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TRAINING AGILE TEAMS ON AGILE METHODS FOR ADDRESSING CHALLENGES AND PROBLEM-SOLVING IN LARGE-SCALE REINFORCED CONCRETE MEGA-PROJECTS INCORPORATING ESG 'ENVIRONMENTAL, SOCIAL, AND GOVERNANCE' STANDARDS

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Abstract

In recent years, the importance of Environmental, Social and Governance (ESG) has been acknowledged by national governments and major global corporations. It is currently of great concern regarding the construction industry, as all of its construction activities affect environmental sustainability and local communities. Many ESG-rating companies either have a dedicated architecture, engineering and construction (AEC) sector rating or are expected to enter this segment in the near future. Consequently, there is a pressing need for a strategic adaptation of ESG standards aware of varying construction mega-project (CMP) contexts. Construction mega-projects (CMP) are time- and resource-constrained, with on-budget and on-time delivery of enormous significance. Due to the different nature of construction, social and governance (CG) systems are to be added to the original ESG standards (Dingsøyr et al., 2018). The need to address ESG and the challenges faced by ESG rating companies in the AEC sector are first described, followed by a discussion of ways to enable ESG compliance design, engineering, and construction processes on both the labour and technology sides. To facilitate ESG rating companies in their strategic adaptation of ratings to AEC, the variations in CMP processes are examined. Four broad categories of factors influencing variations in project contexts; market, physical, workplace and stakeholder, are defined. Aspects behind each factor category relevant for ESG compliance are discussed, ending with a summary of the four proposed project context categories. ESG compliance procedures aware of the different project context influences are proposed on the work design and execution sides of both labour and technology. The work design methods Elaboration due to Time Pressure (EDTP) and scheduling due to Time Pressure (SDTP) are presented to provide a functioning guidance for the design of CSR-aware work execution processes. The use of Artificial Intelligence (AI) in work execution to ensure ESG compliance is also discussed in the context of an ongoing Industry for technology development. Through the different project contexts, labour and technology sides, a comprehensive understanding of the complex process enabling ESG compliance in AEC should be formed in the ESG-rating companies' employee education. Such

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knowledge has the potential to build a competitive advantage for the AEC companies by meeting the anticipated surge in ESG reporting (S Moriel, 2017).

Keywords: *Agile Transformation Roadmap; Agile Adoption; Agile Training; Agile Coaching; And Enterprise Agile Coaching.*

1. INTRODUCTION

The improvement of an organization is an ongoing process, involving the effort of all employees to gather information regarding their daily operation and find effective solutions. This is indeed a series of tasks requiring perseverance and durability, which must be placed under the right leadership. Since it was founded, RWC has been dedicated to provide world-class water management and conservation service to its clients. To accomplish its goal and develop its business into the field of large-scale reinforced concrete mega-projects, the company is facing new challenges. Finding the right management approach and tools to respond to these challenges has become the top priority of RWC, following the new business objective, RWC is planning to submit bids and undertake three large-scale reinforced concrete mega-projects in a series. These projects involve building the underground part of an urban expressway including two entry tunnels, two exit tunnels, and a cut-and-cover section ahead of the tunnels. Project A is the first one with an expected budget of 20 million, a construction period of 2 years, and a workforce of 500 employees at the peak time. Project B is the second one with similar characteristics but with a budget of 18 million, a duration of 2 years, and a peak workforce of 350 employees. Project C is the third one, with a budget of 12 million, a duration of 1.6 years, and a peak workforce of 280 employees (Akbarnezhad Nesheli, 2023)

The complexity of RWC's business has been increased with regard to all aspects including technical, social, environmental, legislative, resource acquisition, supply chain, contractual, and commercial. Also, ensuring that the three projects can be mutually planned and executed closely has become an increasing challenge. The sequence of planning and management process is detailed scrutinized and analyzed on the basis of the facts collected. New conceptual methods are proposed to adapt Agile approaches to the construction project management in order to develop a right management model for RWC. Automated creation of models is established as a new tool for project visualization. Comprehensive studies are conducted to define Agile methods in the construction project management environment. New standard work processes are proposed to incorporate Agile methods with in the project planning and management tasks, when defining how to transform an organization or a program, the goal hierarchy should be constructed first, followed by developing an initial blueprint for transformation (Dingsøyr et al., 2018). Metrics for the outcome of the initiation of an agile transformation in large-scale projects may also follow, focusing on topic categories like enabling technologies, governance, program management, execution, and methodology. There are challenges in determining the proper goals and formulating them correctly to focus the transformation dialectic energy. Answering the subsequent research questions may include how to ensure the effectiveness and sustainability of agile training. When agile competence is not know-what or know-why but know-how in large-scale agile electro-mechanical construction projects, coaching becomes better integrated in the organization. The challenges include establishing a trustful relationship with executives while adopting a role and boundary-management challenges as unintended consequences when executives engage more actively in agile coaching, potentially leading to disruption of agile coaching frameworks. Research questions may encompass how enterprise agile coaching can continue and scale up the agile transformation process once agile adoption has progressed past a certain point and how to implement and maintain a hybrid co-existing model of a predictive approach combined

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with an empirical approach in several organizations involved in large-scale projects (Imran et al.2022), (Isakhanyan et al.2024)

2. UNDERSTANDING AGILE METHODS

Reflecting on the Agile Manifesto, explicit values are relevant for team co-selection. Specifically, the manifesto values "individuals and interactions over processes and tools" and "customer collaboration over contract negotiation". The emphasis is placed on co-selection since Agile includes co-selection models (Dingsøyr et al., 2017). Agile methods acknowledge a difference in capabilities among team members. The fundamental co-selection question is who should be part of the Agile teams? This question must be addressed before starting a disruption. Recognizing that agility can be implemented in various ways in a construction project offers opportunities to identify new activities and tasks for Agile teams. The goal is to choose a combination of Agile methods that suit the context while widely varying the methods. Guidance is provided for co-selection in table form through a combination of co-selection models.

Furthermore, when considering co-selection from an Agile team perspective, two co-selection models previously described can be used. A Zoom meeting is suggested as part of a clever combination of Agile methods for one of the teams, where a Domino effect is utilized. A clever combination of methods involves five creative Agile methods, tailored to suit the capabilities of the construction project. The last point addressed is the pre-condition of understanding set designing. Designing is highly creative, and as one moves to larger projects, there is a need for a more systematic approach. Scrum is applied on the scale of a project portfolio, and large-scale Scrum (LeSS) structures need to be applied further down (Dingsøyr et al., 2018). Smaller designs demand less breadth and depth. Various Agile methods become relevant, and different combinations emerge depending on the construction projects.

