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Field Studies in Sustainable Construction: Current State and End-user Needs in Information Management Systems

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All management systems, even the most innovative and standardized, have to accommodate the needs of end-users in order to be effective. Current corporate and industrial trends for social benefits, sustainable methods of production and respect towards the planet's resources, have highlighted the need to place people and not system requirements, as the top priority for the design of information systems. This paper summarizes findings in a series of targeted field studies, carried out by experts from multidisciplinary academic backgrounds, examines current needs, concerns and suggestions of construction personnel and verifies the conclusions of previous academic research. The current state in the adoption of information systems and their effectiveness is examined, together with findings in user system requirements. Recorded findings range from on-site administration at operational level, to project management at tactical level and to executive departments that handle strategic planning. According to both academic research and conducted field studies, improved project communication can facilitate significant savings, social and environmental benefits and competitive advantage. The dimension of possible reductions in wasted materials and the volume of solid waste is examined in relation to communication systems. Although many problems associated with the dissemination of information in construction remain unresolved, by analyzing feedback from executives and engineers who manage document management systems, a human-centered evolution of communication methods can emerge.

Keywords: green project management, information management, innovative management systems, sustainable construction, waste reduction

Introduction

No management system, even if governed by the strictest quality and technological standards, is adequate without primarily ensuring the needs of the accommodated personnel. Current focus on balancing quality and environmental issues with safety concerns, during the implementation process of modern projects has been documented in such standards as ISO 14001:2015 (ISO, 2024) and ISO 9000:2015 (ISO, 2023). Management systems are steadily converging with the added guidelines that have been established in green policies of the European Commission (EC, 2023). These factors are combined with increased social demand for project implementation that protects natural resources. These trends have brought the need to place people, that is, users and not procedures, to the top of the information systems design hierarchy. The so-called fifth industrial revolution is the springboard for the Construction 5.0 movement, which attempts to address important issues that characterize technical projects with a holistic approach (Kraaijenbrink, 2022). These include hindrances faced by project team members both inside and outside the construction industry. Negative environmental impact and the social value of sound production processes make profitability and performance indicators less important (ICRIBC, 2022).

To incorporate novel principles of digital business management, a set of drivers described as the fourth industrial revolution, all industrial sectors should focus on integrating new technologies. Modernized systems expand competitive advantage and improve ecological performance, both on-site and at corporate level (Xu et al., 2022). Engineering procedures are currently redesigned on principles of both resource efficiency and pollution prevention. Further application of Information Technology (IT) systems can contribute to the achievement of this target, as most environmental considerations can be solved by a clear organizational commitment to adopt operational innovations (Mackey and Sisodia, 2014). Significant savings are possible by implementing *IT* document management systems in the administration of project information, the coordination of communications and the support of supply chain and inventory management decisions. However, successful transition to the suggested centralized procedures is impossible without the prioritization of expected user

and social needs. Thus, the importance of a field study for the examination of the current state of practice, personnel demands and suggestions becomes evident.

The importance of applying sustainability in less-explored management areas

Research on the current state and use of physical and electronic systems for document administration, demonstrates the extent of the adoption of IT and its various applications. This important field of study should not be neglected, as sustainable construction can be accelerated by precise information flows. Although inadequate document management is associated with both poor project waste performance and resource allocation (Giannadakis et al., 2025), there are still areas of these phenomena that are important to clarify. Main characteristics of modern systems, the quality of information supplied and any possible benefits by integrating files to a central system for effective use, must be examined simultaneously. Another objective of research is to identify the most important obstacles that prevent the introduction and use of updated technologies in the construction sector. At present, many different systems are already used in construction management at all stages, from initial design and pre-estimation to final delivery.

This multitude of sources creates a huge variety of produced files, in both electronic and physical form. Further difficulties arise from the parallel existence of information in different files and locations. These vary from on site and company facilities, design team and manufacturers' systems, on the internet or on local servers. Integration and distribution of available information in a centralized system facilitates and accelerates communication between the design, procurement, logistics and accounting personnel. This improves timely and valid decision-making in order to make any necessary corrections or modifications required during the individual stages of a project's life cycle.

