

tion site management, while few focus on the validity of technological supports to improve worker safety. Specifically, an answer confirms the impression obtained by analyzing the data: "for safety it is more difficult, since the only attention is to keep the documents in order".

DISCUSSIONS

The results of the survey conducted allow us to highlight the real problems that the digitalization process is generating in the construction sector in the province of Avellino. A sector fragmented by skills, little available to integrations and innovations.
The greatest limits perhaps derive from the type of companies operating in the construction sector: small businesses not motivated to invest in information technology to manage simple construction sites.
Another limit not to be overlooked is the lack of specific knowledge and therefore
the importance of the study carried out lies in the acquired awareness of the need to promote technological development in the construction sector and to disseminate the benefits deriving from the use of information technologies for the management of worker safety not only to comply with the provisions of the law but above all to disseminate an innovative safety culture.

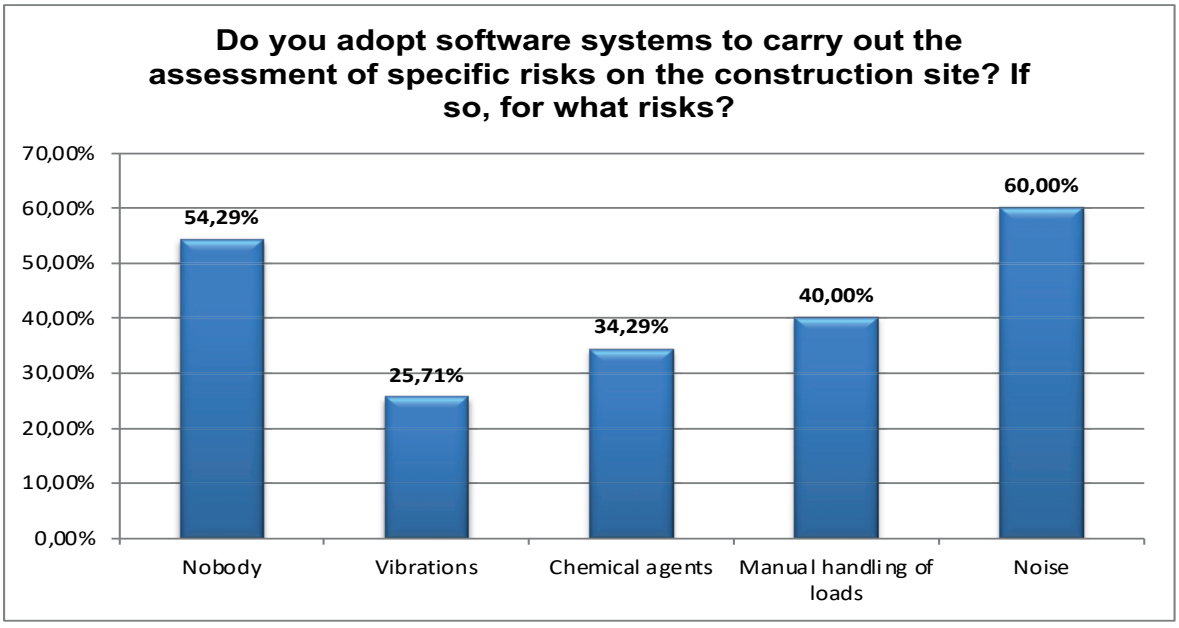

Fig. 11 - *Question 15 - use of software for risk assessment*

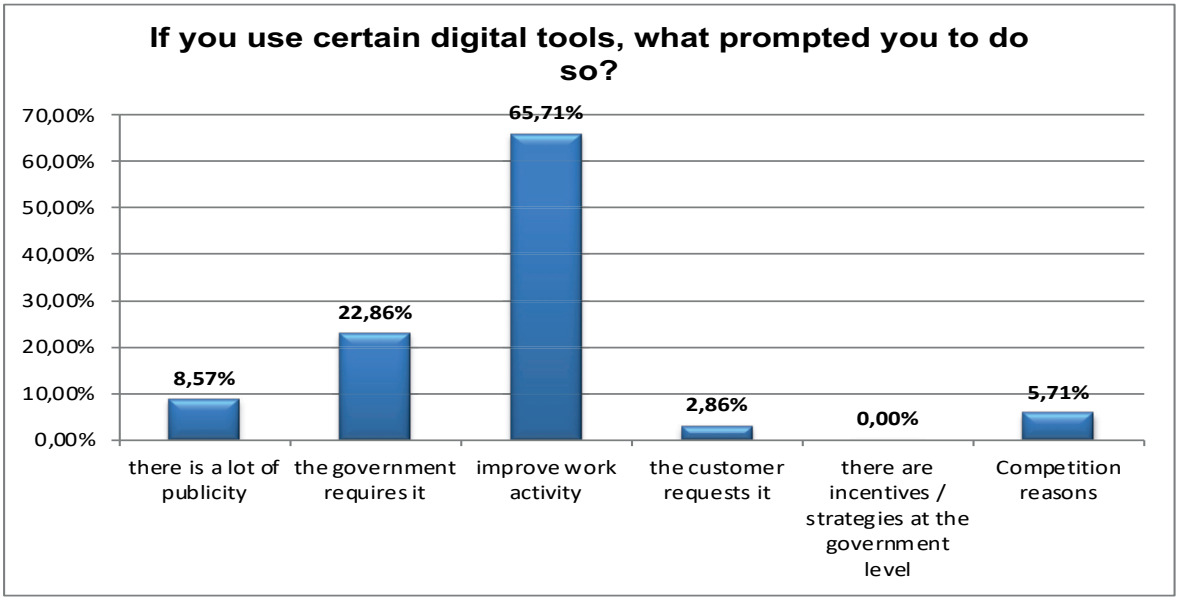

Fig. 12 - *Question 16 - reasons for the use of digital tools*

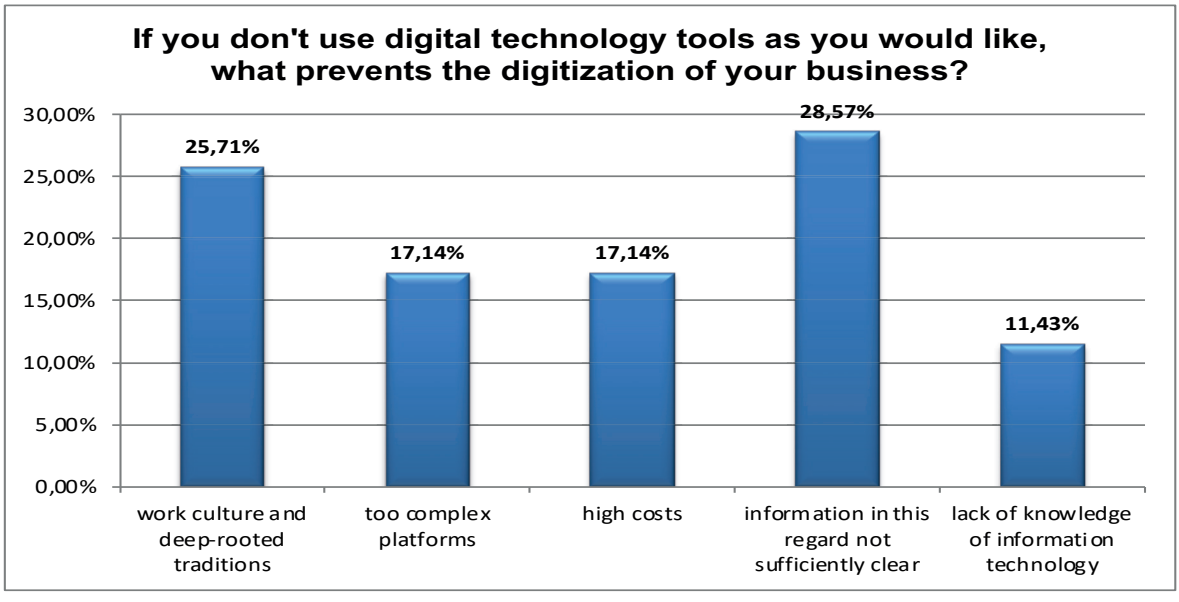

Fig. 13 - *Question 17 - obstacles to the digitization of the business*

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