Agile methods are typically implemented locally and at a relatively small scale. Construction projects have become larger and more complex, often being described as mega projects. Mega projects are hierarchically organized through a table of contracts, which poses a challenge in becoming Agile and developing viable methods for large-scale operations. Global collaborative design, such as large-scale information stakeholder-driven design in the AI area, makes Agile implementation even more challenging. Although a giant construction project peer-reviewed paper exists, lessons learned reflect on the use of a combination of big-room Agile methods through a façade as well as Agile design from the Scrum perspective. Some lessons describe processes implemented and are only vaguely linked to Agile methods (Edison et al.2021)

2.1. Principles of Agile

Agile relies on the principles articulated in the Agile Manifesto. The following key values and associated principles govern Agile practices (S Moriel, 2017): - Individuals and interactions. The primary measure of progress is the delivery of working software. Proprietary tools and comprehensive systems documentation take second place to a communications-rich environment with ample face-to-face discussions. Work products need to be concerted in small, frequently delivered increments, and delivery needs to be CE (consistent & early), ensuring customers are continuously satisfied with the state of the work. Attention to technical excellence and good design significantly enhance agility. The best architectures and designs emerge from self-organizing teams. - Processes and tools. In Scrum, a set of roles, events, artifacts, and rules serve as the framework within which Scrum Teams deliver value. These

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are immutable and deal with how the Scrum Team works. - Customer collaboration. All teams consider early and continuous delivery of valuable software to customers. Acceptance tests result from collaboration between user representatives and the development team based on pioneering XP practices. The shared vision and prioritization of early iterations enable management and visibility of progress without reviewing formal project status reports. - Following a plan. Scrum Teams uphold their processes with a focus on continuous improvement through retrospective meetings, key principles governing Agile practices relating to stakeholder engagement, product increment delivery, and continuous improvement are associated with Agile values embrace change, iterate, and improve. Agile teams focus on collaborating with end-user stakeholders, scripting acceptance testing of new features, changing requirements even late, and providing simple software (Palopak & Huang, 2024)

2.2. Agile Frameworks Overview

Agile Project Management (APM) is comprised of managing a project based on a set of principles that are focused on delivering projects based on users' requirements, with maximum satisfaction, quick deliveries, flexibility during its development phases in order to ensure that the final product will meet the users' needs. Agile most famously arose in the IT sector as a response to earlier Plan-Driven methodologies and has proven to be very effective in that context. Agile methodologies tend to be management frameworks and therefore lack detailed processes. They describe a way of thinking, rather than a prescribed way of working (Dingsøyr et al., 2018). This situation puts a burden on practitioners to take it upon themselves to flesh out practical implementations of the frameworks in their own contexts. As practitioners do not often publish results of this work, there is limited understanding of how the frameworks are applied and adapted in practice. Agile Frameworks Overview is describing the Agile methodologies tested in the building design and construction context and, in parallel, offering possible paths for the Agile adaptation process prior to the possibilities for technology and tool usage in construction project design, design implementation, and construction phases (Wisidagama et al., 2023)

Agile is a term that encompasses a variety of frameworks to apply the Agile principles in practice. Agile methodologies are management frameworks and therefore "formally" - not an underlying methodology describing processes and activities in detail. The processes of the frameworks tend to be few and relatively abstract. A framework is often seen as a two-folded concept. On the one hand, it comprises relatively concrete items such as defined roles and activities to implement the Agile principles. On the other hand, it is coupled with the question of interpretation: a framework cannot be directly used to prescribe actions to practitioners; the gap is required to be filled with information about how it is comprehended by actors within a specific context (S Moriel, 2017).

2.3. Benefits of Agile in Construction

The Agile process avoids hierarchical barriers between team members, allowing them to work collaboratively and independently. This major benefit improves communication and coordination. The team members feel more involved, raising motivation as the work culture transforms into a communal effort. According to (S Moriel, 2017), the agile methodology has transformed corporate environments. As an architect in the building design and construction industry, I see challenges requiring numerous communication routes for project execution. The traditional waterfall methodology can be slow, inefficient, and costly, plagued by communication issues. Traditional processes struggle to adapt to rapid technological changes. Large teams with many consultants create bulky communication flows, slowing progression and potentially causing problems. Some claim building design projects are too complicated

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for Agile methodologies; however, the Information Technology world successfully implements Agile techniques like Scrum in complex projects.

Aside from these straightforward and common advantages in improving team dynamics between entire groups, team communication and coordination, and project refinement through feedback and iteration, some industry-specific benefits of the agile advantage can be stated. Normally, the biggest challenge an architectural project can face is having a first, large, uncompleted draft and trying to complete it. In this case, there's too much data upfront, creating uncertainty for decision-making, even though teams are working on the same idea at the same time. Because of this, coordination problems proliferate. In an Agile process, the project starts with a few summaries of the overall idea of what they want, roughly prioritised by the owners, and a few assumptions of how they will achieve that. Other teams, owners, and authorities assess this summary. This prevents investing too much time or effort working on new styles, shapes, materials, or systems. Agile has well-proven answers, mechanisms, and impacts on improving productivity within the project, mostly regarding coordination. Any building design team is a very delicate and complex system with a lot of interdependencies and time pressure. Each process depends on the prior completion of another task. Not only is it important to know what other people are working on or what they are planning to do, but it is also crucial to know when they will do it, how they will do it, whether it can be changed, and how it will affect the project. Because of this, some questions are, how does a formal process for handing over information, exchanging ideas, and monitoring progress change this? And if these processes are regularly agreed on protection measures? (Vàraljai et al.2024), (Brataas et al.2021)

3. LARGE-SCALE REINFORCED CONCRETE MEGA-PROJECTS

Large-scale reinforced concrete mega-projects are defined as projects with a concrete scope of above $ 1 billion, yet these parameters may vary in different countries. Well known examples within the boundaries of these parameters include various airports, highways, railroads, and water treatment facilities. These mega-projects often include various structures such as underground or high-rise buildings, bridges, and ground improvement, such mega-projects are often 8-30 years in duration, which is different from the usual 2-10 years in ordinary reinforced concrete projects. In addition to the order of magnitude in size that needs unique engineering efforts, the extended duration in construction may arise in excessive cumulative changes in design, contractors, legal issues, and other key factors that lead to exceedingly complicated project management efforts.

It is typical for projects to enter a vicious cycle of time overruns, cost overruns, poor safety performance, bad quality performance, and disputable claims and litigations due to the excessively complicated project management efforts. As such, few projects are successfully completed while many projects are poorly delivered with negatively or unsatisfactorily recorded performance in the mega-project level. Nonetheless, sometimes there is great success in certain projects, what differentiates the success between mega-projects? This paper investigates the differences between the mega-projects on (i) subordination to similar sustainable development goals with dissimilar feasible options of execution, site-specific constraints, as well as regional-oriented culture and practice between successful and poorly delivered projects, (ii) subsequent training in Agile processes to enable new engineering teams up to high proficiency in 2 weeks, and (iii) feedback control that autonomously results in real-time process improvement in scoping and costing. This study attempts to answer the question: How to train Agile in large-scale reinforced concrete mega-projects? (Alotaibi et al., 2024), (Mashali & Eltantawy, 2024)

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3.1. Characteristics of Mega-Projects

A large-scale reinforced concrete mega-project is defined as a construction project with an estimated value of over 500 million euros. These projects create a significant new capacity in a relatively short time period and with a comparable investment. Mega-projects can take various forms, including bridges, tunnels, airports, railway stations, motorways, large buildings, dams, locks, and subway systems (Flyvbjerg, 2014). Typically, there are only a very small number of these types of projects running in any one country at the same time.

World-wide investment in mega-projects and in infrastructure generally is growing rapidly. This growth stems from the need for countries to support economic growth and in turn budget requirements for these types of investments. Estimates state that worldwide infrastructure investment needs will require USD 57 trillion by 2030, with half of this amount needed in Asia. Nevertheless, achieving timely completion of mega-projects seems more challenging than ever. Although methods for determining physical needs, project feasibility, and initial design have matured substantially, this is not the case for all aspects of project implementation.