The main weight of further research should be placed on the importance of proper management and cost control of all the individual technical and accounting data. This valid administrative information is recorded in many separate systems and often in scattered documents. Consolidation of information management has direct positive impacts on the main factors of project success and profitability. These include improved

customer value, reduction of material and energy waste and improved execution time. Delivered project quality is increased due to better and timely harmonization with technical specifications. A solid confirmation of the impression that without duplication of work and waste of materials, a reduction of cost and execution time is feasible, is also in the interviews' scope. Finally, improvements in the overall digital skills of the sector's personnel and the acceptance of new management technologies, is examined as a driver for raising awareness of using modern techniques, especially in organizations that employ updated technology on a small scale.

Methods

Field study aim

System logic of *IT* document management solutions, is performed by mapping communication flows and standard procedures as defined by technical regulations, legislation and quality standards. Research on personnel remarks and demands is usually based on statistical analysis of questionnaires or fixed sets of questions, without possibilities of spontaneous answers. A majority of previous studies has been carried out within the operational and tactical levels of project organizations. Focus on cross-level interactions and strategic scope has therefore not been extensive when examining the situation in documents administration.

Therefore, a series of targeted field studies has been conducted, with experienced executives in the building sector. Study aims include the observation of current practice, the registration of unrecorded personnel concerns and suggestions and the verification of any previous research conclusions.

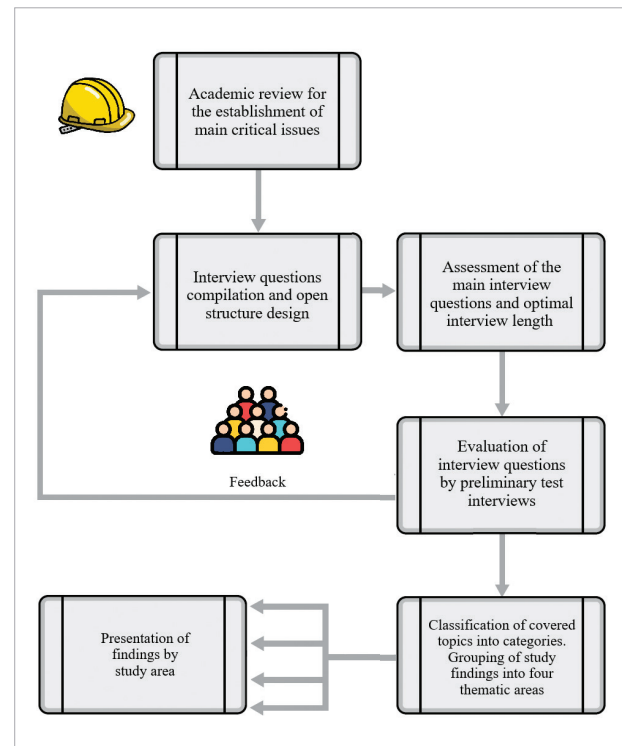
Information collection and criteria

Experts from multidisciplinary academic backgrounds and top organizational authority were selected, so that in addition to extensive experience, participants in the field studies combine both technical and staff duties. Qualitative research by personal interviews was performed, in order to examine as many issues under consideration as possible. Open-ended questions were employed, so that a flexibility to alter wording and the order of questions is provided, in addition to an opportunity to facilitate additional personal comments.

Direct interviews were conducted, for the participants to cover each topic in depth and as comprehensively as possible. Diversification of experience in construction projects and relevance of managerial position was the major criteria for qualification as a participant in the field studies. Professional record and multidisciplinary perspective of the nominated personnel formed a significant further selection criterion. Extended executive experience contributed significantly to the verification of existing research conclusions and more importantly, to the statement of neglected suggestions.

Selected citations to conclusions drawn from previous academic research are included after the main findings in the interviews, when applicable, as an on-site confirmation by the field study. Possible benefits of systemized document administration are also explored, together with participants' suggestions in the architecture of such systems. An assessment of the main interview questions included possible thematic omissions and optimal interview length. Interview question sets have been evaluated by two preliminary test interviews, with one participant at a time. A schematic layout outlining the research procedure is presented in the following Fig. 1.

Fig. 1. Schematic outline of the research procedure



Results and Discussion

The main aim of the field study was the investigation of current document communication practices in construction, according to the perception of the interviewees. The provided insights highlight issues in successful digital transformation, the benefits of using IT for document management and remarks on the daily application of communication systems. This revised paper combines recently published findings (Giannadakis, 2026) with added comments and serves as a guidance short-list to be considered in future IT system engineering. The classification of topics covered into categories has been finalized after analysis of the results, previous research conclusions and recent academic review. Findings were thus grouped to four thematic areas: *current state and progress in the adoption of modern information systems, effectiveness of communicating documents with currently available means, user requirements for effective information management and the environmental significance of waste and rework caused by poor communication.*

Field- study demographics

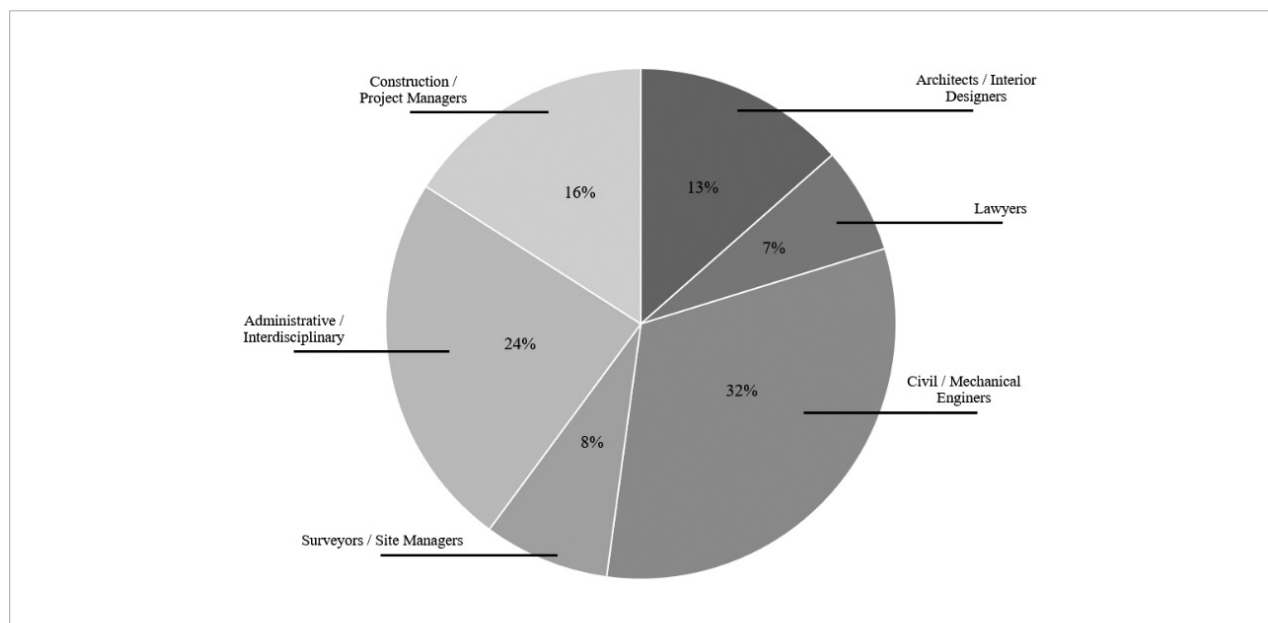
Administrative positions of the personnel examined match their main technical training background and are displayed in Fig. 2, sorted by discipline, as an indication of their related duties. Interview findings and remarks, are

summarized in the following parts of the paper sorted by topic. Selected conclusions that are verified from findings of the interviews and past academic review, are followed by indicative references to previous research.

Construction sites that the interviewees have been employed in, were classified according to the categorization employed by the Building Research Establishment (BRE, 2012). These combine leisure projects such as hotels and casinos, industrial buildings and units, public buildings, schools and training facilities, commercial buildings such as offices and shops, as well as residential developments. All participants have professional experience in private projects and over 70% of them in public sector works as well. The academic qualifications of the field study participants include doctoral and master's degrees holders, as well as university graduates.

As in other related environmental management research (Emmanouil et al., 2025; Raymond et al., 2010 and Zasada et al., 2017) documenting the opinions of experts is a matter of importance. Participants in the field study included executives of both sexes, with multiyear administrative, technical and legal training. Work experience of the experts includes multiple building sectors and their support services, in projects with extended complexity. Academic training of the interviewees consists mainly of architects, civil engineers, interior designers and mechanical engineers, together with

Fig. 2. Current administrative positions of the field studies participants sorted by discipline



building legislation solicitors and graduates in business administration. Examined personnel age ranged from thirty-six (36) to sixty-seven (67) years, on the day each interview was completed. Working experience spans from thirteen to over thirty-five years in the building industry, primarily in technical corporations and firms, design offices and legal support companies. Agreement to participate was arranged after each candidate was selected and contacted by phone. The net duration of the interviews ranged from 37 to 65 minutes. The field study interviews took place between Thursday, May 30 and Tuesday, October 1, 2024.