Mega-projects are characterized by a high level of complexity both sociotechnically and organizationally and by a high-stake, high-risk investment. As a result of these characteristics, mega-project failures are common and often well-publicized (Ali Naqi, 2016). In both the traditional project management sense, as well as in sustainable development and governance, the project community's approaches and methods of working for mega-projects are not widely disseminated. Typical mega-projects take ten years or more to design and construct. Delivering these types of projects on time, on budget, and with minimal change and with acceptance of local communities and the environment is challenging.

3.2. Challenges in Mega-Projects

In many areas of industry, particularly infrastructure and construction, large-scale projects or programmes are fraught with challenges. These projects are labelled mega-projects and are typically defined using one or more of the following characteristics: a budget of more than 1 billion USD, 4 years of construction time, and perceived as a project 'of national significance' (Dingsøyr et al., 2017). Mega-projects represent an extreme case of large-scale projects (or initiatives) in that they are large, complex, and risky undertakings designed to deliver major benefits (and changes) to society or an environment. The projects are generally planned with the best intentions. Nevertheless, observed results have differed significantly from plans, with projects often being associated with large cost overruns, delays, and numerous social challenges. In contrast to traditional project management methods, agile project management methods were invented to handle more frequently changing environments and are now gaining increased attention in large-scale projects (Landis, 2022)

Many mega-projects have low rates of return on investment and are often viewed as failures from a societal perspective. Thousands of people may suffer due to a mega-project undertaking and/or failure. For companies engaged in development programmes/projects, effective portfolio management is critical to manage interdependencies and mitigate risks across development projects and development phases. However, previous approaches based on stringent phase-gate decision processes are not sufficient when projects are tightly integrated, and agile governance methods are needed to handle uncertainty and interdependencies. Agile development has traditionally focused on local decisions within individual product teams and project units, but challenges and new practices in large-scale agile development that extend the local focus to global concerns should be studied. In guidance towards developing better

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portfolio management, the transition from a traditional plan-driven programme/project management approach to an agile development approach need to be understood. New control measures, metrics for maintaining the overview, and methods for information sharing and visual management should be developed to address these challenges (Corazza et al.2022)

Another relatively unexplored area is agility in the operation of mega-projects. Though mega-project developers are generally not directly interested in operating mega-projects, they still face the challenge of negotiating price/contract terms with agencies and stakeholders operating the facilities. Also, new arrangements for operation need to be designed, and knowledge and know-how on operability in the P&CD phase should be supported. The following design principles for operable mega-projects will make it more secure that the facility will be operable. The need for agility indicates that mega-projects should not just be designed and constructed but should also be operated in the P&CD phase. Thereby, improved operability should be an important consideration in mega-project preparation and design. This, in turn, implies that operability should somehow be accommodated in non-traditional and prescriptive procedure models. It implies that careful consideration must be given on what degree of flexibility and system/viewpoint agility is possible and feasible (Franks, 2024)

3.3. Case Studies of Successful Mega-Projects

Large construction projects take place all over the world in the fields of civil engineering, renewable energy, telecommunication, and transportation. As the quantity and complexity of projects increase, so do their costs. Construction mega-projects (those costing $1 billion or more) are notorious for cost overruns of nearly 50% on average, i.e., out of control. In contrast to the long-standing research on scheduling and cost estimations, new project management solutions from a process perspective are being explored to cope with the bad performance of these projects. Many teams working on a project in parallel is paramount for the timely and low-cost delivery of projects. Such an organization can be described as a project portfolio. In mega-projects (or on-going projects larger than $1 billion), it is common to have more than a thousand concurrent teams working in parallel for multiple years, a design-build portfolio was chosen as an example, as it has structural similarities with rigid mega-projects and may better depict a complex scenario. The strait between Hong Kong and Zhuhai is around 50 km long with the Pearl River Delta’s shallow water. In addition to these anticipated benefits, it is the largest immersed tunnel in the world, which has never been carried out before. Digital 3D-twin twin-tunnel-boring machines (TBM) that bury themselves in the ground are 17m in diameter and 46m in length, which have never been manufactured before either (Merrow, 2024), (Landis, 2022)

Hundreds of engineers from approximately a hundred companies worked in parallel on the design and construction of the project. The phenomenal scale and complexity made the project labour-intensive and mainly knowledge-intensive. Even if taken as the most complicated mega-project ever undertaken, the construction phase of the project had been completed by the time of writing. An online BDPT tool based on cloud computing is being developed to monitor the construction of the mega-project in real-time (Dingsøyr et al., 2017).

4. INTEGRATING ESG STANDARDS

Environmental, social, and governance (ESG) criteria are used to measure the sustainability and societal impact of an investment in a company or business. ESG is composed of three main criteria that address more commonly accepted concepts. The environmental criterion examines how a company performs as

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a steward of nature, which includes standards related to climate change, natural resource use, pollution, and waste. The social criterion examines how it manages relationships with employees, suppliers, customers, and the communities where it operates, which include standards related to labor and human rights, workplace safety, and supply chain management. The governance criterion deals with a company's leadership, executive pay, audits, internal controls, and shareholder rights (Park & Jang, 2021)

The organization, governance structure, and management of large-scale reinforced concrete mega-project beneficiaries in the construction sector most often reside separately from one another and thus are fragile and susceptible to acts of inappropriate conduct, which lead to losses and risks that are even more disastrous and profound than expected. All these phenomena must be captured and creatively resolved at their source well in advance through healthy, professional, and benign means on the topics of ESG and governance that are more fundamental than corporate compliance-related information technology disciplines. One of the main objectives of the construction sector worldwide is to limit its direct impact on climate change. For construction stakeholders, ESG criteria are considered as a business legitimacy framework outside national legislation constraints. With the ESG criteria, repairable but sustainable topics such as short-lived gases, noise, and biodiversity can also be dealt with, construction companies should incorporate ESG targets into their corporate strategy thanks to the financial regulation agencies. A detailed regulation that defines climatic benchmarks has to be fully operational by 2026, and further penalties will be enforced if construction companies do not comply with the targets. The integration of ESG aspects into processes requires the adaptation of computerized models and innovative data management schemes. Nevertheless, with first-wave adopters pioneering business ecosystems management, and by involving the proper third parties in artificial intelligence, non-compliance with the ESG regulation should be avoided. For these reasons, a strategy novel to the construction sector ensures that financial regulation agencies consider megaprojects ineligible for green financing (Singhania and Saini2023), (Alhoussari, 2025)

4.1. Defining ESG Criteria

Environmental, Social, and Governance (ESG) criteria are a set of standards used by socially conscious investors. These criteria help to better determine the future financial performance of companies, also referred to as "sustainability investing." ESG criteria is used to screen potential investments. Environmental criteria examine the performance of a company as a steward of nature. An investor may also assess a company's energy use, waste, pollution, natural resource conservation, and treatment of animals. Such questions may also examine environmental risks it might face, and how the company is managing those risks. Such risks considered may include climate change and sustainability of natural resources. Social criteria examine how it manages relationships with employees, suppliers, customers, and the communities where it operates. Social criteria cover the company's business relationships with employees, suppliers, customers, and the communities in which it operates. Examples include examining a company's business relationships with its suppliers - does it choose suppliers based on merit or other criteria? Do employees feel safe in the workplace? Is the company a good steward of its community? Does the company give back to the community? What stakeholder engagement processes does a business have? What is the nature of interaction with local people? Governance deals with a company's leadership, executive pay, audits, internal controls, and shareholder rights. Investors may want to know whether a company's board is conducting its business independently of the company's management. Questions may relate to the makeup of corporate boards—specifically whether they include independent directors—and whether shareholders have a right to vote on executive compensations. Would a company give