Findings on the current state of information systems utilization

Although there has been notable progress in the incorporation of systems that administrate project information, their implementation across the sector remains fragmented or limited (Gumay et al., 2020). Major construction sites, or where multinational and usually complex projects are undertaken, document management principles and standards are indeed applied. However, these regularly concern ISO and quality standards, process or components certification, or the administration of contractual issues and legal documents.

Innovative technologies are applied in distinguished construction sites such as in the examined *Ellinikon* recreation, currently the most extensive construction project in Europe (Lamda Development, 2024). To a large extent, however, these are introduced only when pioneer local companies or major firms from abroad are involved, like the project stakeholders *Fosters* design office, the *Bouygues Batiment International* development company and their joint venture with the construction company *Intrakat*. On most small and medium construction sites, there is no centralized management of documents and information for the administration of daily duties. Adherence to the schedule and the organization of information is based on staff experience and short-term on-site planning.

Medium-sized and major construction companies usually employ an *Enterprise Resource Planning* (ERP) system to support major management decisions, along with accounting or logistics software that coordinates their finance and supply chain procedures. Although such systems support a wide range of operational functions and capabilities, a unified system that deals with the overall organization of information is rarely in place, regardless of whether it is technical or

administrative data. It is also reported that even when ERP systems are in place, these seem to cover formal obligations or specifications, such as compliance with quality standards, without any further substantial exploitation of the data accumulated. Even the largest projects do not systematically use information systems for the administration of everyday production. The value of incorporating *Building Information Management* (BIM) technologies, is now being realized by many companies in the sector. However, this transformation is carried out at a slow pace and does not resolve all problems of information administration, but mainly issues related to design and associated conflicts.

In small and medium-sized building organizations, information systems are frequently not used at all. This applies particularly to tactical and operational project levels, such as subcontractors, production management departments and suppliers. It is reported that the majority of personnel consider such systems a waste of time and continue to ignore the procedures of necessary data entry in order to structure and operate management software. Therefore, team member integration remains limited, although collaboration and effective coordination among them is of the utmost importance (Simanjuntak, 2021).

Regardless of organizational position and authorities, personnel lacks time and resources to make the most of existing systems. In a majority of sites, non-interoperable systems are still utilized. Employment of modern principles to a greater extent than at present is lagging, although the technical means already exist. As a result, building speed is reduced, but often so is the quality of the final product. The reason is deficiency in documentation and the dissemination of information required for correct production planning (Molenaar and Songer, 1998).

Despite the initial disturbances expected by the incorporation of novel technologies, current IT channels of communication, even in parallel, have demonstrated improvements in the organization of information. The successful implementation of innovative systems depends on the ability and will of the users to evaluate available information and incorporate new practices in any production process. The global dimensions of building material logistics make the need to develop practices that improve communications with global partners imminent. The implementation of a collective information system can become a starting point for the cultivation of this international dimension.

Table 1. Main study findings regarding the current state of IT document management systems implementation

Recorded study findings	Main consequences in project administration
Adoption and use of systems specifically in major or distinguished construction sites, but with fragmented or limited implementation across the sector, focused on quality standards or formal regulations	Current progress in the introduction of modern information systems is still limited
Existing corporate systems (usually ERP) are rarely unified in a single centralized system for overall information administration	Documents and critical data are isolated at different organizational levels, reduced systems interoperability
In small and medium projects adherence to time schedule and information dissemination is based on personnel experience and short-term on-site planning	Non-optimized site and production management, operational and tactical administration
No existing centralized management of documents and information for everyday tasks in the majority of construction sites	Reduced production speed, delays in specifications management and procurement
Personnel are not able to make the most of existing systems, especially when these are non-interoperable	Poor coordination of information on all organizational levels
Small and medium construction enterprises lack information systems at tactical and operational levels	Loss of tactical and operational data and statistics

Findings on the effectiveness of communicating documents with currently available means

All participants in the field study confirm the reality that communication of information is a complex process and often problematic (Okello et al., 2024). Any document containing necessary pieces of information is usually not immediately available, unless sought by. This way, administrative resources of the user and the organization that seeks the document containing the necessary data are consumed. Hence, the cost of finding information is transferred indirectly to the operational cost of the project.

It is verified that practically the entire documentation for any project ends up in a digital file and rarely in printed form. However, included information is not disseminated in its entirety to the communication ecosystems of the examined projects. The basic functions of managing documents and data in them are therefore still impaired in terms of actual control and organization. Inefficient planning of timely document distribution further reduces the effectiveness of communications.

Simultaneous operation of different organizational departments and project groups, combined with the constant need to modify and update data, are cited as the major causes of communication failures. Flawless coordination and communication are required for the targeted result to be achieved, especially in interconnected schedule and budget milestones (Wu et al., 2020). In addition, the focus of each team and contractor

exclusively on a particular piece of procured work or on work packages that need to be delivered immediately, results in a very narrow and selective scope of information exchange. This is particularly the case in larger, complex projects where fire-fighting delays is accomplished by transferring all possible manpower and resources to critical deliverables, one at a time.

Current technology provides fast means of communication through the available smart devices, software and the internet, yet problems in document management have not been eradicated. Applications that assist personnel from on-site duties to headquarters and supply chain administration are already in place. The average construction manager however, is still unfamiliar with the process of communicating data to multiple people. Making a digital record of that information, so that it is then indexed and permanently available, is also neglected. Facing timetable constraints in everyday administration, many project team members, both in private and public projects, are incapable of monitoring effectively all the incoming data. Thorough knowledge of information that will prove of importance in future decision making is thus gradually hindered, leading to inadequate planning, cost overruns and delays (Ramadhan et al., 2025).

Paper-based communication has not been eliminated from the construction industry, despite technological advances. It coexists and at the same time multiplies

the volume of electronic bureaucracy, magnifying the problem of isolated, parallel communication channels. In some cases, the accumulation of data in written form is created purely out of habit, like printed design documents in particular, that are being stored up. The phenomenon is multiplied by an outdated sense of standard procedure that drawings, from the contractual version and on, should be printed, even when these already exist in digital form with all related browsing and scaling benefits.

Table 2. Main study findings and consequences in project administration regarding current effectiveness of document communication

Recorded study findings	Main consequences in project administration
Although practically the entire project documentation is contained in digital files, information contained is not disseminated effectively within the communication ecosystem	Constant re-entry of data and administrative cost to seek information
Construction management and administrative personnel are still unfamiliar with the process of data entry and communicating documents to multiple people, reducing information availability	Important decisions or reports are not available in digital documents and are neglected
Documents containing required information are not immediately available unless sought by, consuming administrative resources	Multiplication of workhours wasted in acquiring data
Paperwork has not been eliminated, coexisting and multiplying digital bureaucracy, exacerbating the problem of isolated and parallel communication channels	Need for digitization and indexing of information circulated outside digital channels
The existence of many different contributors simultaneously, in combination with the constant need to modify and update data are cited as causes of serious communication failures	Increased material waste and rework related to quality and specification fails

Findings on user requirements for effective information management

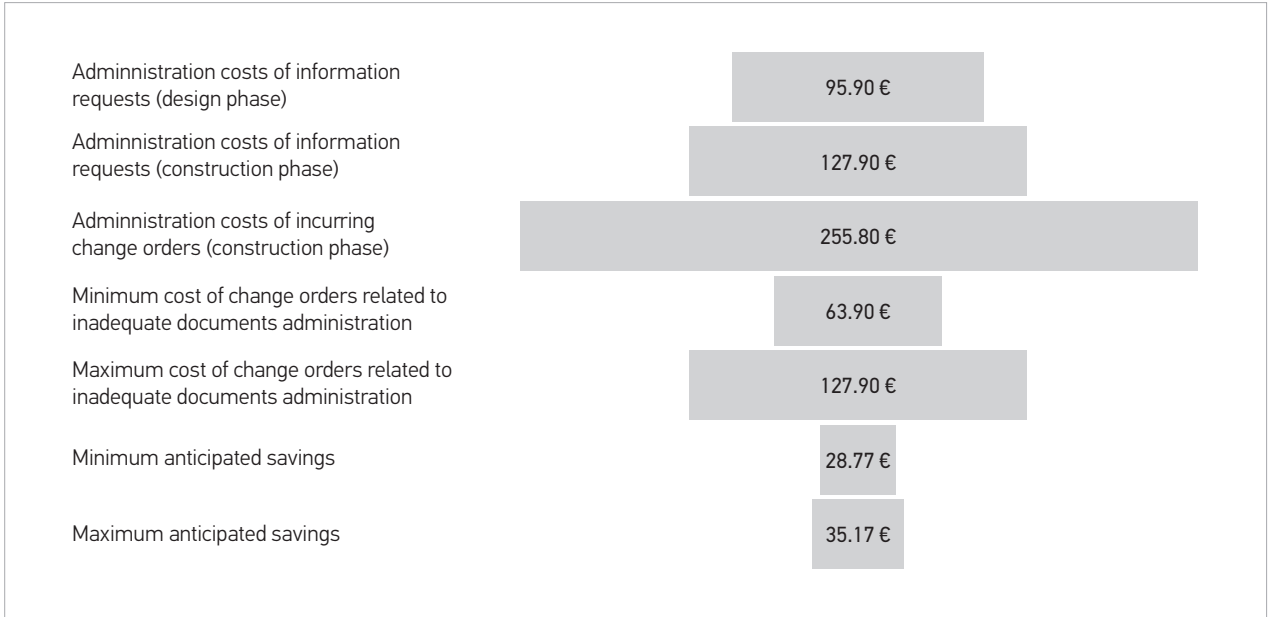
The following requirements for effective information administration emerged as suggestions from interviewed personnel during the field study. These points can serve as guidelines in the design of system architecture and principles, when considering the introduction or customization of document management systems.