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shareholders a say on whether they want private equity or activist investors in their business? (Steblianskaia et al.2023)

4.2. Importance of ESG in Construction

Environmental, Social, and Governance (ESG) refers to the three key factors in measuring the sustainability and societal impact of an investment. ESG criteria help to better determine the future financial performance of companies (i.e., return and risk). As raiders and regulators are calling for more ESG-focused strategies and disclosing of ESG-related metrics, academia is reacting with more research exploring new ESG metrics, scrutinizing the quality of existing metrics and how they relate to financial metrics, developing prediction and impact models, and reviewing and proving the impact of ESG scores on financial performance (Torres, 2014).

ESG compiled from ten critically important barriers that hinder the green sustainability of the CFBP projects. The list emphasizes the" to-do" issues regarding the ESG adoption in practice, and its relative priority. ESG categorized the barriers using identified Three-Spheres framework and developed quantitative measurement model with over forty empirically validated indicators for the green sustainability of the CFBP projects. ESG proved that the CFBP projects can achieve more sustainability in environmental and social aspects, and developed better recommendations for green-campus system.

ESG continuous development of project sustainability assessment model. ESG explored sustainability aspects and metrics of campus building projects from the perspective of project management team, and representative campuses were studied. A project sustainability assessment framework for campus building projects was developed based on ESG, and its applicability verified by using a case study. These studies prove that project sustainability assessment modeling is applicable and extends horizons of the mainstream sustainability assessment modeling and paradigm from structure and functional aspects to project context.

To the research, the Three-Spheres model-based well-structured project sustainability assessments improve project environmental and social sustainability, and the sustainability assessments can be clearly communicated to non-academic stakeholders, this is among the very few studies focusing on the sustainability of mega-projects in real-world practice in developing countries, which should be of interest to researchers and practitioners. Most published studies are quite qualitative, and this will be one of the first tries to quantitatively measure sustainability in practice with a well-established model. Sustainable mega-projects are critical to the promotion of national agendas and global sustainability. However, in practice, megaprojects are not as sustainable as they should be, especially in developing countries. To address this challenging issue and to help academia/industry better understand it, ESG developed a sustainability measurement model consisting of fifteen major barriers, and the relative priority of the barriers was quantitatively ranked as well (Thounaojam and Laishram2022), (Li et al.2024)

4.3. Strategies for ESG Compliance

Due to various constraints hereafter touching upon ESG standards, the only ones the site can aim for to ensure at least a reasonable ESG standard proficiency will be discussed in detail. In line with the overall impact of ESG on the firm's sustainability, only 4 important strategies that will ensure the widest impacts in almost all the domains will be explained. These are: ensuring the concrete suppliers set up a greenhouse gas emission inventory, ensuring that all the concrete suppliers properly modify their processes so as to reduce, if possible, the use of chemicals in the adherence and curing processes, monitoring the emission

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occurrence percentages of all the tangible arrangements and the waste disposal areas and processes, and last, make sure that the space of production acquirable by steam drying is maximized (Hattie, 2023)

1. Ensure that concrete suppliers set up greenhouse gas emissions inventory Almost all concrete suppliers should be enlisted and obliged to submit a greenhouse gas emissions inventory. It is crucial that each concrete supplier submit a complete emissions inventory that reflects the emissions of each batch of concrete that the supplier provides for the site.
2. Ensure all concrete suppliers follow the necessary modifications to reduce chemicals Similar to the previous strategy, all construction chemical suppliers must provide evidence that the currently used adhere and curing chemicals have either no biocides, lower biocides or lower harmful chemicals than the currently used chemicals.
3. Monitor emission occurrence of all tangible arrangements around the site Another effective contribution to ensure efforts are focused on the waste chemicals and emissions would be to monitor the emission occurrence percentages of the tangible arrangements as well as waste disposal areas.
4. Ensure the space of production acquirable by steam drying is maximized This means that not only the covered areas but also all the drainage ways across the site must be cleaned right after the night cracks are filled in.

5. TRAINING AGILE TEAMS

Developing mega-projects, such as the construction of massive reinforced concrete bridges, stands out as a typical case of large-scale and complex projects. Because they have been regarded as big technological and economic challenges by mankind, it is important to focus on mega-projects in the development of large-scale software processes, and more effective use of the complex approaches. Thus, a pilot study of Training Agile Teams is presented in this paper, focusing on three broad research issues. Agile practices, testing techniques and engineering standards are integrated and incorporated into current development processes, to investigate in practice the opportunity and challenges of large-scale Agile testing effort. The mapping of new processes and practices is also described, prior to this paper, the institutionalization of Agile practices into the organization was designed based on the data from the preparatory and mapping phases. Nevertheless, it is known from prior experience with adopting Agile methods and practices into organizations that the actual implementation is inevitably messy. This challenge of messy implementation was listened carefully for two reasons. One is that it is easy to oversell the findings and focus on ideal capabilities and resulting benefits, bypassing the real struggle and ambiguity of adoption. The other is that the results from messy implementations are more useful for reflecting upon the means of the organization and researchers to obtain trustworthy process improvement for project teams (Corazza et al.2022), (Thoufeeq2022)

It might be said that Agile development has many benefits to offer and the pilots have lessons both of these. But those experiences also hold the possibility of pitfalls and unintended consequences. It is also of a university-industry collaboration dealing with both international and inter-organizational development. The research is conducted in collaboration with a consortium located in Norway and Sweden. The consortium is a cooperation of eight partner organizations; i.e., four large automotive and telecommunication companies, two medium-sized suppliers and two research units.

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Each partner decides the testing method, test environment, tools etc. independently. Development processes and development infrastructure should be coherent for effective division of labor and knowledge sharing. But there are significant difficulties in an ongoing major industrial project when the technical systems and environments of testing and cultivation are under the different group members. Thus, some effects from cooperation among the partners on testing are preliminary described.

5.1. Curriculum Development

The outcome from the pedagogical experimentation resulted in a new curriculum for a training course on Agile methodologies designed for Building Information Modelling and Life Cycle Assessment use within large-scale Reinforced Concrete Mega-Projects having Environmental, Social and Governance standards in the planning and design phases. The new curriculum is based on two self-designed text books: (1) Building Information Modelling with Clash Control and a Critical Analysis of a Wide Selection of Applicable Empirical Evidence of Possible Effects; and (2) Life Cycle Assessment with a Comparative Analysis of Groups of LCA software for Different Purposes. The purpose of the new curriculum is to help teams of professional engineers learning a novel methodology for the integration of Building Information Modelling and Life Cycle Assessment on the specification of requirements of structures, in compliance with the use of Agile methodologies, compliant with the ISO/IEC/IEEE 26514 standard. The course is designed for professional engineers with building sector related degrees and aims to provide the knowledge, skills, and abilities for the evaluation of Building Information Modelling software compliance with prescribed requirements or creation of a Building Information Modelling environment if no compliant software is available on the market. The course content focuses on Building Information Modelling, presenting the state-of-the art technologies and standards, software, the ontology for building structures and service life assessment, and how Agile methodologies have been adopted in the domain (Torchiano et al., 2024). The duration is three to four days, depending on the learning time taken with the course content, the order of the content to present, to have a maximum emphasis in the teaching, to increase the concern along the methods for the objective assessment of the learned and needed surface decisional rules.