The most important features suggested are the immediate notification for changes and the availability of updated information in the containing document. An active, up-to-date database is required, easily accessible, and therefore with a simple interface, so that each related user can obtain the required record. Another critical requirement is the simultaneous notification of all affected parties at the time of each modification or submission of documents. Applicability to both private and public sector projects is an important factor to be considered.

Reduction in workload is possible at all organizational levels by having an active database linked to a constantly updated repository of all project documents.

The ability to search in all types of documents, especially those related to accounting, such as invoices and delivery notes, is crucial so that quantities to be ordered, received and stored are correctly updated. In this way, inventory management processes are simplified, waste is reduced and economies of scale are achieved by the purchase of materials in bulk orders. Expected savings in costs, specifically related to poor documents management, increase by the final built area. Certain administration processes, namely requests for further information and change orders and their related expected costs of waste per one hundred square meters (100 m²) of final constructed area are compared to the estimated monetary savings after applying a coherent document management. Benefits are estimated to 10% of the total administration cost related particularly to documents handling. These can reach considerable amounts for larger building projects, varying between 28,77 €/100 m² and 35,17 €/100 m², as displayed in Fig. 3. These benefits cover environmental and financial aspects and can be significantly improved, if combined with prefabrication methods and controlled assembly processes (Njoku, 2024).

Fig. 3. Operational processes and their related cost per 100 m² of final constructed area in comparison to estimated monetary savings after the application of a document management system



The ability to display available stock of materials is especially important for an information management system as it provides a much-demanded ability, especially by personnel involved in procurement and supply chain administration. Updated tables of material quantities and their estimations, in combination with links to corresponding invoices and budget articles, improve project logistics and provide the foundation for the extraction of useful statistics in the future. Project metrics and stored historical data, can be utilized to calculate demand forecasts for materials and services. These predictions can be submitted for review to relevant team members or logistics executives, regarding the type and lead-time for procurement items, but also as a forecast and estimation of when each task must be completed. Currently evolving applications of artificial intelligence (AI) can form ideal analytical tools, with multiple uses in a centralized document management system.

Interface and logical organization of IT systems employed must be characterized by simplicity, ease of learning and use. For effective utilization as an inventory database, besides as a document repository, data entries and record submissions need to be finalized promptly and in straightforward input procedures. Findings demonstrate that participants expect system aspects not to be more complex than necessary.

However, users under 50 years of age tend to accept the need to spend more time training in an innovative system than older personnel.

Drawings, specifications and other files kept in a document repository, in addition to the benefits in effective administration, offer a large volume of useful data in project evolution history. By adding interoperability, graphics, drawings and BIM files, document management systems can exchange information with ERP software. This addition is particularly helpful in strategic and tactical business decision-making and in exploitation of corporate intelligence. In this way, an existing foundation for the development and management of corporate knowledge is formed, with a complete history of previous records that can be harnessed in data mining techniques. Incorporation of AI algorithms may offer automated suggestions for production management, future implementation sequences, schedule adherence, and forecasts of material stock and order placements.

Findings on the environmental significance of waste and rework caused by poor communication

Sound materials management is an important financial and environmental responsibility for construction

Table 3. *Main study findings and expected benefits regarding system requirements as reported by participants*

Recorded study findings	Main consequences in project administration
Applicability to both private and public sector projects without the need for interface modifications	Construction firms and subcontractors require both available options
Immediate notification of changes and online availability of corresponding updated documents	Prevention of erroneous information circulated in outdated files
Inventory and procurement management capabilities, with the provision for AI employment	Support in administrative decision making and waste prevention
Requirement of live up-to-date database, employing a user-friendly interface characterized by ease of learning	Reliability and availability of the provided information in stored files
Maintenance of an active searchable repository of all project documents, constantly updated	Provision of a reliable single reference point for the entire project documentation

companies, from top management level to operational procedures on site. Lean processing of available resources is a vital part of all sustainable material management systems. Building materials are expensive and difficult in treatment and consequently wastage represents a significant financial commitment and environmental burden. Material waste is one of the main issues in construction logistics, as they form a by-product generated throughout the entire building project life, in various forms and quantities. Wood, metal, plastic, bricks, cardboard and other waste is generated, discarded, burned, dumped or buried during construction (DEFRA, 2021). In addition, personnel involved in the production process generates further waste, such as paper, aluminum cans and glass.

Solid material waste is a perennial symptom of environmental encumbrance caused by construction. Early studies estimate the amount of solid waste from construction works to 15% of the total materials committed to new projects (Arsenos and Giannadakis, 2023). This amount is usually significantly higher in renovation and remodeling, as these projects involve extended dismantling and demolition. The percentage of solid waste volume from the building sector, including demolition, has been estimated to exceed 25% in typical municipal landfills. The Egan Report (Egan, 1998) estimated that at least 10% of materials in construction projects are wasted. Furthermore, reports in the European Union (RES, 2017) estimate that in addition to direct solid waste, 13% of raw materials ordered are discarded unused and therefore

entirely wasted. Study models (Fadiya et al., 2014) estimate the economic cost of construction waste at 30.36% of the total material cost of the project.

The importance of early personnel commitment in order to improve information dissemination and thus as a mean to reduce waste, has been recorded repeatedly in the current field studies. The very nature of construction project management dictates the execution of work in visible separate phases, with partial assembly of deliverables and with responsible team members not participating from start to finish in communications (Halttula et al., 2015; Matthews and Howell, 2005). This tendency immediately creates problematic delivery of information (Lohikoski and Haapasalo, 2013), which in turn reduces the efficiency of the project production system, maximizing operational and material waste, mainly by generating unnecessary repairs.

The importance of adequate information management has clear environmental dimensions. Even in early surveys with the objective of identifying ways to improve the quality of building design control, main factors affecting quality were found to be related to information dissemination or design management (NEDO, 1988). Some of the most important causes leading to rework and material waste include lack of coordination between the design team and construction management personnel in conjunction with the circulation of unclear records or missing documents. Poor workmanship, either due to lack of care or unclear specifications, was also considered as a significant factor. Further surveys

yielded almost identical findings. In an analytical survey of 51 private sector projects and 308 public sector construction projects (Endut et al., 2009), only 20.5% of public sector projects were completed on schedule and 46.8% of projects were completed within budget. Correspondingly, 33.3% and 37.2% of private sector projects were completed within the estimated time and cost. Although the exact cost of repairs due to poor communication is not always accurately recorded, it is a contributing factor of financial and environmental burden that is among the main reasons cited (Rahman et al., 2012). Lack of coordinated information management is verified as one of the main reasons for repairs that occur over time in construction projects, wherever they are carried out (Alaghbari et al., 2007). Thereupon, even a proportional improvement in document management and communications systems can significantly reduce the amount of materials that end up in landfills, the indirect waste generated by the building procedure and operational costs.

Remarks on questionnaire responses and interviews

The analysis of system benefits should examine all the application aspects simultaneously and not separate divisions into individual subsystems as if they operated autonomously. Issues for further research should therefore be examined in terms of the overall interaction they present with each other and not as single isolated questions (Adekunle et al., 2022). It is therefore the interdependency of all subsystems at work that should be investigated and highlighted. Fragmentary analysis of each subsystem and the improvements it brings separately, as in most research and case studies to date, provides only partial insights. By highlighting the benefits in all possible areas simultaneously, their quantification per subsystem and therefore the improvements and profits accumulated, the use and introduction of innovative technologies is encouraged.

By importing advanced information systems in project management practices, the necessary modernization of operational and tactical administrative methods is cultivated, providing tools that were currently limited to enterprise resource management at strategic level. Although system-coordinated accounting and financial management of construction projects is common, the remaining processes and information required at lower

organizational levels or across sectors are still not consolidated. Shared access to inventory data, for the entire organization at the same time, allows for resource savings through mass orders, by grouping of materials and their respective suppliers. Lean production practices provide economies of scale and waste reduction (Alarcón et al., 2005) with capabilities of transferring surplus or readily available materials from one project to another.