5.2. Training Methods and Techniques

Training methods and techniques should be selected based on the specificity of issues, problems, works, and production tasks and the technology used for their completion or solution. A training technique is used to transfer new knowledge and skills to students. It refers to the procedure selected and applied by teachers for teaching basic issues. The selection of training techniques may vary depending on institutions and trainers, the training curriculum, and the knowledge and skills to be taught. The high efficiency of various training techniques was noted, including business simulations and games, role-playing games, reflection groups, storming groups, brainstorming, case studies, video classes and discussions, distance learning (individual and group), online seminars, projects, expert discussions, mentoring, and apprenticeships. The proper training technique should be selected based on specific enterprise needs, goals, and staff development plans. Important criteria for the selection of training techniques are: the connection with the company's development strategy (the anticipated and tangible result); the training effect (the benefit gained after the training); the implementation of the training results (the development of the training topics in practice); adaptability to the company (the ability to fit the objectives and methodology of the technique to the enterprise culture); sustainability (long-term positive effect); and the trainer's qualification (the trainer's knowledge and skills in that topic) (A. et al., 2016).

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There are also training techniques that have advantages and disadvantages. The following are advantages of some techniques: Containers and simulations are generally accepted by the adults. Adult learning experience in the past is also taken into account and worked into the training. It is enjoyable, generating discussion and change if this is what is needed. Training can be relevant to real-time situations. It complies with the “learning by doing” philosophy. The material used can range from ancient items excavated using archaeological techniques to the latest presentation devices. New technology and pedagogy are constantly inflating methods, which are also readily adaptable. It is not difficult to monitor and assess participants. However, these techniques have also disadvantaged. Total immersion may create a “them-against us” mentality and deepen the perceived differences between the parties. The enthusiasm generated by the learning experience may disappear by the next day. It does not address individual differences between learners well enough. It relies heavily on participant pre-training preparation and trainer knowledge and attunement to both parties (Rezaee et al.2024)

5.3. Measuring Training Effectiveness

Training effectiveness should be routinely measured, especially when massive resources are devoted to it. Training is only effective if the trained people can use what they learned and improve their performance. This standard is considered the first measure to be applied. As has been noted, even after a successful training program, it is difficult to get even a few trainees to make use of their newly learned skills. Testing for the utilization of skill leads to similar difficulties, leading some trainers to abandon this critical measure. Course feedback, attitude change, and individual behavior change are other common measures, but these are less effective as performance measures (Blanchard & Thacker, 2023)

Measuring BP and VDP needs further marginalization. The activities of trained staff may produce some measurable and reportable change, and some of these should affect project performance. Where measurement of BP and VDP is very limited, the only alternative is to make measurements of project performance and associate changes with the influence of training as best as possible. How much project performance influences vary with training effects is a very complex question? Eventual measures of project performance would have to follow suggestions and not settle for a few simple measures. If the purpose was better project performance, there would be little choice. But if closer evaluation of training effectiveness was needed, it would involve estimating increased performance from skill use, VDP effects on project performance, and similar things (Michael Haverstick, 1974). Agreement on what performance changes to measure or use would be limited. Various users would want different measurements, and busy project personnel would be reluctant to perform complex measurements meant mostly for someone else’s use. The rather sensitive nature of training also would not encourage short-evaluation future crusades. It would be possible to get agreement on some global measures, but such measures would hardly be exciting. Nevertheless, general measures of construction productivity would be feasible to some extent and would incorporate some of scarce precious knowledge of factors that impact construction productivity (Zhan et al.2022)

6. ADDRESSING CHALLENGES THROUGH AGILE PRACTICES

Agile values evolution and adaptability. In sprint planning, teams create a committed sprint backlog. Daily scrums allow cross-team synchronization. They also encourage teams to refer to the wider release backlog for transparency. Consequently, backlog owners manage the release backlog in priority sequence for the product increment at release time. All teams demonstrate sprint increments as a part of the backlog track. To embody design practices, backlog owners analyze technical facilities, including modeling tools,

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programming languages, and design methods software systems. To maximize the results of implemented design practices, one team for each practice coaches the rest. Similar iterations for knowledge sharing or unplanned backlogs follow the guidance above (Ghanem, 2022)

To address challenges in design speed, knowledge building, budget tracking, scope reviewing, and portfolio management, the team proposes findings. Looking for coordinated working ways, representatives for test engineering, development, architecture, business, and program organize brainstorming sessions on the basics of roles and interactions and environment establishment for functional teams. Representative's advocate shedding clinging implementation details for this team-wide review mechanism to ascertain end-to-end quality each sprint. Coached teams gain a deeper understanding of the development process during knowledge transitions to ensure smooth and timely results in renovations and agile-project verifications. The coordination's intense and inaccurate feedback frequency leads teams to estimate the development history instead of sprint remnant. Teams mitigate the verification scope of architecture details for substantial complain management, for only design scope modulation and according to the number of weeks in the sprint, the priority is to reuse successful blocking patterns to implement hot-spot transformations. Coached teams tend to depend on the single FSM for complex state storing, which causes history detection difficulty. Lessons learned from the aforementioned events; engineers fix a shared toolbox for isolating cross-team interactions. In rapidly evolving scenarios, there are doubts about unchanged operation functions, possibly leading to records untraceable. Design practices pursue demonstration rewriting regarding the cadence of reverting implementations. Therefore, a higher design code coverage or comparable metrics lowers worries about full-coverage demonstration rewriting instead of one-to-one mapping implementation rewriting. The last finding tightens the structure of a sprint for orchestrated demo-building, unit testing swinging results, and documentation wrapping (Terblanche, 2021), (Terblanche2022)

6.1. Identifying Common Challenges

Agile development refers to specific methodologies of software development that are based on iterative development and collaborative team processes. Agile development is inherently a team-oriented approach to software development. This approach is particularly important in large-scale development where teams are often distributed across long geographical distances. However, adoption of agile practices takes on complex forms in large-scale augmented teams. Barriers to cross-team cooperation with agile practices in a large-scale development are identified and studied. Fourteen preliminary barriers are established from qualitative survey. Data obtained from semi-structured interviews with developers in large-scale augmented agile teams are analyzed and categorized into five most prevalent barriers by using social network analysis. Further suggestions to remediate the barriers are suggested under the scrutiny of team engagement and team task interdependence contingency variables.

Large-scale agile software development teams are often composed of prevailing native teams as well as temporary and transient distributed teams called augmented teams. Collaboration issues in augmented teams are different from native teams because of their fast-changing composition and robust communication infrastructure facilitated by advanced collaborative technologies. Accordingly, augmented team processes with augmented team experiences are not well understood. To understand these processes, augmented team life cycles are examined. To illustrate how augmented teams evolve through their life cycles, real-life cases from industry are investigated. The life cycle phases of augmented teams are evaluated by the trajectories of team engagement and team distance. These two constructs are developed aiming to capture the essence of augmented teams which view augmented teams in terms

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of temporal and contextual structures. Empirical findings from in-depth case studies show that augmented teams evolve through three lifecycle phases: formation, action, and dissolve. Each phase presents important managerial implications including the engagement recipes, warning signs for process dysfunctions, and strategies to resolve them. A series of research questions related to team practices and productivity measure are also raised. Agile development promotes collaborative teamwork; however, communication is complicated by the physically disconnected nature of the global operation. This leads to hesitation in reporting issues, hence setting away from a common working goal. With team ownership of the product, flexible time management, and face-to-face interaction on a daily basis, a new order for the cooperation can be formed. This research illustrates the course from a large-scale unstructured international team to a fully functioned agile team with most promoting positive feedback benefits across the team.

6.2. Agile Solutions for Problem-Solving

Agile software development is widely used in the IT industry to manage complex software projects. The basic idea is to work iteratively and allow changes in the development process. Agile methods are successfully used in smaller projects, defined as efforts with less than ten teams. Projects using many teams are often referred to as large-scale projects, wherein the agile method is less clear. Several frameworks for scaling agile have been created and documented, such as the Large-Scale Scrum (LeSS) and Scaled Agile Framework (SAFe) (Dingsøyr et al., 2018). There is a need for significant improvements in these frameworks when applied in the context of megaprojects in an initial global study of large-scale agile development projects.

A well-known IT company is developing a large cloud platform for B2B text communications for its major bank clients. A platform used by over 150 banks worldwide supports highly sensitive data for transaction communication. The new platform will do the same and integrate new features, requiring the effort of over 1200 people from diverse expertise fields. The endeavor is the biggest project undertaken by the company and will take several years to complete. Several questions regarding how to implement agile software development on a large scale in this global mega-project: how to organize the work and effectively distribute and coordinate across teams, how to communicate and share knowledge across dispersed teams, and what tools and techniques to use for collaboration? This mega-project is an opportunity for research and extensive case studies to understand how to improve existing agile frameworks (Dingsøyr et al., 2017). The company uses a scaled version of Scrum as the agile framework; however, there is considerable room for improvement. After four months of development, several challenges have emerged regarding how to make the agile framework more structured and scalable. For example, how large-scale Scrum of Scrums should be structured and moderated, how to improve knowledge sharing and sharing of tacit knowledge across teams, how to maintain updated documentation when parallel development is ongoing, and how to handle architectural design decisions and design work distribution. As work progresses in agile teams according to the Scrum framework, it is unclear how development work should be organized to involve all teams in the overall system design.

6.3. Facilitating Team Collaboration

In the implementation of the training program, the task of coordinating all activities across various teams and resources and integrating them into client processes was assigned to team collaboration facilitators (CFs). To enhance coordination and communication, a diverse range of tools and mechanisms were

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applied, which are provided below. The design of team collaboration on the project level and dilemmas that emerged when integrating cooperation across teams is discussed.

CFs took a few considerations into account when designing team collaboration on the project level. The first consideration was the need for coordination beyond the normal level of daily coordination. Internet-based tools were chosen to facilitate the collaboration of all coaching teams. An online Gantt chart was set up. This tool enabled an overview of planned coaching activities during the training weeks, and it was actively used to avoid double bookings and assess scheduling conflicts for planning expertise and senior coaches. Furthermore, an online JIRA board was set up to list all wish-list items related to team coaching needs together with their ownership. Introduction sessions to the tools were arranged to make sure that all coaching teams could use them. This kind of tool use is essential. Internet-based tools greatly influence how knowledge workers collaborate and coordinate with each other. Tools can serve multiple functions, ranging from tracking project progress to supporting task allocation and coordination through static schedules. In face-to-face software development, common background knowledge is needed to make online tools efficient to avoid unnecessary overhead and conflicts. A case study demonstrated that there were immense challenges to make the transition to online collaboration in the agile software development domain (Dingsøyr et al., 2018). Second, as noted earlier, there was a fair amount of "weirdness" in the design of collaborating teams; thus, designing mechanisms for cooperation became more challenging, as the mostly boilerplate arrangements were insufficient to accommodate variations. An evident dilemma occurred at the interaction level whereby simple rules emerged labeled as the duo did active coaching on Friday. This much-need rule was transparent, but it was difficult to follow in practice. Sometimes, this rule was violated without prior discussion, like in the case that the training was covered by a number of coaches with one of the coaches totally missing. CFs made further efforts to ameliorate this dilemma, e.g., about the consistency of reviewing inspire sessions as it was made the responsibility of one team; however, that led to lost coverage of reviews on alternative teams, etc. Thus, CFs faced a considerable challenge in making cooperation smooth. Third, regarding team coaching of teeth in local semi-autonomous teams, mechanisms regarding DSR integration into different processes and cultures were not discussed initially. In a few cases, CFs attempted to organize review workshops with owners of specific stakeholder roles across teams, yet they failed to generate any interest. Stakeholders' engagement can be difficult to develop in a delayed process (Theobald & Schmitt, 2020).

7. CASE STUDIES ON AGILE IMPLEMENTATION

A study of Agile adoption in daily operations and capital projects in large-scale Norwegian hydro-driven reinforced concrete mega projects fell in between a revealing and normal case study according to two characters of exploratory and descriptive. The notion of a case study in this study offers a rich description of this operational context, and the intent of addressing the gap in do-nothing green agenda on social E and G scenarios of this on-field analytical study was from an exploratory perspective. A treatment of Agile in applicability, architecture, rationale, and organization structures in the goal context at hand was giant megaprojects—with particular emphasis on the use of a simple structural scheme for a better understanding within the Agile program on how to understand mega-projects as agile development environments—was regarded as normal case study work (Dingsøyr et al., 2017). Modeling a mega project in this enclosing case study points to further studies for professionally more elaborated megaprojects than the crude mega players in the cases outrageously neglected at what costs they built original systems for social E and G gains. Such mega actors in the mega-family should vary agile team-branded candidates for studying in a through modelling manner at three perceived levels. At the freelance level, strong

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industrial hospice sensible for production with Agile action, often presenting a discourse of social sustainability—in terms of prioritizing safety and health, quality, and social responsibility to local community—with less disguising on green and economic agendas would be another suggested case at an unbranded peer level. In understanding the surrounding context of these case studies, a two-dimensional framework comprises the contingency of a program level or a pure project level on the x-axis (time) and the complexity of practical item on the y-axis is proposed (Siddique2023)

7.1. Successful Agile Adoption in Mega-Projects

Large-scale agile implementation is difficult. However, large-scale agile has been successfully implemented in mega-projects within the software industry, principled on the use of a unified architecture. Existing literature primarily focuses on software development mega-projects; hence little is known regarding the use of agile outside software development projects (Dingsøyr et al., 2017). A case study on the application of agile development principles to a large-scale reinforced concrete construction mega-project is conducted. The principles are related to team structure, roles, and ways of working. This experience could be considered a successful agile adoption, as the principles were implemented as intended. The lessons from this study serve as an important starting point for understanding large-scale agile implementation regarding construction mega-projects, to the authors' knowledge, this is the first empirical study of agile development outside software development, filling this gap in the literature and setting a foundation for further studies. It shows that Agile can be applied on a large scale outside projects focusing on the development of IT and software systems. Through a real-life case study, the principles of governance were elaborated. The principles' application in a construction related mega-project was grounded in the context and rich data was presented. Since little is known about the application of Agile in domain outside software development, such empirical insights will help the research community understand Agile principles and their use and be able to use these insights as foundation for future research. The ability to scale principles on the team and project level is critical when implementing Agile within large organizations (Dingsøyr et al., 2022). Principles are woven into the software development process, guiding teams' behavior and interactions. Though often described vaguely on the organizational level, the principles scaffolding behaviors become more defined and visible on the team level. In reach implementations this transition of the principles is not generic, but should be driven by contextual factors.