These benefits should be translated into incentives so that new technologies and the best practices cultivated by them can be applied at all levels of management. Improvements in neglected management areas like document administration can lead to significant reorganization of production procedures. It is important to demonstrate the potential gains from better fulfillment of contractual obligations and the use of innovative technologies required by the client. Further gains can be achieved by the improved implementation of environmental regulations and legislation to reduce discarded materials, and easier document certification and standardization of project processes. Application of IT systems, in combination with the generated social and environmental benefits, improves the competitiveness and corporate profile of each organization, with better marketing possibilities and increased profit margins (Sandhusen, 2010).

Limitations and directions of further study

Interview results can reveal and demonstrate less reported issues of poor management. However, these are not always quantified with irrefutable statistical data. The exact actual financial cost, the number of man-hours or the volume of materials is subsequently a field of further study. A significant part of these results is based on qualitative approaches such as executive estimates. As a result, some conclusions can be characterized as well-calculated assumptions or mere guesses by instinct.

Waste of human, material and environmental resources is usually included as an extra burden to the final budget of the project. Lack of a sufficient number of long-term case studies on cost performance does not provide the hard data required to support reported results. Research in the comparison of projects that implement a document management system in relation to similar organizations without one, creates prospects for an irrefutable proof of the benefits.

Critical management costs in their exact values and their association with specific activities and project deliverables must be examined in future studies. These shall enable more accurate forecasts and ultimately the thorough measurement of preserved resources, promoting green awareness and sustainable construction. Continuous feedback to team organizations with new data can reveal areas that are not yet positively affected by the operation of current systems. Therefore, such inflexible sub-parts and the associated system functions are where improvement is needed the most. By providing a roadmap of system mechanisms that can be redesigned, innovative document management can be implemented efficiently and then continuously cultivated.

One of the most important areas for further investigation is the definition of the exact relationship between fragmented communications and resulting overlapping responsibilities. An estimate of the frequency and amount of waste and repairs caused by poor information dissemination can then be established. Many causes of the above phenomena are common but their exact relationship remains unverified by academic research to date. Results hint that eliminating some causes of one phenomenon simultaneously reduces the rate of occurrence of the other, but the manner in which they interrelate has to be examined.

Conclusions

Numerous technological applications have gone through all stages of development and implementation, in a constant effort to improve project communication in the building industry. The realization that the optimization of information management provides a competitive advantage (Porter and Millar, 1985) has cultivated the widespread use of modern technologies. These are supplemented by currently available mobile and smart devices, especially during the implementation phase. As a result, the development of applications for improved project information and documents management has increased significantly. These include both construction administration tools and information management systems which provide required files, such as drawings and BIM files. However, communication problems remain largely unresolved.

To reach a truly human-centered evolution of communication methods in construction, multinational

comparative studies with personnel feedback and suggestions (Ugural et al., 2024) from users who actually man the systems, must be analyzed systematically. Observations must extend from on-site administration at operational level, to project management teams at tactical level and to headquarters executives for strategic planning. The results of the presented field studies have focused on identifying issues that are of concern to team members at all positions and levels of hierarchy, in order to establish current hindrances and possible policies to overcome existing barriers. These can include personnel and executive management training, adoption of lean production and waste reduction methods, legislative and financial incentives and modernization subsidies to digitalize the sector (Rosli et al., 2020).

Rigid technocratic approaches that have been applied to the design of such system architecture have been based on strictly administrative criteria and in this manner have failed in the optimization of information management. With the imposing need to place people and the environment at the center of corporate development and technical innovation (EC, 2024), the transformation of production support and coordination systems becomes imperative. New methods adopted focus on respect to social impacts, personnel safety and health, and at the same time, on protection of natural resources and the reduction in pollutant emissions. Systems that facilitate waste prevention and reduction are especially critical to the European Commission's Green Deal policies, making research on the field more important than ever.

The construction industry can be thus shielded against future legislative and technological challenges, converging with citizen demands and the expectations for modernization of its methods and personnel. Rapid industrial changes and the importance of their utilization to promote social, environmental and financial progress already transform business practices in the building sector (UKGBC, 2023). Intensifying global competition and the transformation of production and communication methods make the need for innovations in document management one of the most influential factors in the evolution of construction management.

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