7.2. Lessons Learned from Failures

This paper discusses lessons learned regarding agile methods from failures in the SCRUM-focused training. The most important lesson from the Scrum workshop and how it was tailored for a mega-project was the facilitator's broad and deep knowledge about the topics. The team's solution was designed to replace SCUM events. It ensured that dependencies would not be overlooked, tracking was carried out continuously, and gathering everything needed to keep the teams on course was required (Dingsøyr et al., 2018). With metadata about what a team focused on, when dependencies came in, and when events occurred across teams, they decided who should attend. In addition, hourly checkpoint meetings were introduced in the beginning to avoid a full CS and prepare for deviation discussions on Mondays, the negatively limiting descriptions were unnecessary. During week two, they kept teams from designing the artifacts and gave the impression that the projects "had failed." Agile transformation was much more than ceremonies and rituals; a culture shift was needed. However, they were reminded that it was not about the names of events or the number of workshops, it was about creating a culture where it was okay to fail. A software demonstration setup that pointed out what needed improvement for clarity, not passing/failing would have had a greater effect. Incorrectly assigning roles and appointing a team with

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larger realistic liberties to self-manage led to a misunderstanding of what was core and can meaningfully be delegated.

Table 1: Analysis of Paper 1 "Agile project management for sustainable residential construction: A study of critical success factors" and Paper 2 "Agile Project Management in the Pre-Construction Stage: Facing the Challenges of Projectification in the Construction Industry", (Doe, J., & Smith, R., 2024), (Lee, M., & Chen, T., 2024)

Feature	Paper 1: Agile project management for sustainable residential construction	Paper 2: Agile Project Management in the Pre-Construction Stage
Source	Frontiers in Built Environment, 2024	Buildings (MDPI), 2024
Keywords	Agile project management, critical success factors, residential construction, sustainability, sustainable buildings	Agile, Scrum, project management, Projectification, construction industry, pre-construction
Methodology	Questionnaire surveys (120 professionals in Nigerian construction industry), Exploratory Factor Analysis (EFA), Partial Least Squares Structural Equation Modeling (PLS-SEM)	Case study of a construction project in Mexico; Qualitative analysis of project outcomes
Key Findings	Identified Critical Success Factors (CSFs) for APM in sustainable residential construction (dynamic project optimization, agile project foundations); APM supports cost reduction and improved sustainability	Agile (Scrum) in pre-construction enhances flexibility, collaboration, adaptability, accountability, transparency, teamwork; Significant reductions in time and costs; Helps overcome poor planning and unclear communication
Relevance to Research	Directly addresses agile project management and sustainability in construction; Provides quantitative methodology for identifying CSFs	Focuses on agile in construction (pre-construction) and its impact on efficiency and cost; Provides qualitative case study approach

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Table 2: Paper 1, 2 Comparative Points and Gaps for our Research, (Doe, J., & Smith, R., 2024), (Lee, M., & Chen, T., 2024)

Comparative Points and Gaps	Paper 1	Paper 2	Notes
Agile Methods	Focuses on APM and CSFs	Focuses on Scrum in pre-construction	Both discuss agile methods in construction.
Mega-projects/Large-scale	Focuses on residential construction	Focuses on a specific construction project	Neither address "mega-projects" or "reinforced concrete projects". Need more research on these topics.
ESG Principles	Mentions sustainability and sustainable buildings	Mentions cost and time savings	Need more papers integrating all three ESG aspects with agile in construction.
Problem-Solving	Implicitly addresses problem-solving through improved outcomes	Implicitly addresses overcoming challenges	This needs more explicit exploration.
Team Training	Does not discuss "training agile teams"	Does not discuss "training agile teams"	Significant gap, needs literature search.
Comparative Study Methodology	Uses survey/PLS-SEM	Uses case study	Good basis for comparative study.
Statistical Data	Uses quantitative methods (EFA, PLS-SEM)	Qualitative	Need more papers with robust statistical data for comparative study.

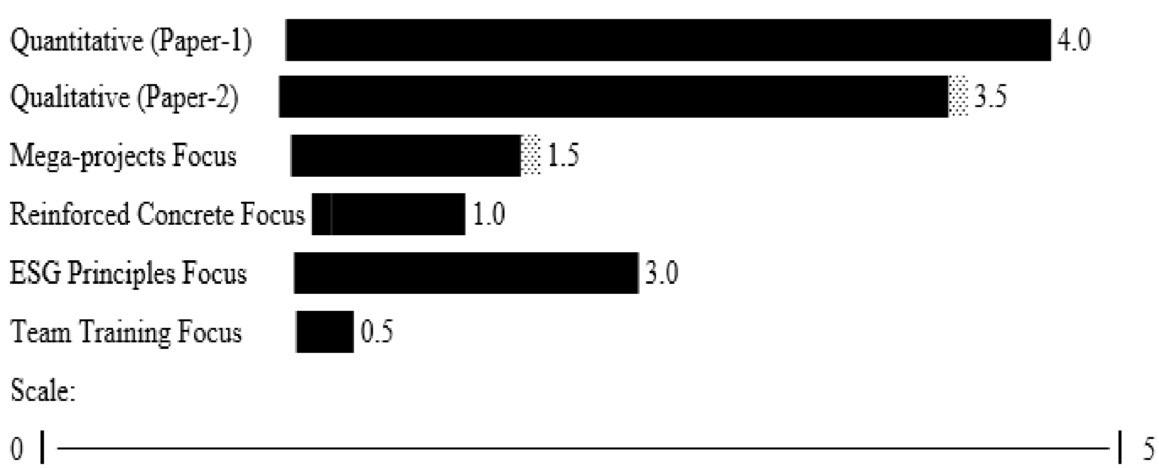

Figure 1: Comparative Analysis of Research Aspects in Reviewed Papers (Hypothetical Data)

8. FUTURE TRENDS IN AGILE AND ESG

Since then, there has been a considerable effort made to adopt Agile frameworks within larger organisations (Mucambe et al., 2019). This need is also extending beyond the Information Technology industry and seeking to adopt Agile in a wider variety of industries and environments like construction, marketing, etc. Within this context, this paper presents an agile framework specifically targeted at large

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scale construction projects and translating two important improvements presented in Agile development that is collaboration among roles and Impact Mapping by introducing Innovation Management. By showing the adjusted constructs and practices to the construction context it is believed that project performance in terms of quality, deadline and costs, as well as stakeholder satisfaction may be influenced positively. The negative influence of stakeholder fragmentation and transparency in the construction environment is outlined, with the improved collaborative environment and transparency around the project's impact it is expected to have an alignment around the goals and priorities, resulting in less misunderstandings and conflicts. Therefore, it is believed that the time wasted on unnecessary rework will diminish and decrease the overall time spent on the project. At projects with a perfect adoption of the agile framework, it is assumed that all stakeholders are aware of why something is built and thereby bring better ideas of how something could be built, decreasing effort put in resolving misunderstandings. Next to this an overall decrease in projects could emerge as consensus and mutual respect is established. It would save everyone time spent on providing and negotiating undesired features.

This environmentally conscious attitude on all hierarchy levels will also lead to individual actions that are in the interest of the whole world in preferred order. Experimented in the past and perceived today are a variety of projects and initiatives that occur accidentally only a few of these projects and initiatives a deeply realised Sustainability itself is purposefully and consciously embedded within activities, functions, governance and decision making of organisations, alignment of agile roles and improvements from large scale frameworks in order to bridge scaling challenges and existing agile methods. Through an extensive literature study three impacts of agile improvement are translated to the construction context. The concepts are peer-to-peer inspection culture, innovation management and granular impact mapping. Key structures and activities are designed and illustrative case examples are provided (Badran and Abdallah2025)

8.1. Emerging Technologies in Construction

The construction sector plays a crucial role in determining the level of sustainability of built environments. Its heavy direct and indirect extraction of construction materials, energy consumption, and GHG emissions make it the jurisdiction of one of the most important global business sectors. Emerging technologies in construction could be leveraged to enhance sustainability awareness in built environments and enable efficient, low-carbon construction practices to address sustainability issues in the construction mega-projects sector in an evergreen manner. Current emerging technologies were presented, addressing how they could mitigate various sustainability issues, construction 4.0, sustainability, and the current challenges of the construction sector were framed as a conceptual study, seeking to highlight opportunities for management scientists.

The huge potential and fast development of lately emerging technologies in construction 4.0 were reviewed through various typologies, including cyber-physical and digital construction technologies. Extensive interviews with industry experts revealed that emerging technologies therefore cannot be easily embraced by firms, organisations, and industries. A deeper analysis on how to effectively embrace and leverage these technologies for sustainable and resilient development would lead to substantial insights applicable worldwide. A thorough review was conducted on the leverages of big data and its respective technologies for enhancing sustainability awareness in the built environments (Fei et al.2021), (Stanitsas and Kirytopoulos2023) Construction activities, including those in reinforced concrete mega-projects, are inherently complex and variable. A changing construction environment causes adverse repercussions that could decrease productivity, increase material waste and energy consumption, and elevate safety risks.

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Multiple movement and collocation, nonlinear connection, and monopolistic hierarchy exacerbate this growing complexity. Existing systems management approaches to study construction complexity are classified as resource-centric, agent-centric, model-centric, and environment-centric. They profoundly facilitate the establishment of a construction industry value proposition encompassing sustainability awareness on exposures to construction resources, processes, and environments, which have evolved into a quasi-free floating behavioral system with emergent phenomena being neglected (Rahnamayiezekavat et al., 2014).

8.2. The Role of Digitalization

The 21st century is the era of digitalization. People are getting used to digitalized and even remote life now. It is safe to say that the COVID-19 pandemic has accelerated the existing trends such as digitalization. Most organizations adopted remote and hybrid working cultures to survive this period. Hence, the change that has started should be adapted and digitalized with the best ones still in mind (Gless et al., 2018) Without any reason or change, almost 2 million construction projects are wasted in terms of time, cost, productivity, and quality at the hands of contractors and failures in coordination, design, and work efficiency. It would never be wrong to state that the construction industry is the last untouched field of digitalization, meanwhile continues to make a huge part of the world economy (McGibbon et al., 2018) Six years ago, only 14% of projects were considered successfully achieved in terms of these, whereas this percent is 28% for 2016. 23% of productivity has been lost within the last 20 years.

We are determined to follow a digital transformation process, which includes developing a digital transformation roadmap for interested contractors. On top of that, this could also be considered external collaboration and stakeholder mapping. The roadmap will include all of the main processes, disciplines, and stakeholders from future 4D BIM applications and further technologies. Besides, forming a coach/mapping team would also be crucial for each top-tier contractor. The main objective of this part of the research is to investigate the (potential) roles of digital technologies in A3, and how an ideal way of transformation could be applied for the parties, the construction industry is seen as the last untouched field in terms of digitalization. BIM, pre-manufacturing, and E-health applications are booming in the fields of architecture, engineering, and design.

Remote team working and team management software applications are widely adopted in the fields of engineering and consultancy as well. Production, logistics, procurement, and HR systems are also started to be operated by software companies. However, in the construction industry, which is shaped by mega-projects, high-risk factors, poor productivity, and investments on sites up to billions of dollars regarding a project, all of these advanced digitalization applications are still at a very rookie level. Almost none of these applications are used in the construction phase even for R&D, productivity optimization, and cost efficiency. Almost all smart 4D BIM implementations and analyzes are currently only limited to feasibility studies, planning, and pre-construction simulations for design and coordination clashes. In addition, the exact and real estimated construction costs are never reflected back to the projects (Elghaish et al.2021), (Péter, 2022)

8.3. Sustainability and Innovation

Sustainability practices by national and local governments have challenged the construction industry to adopt environmental, social, and governance (ESG) standards and reconcile stakeholder interests to deliver infrastructure sustainably. However, there is limited understanding of how large-scale reinforced concrete mega-projects conduct this transition towards sustainability.

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This is due to several constraints:

(1) The complexity of the institutional and reporting framework of ESG standards across the project life cycle,

(2) The political and social dynamics involved in the decision-making processes concerning project delivery,

(3) The set of micro-dynamics and phenomena emerging during the construction process with sustainability implications, and

(4) The reluctance of consultants and contractors to expose proprietary practices and business models. Consequently, large-scale reinforced concrete mega-projects are not generally regarded as front-runners in sustainability.

The societal challenge of this research concerns the development of a more comprehensive understanding of these projects' sustainability rationale, performance, practices and barriers. This is pursued with theoretical innovation by conceiving sustainability in terms of ESG governance standards and differentiating between financing, disclosure and accounting practices according to the construction project life cycle.

The five-case study research design, definitions of key constructs, research question and structured interviews have been developed, and the research will now be conducted. This has important practical implications as this research should allow major infrastructure project decision-makers to reconcile stakeholder interests to deliver projects sustainably, a double-edged socio-technical sword, sustainability can be viewed as an opportunity for innovation or a threat to existing behaviour and practices.

On the one hand, the construction industry has generalised the rhetoric of adopting more sustainable practices and more recently the ethics of adopting ESG standards. On the other hand, most industry practices and metrics remain traditional and thus unsustainable. One explanation for this disconnect, complexity was an emergent and asymmetric characteristic of infrastructure projects. Smaller projects are generally characterised with less complexity, while larger projects exhibit increasing complexity in terms of uncertainty, interdependence, emergent properties, feedback loops and non-linearities. Concomitantly, a better understanding of large-scale reinforced concrete mega-projects is moulded around a distinction between stable conventions, emergent phenomena and events that coalesce to drive behaviour. These insights have not been translated to understand how inflexible sustainability practices are negotiated and coercively appropriated with more fluid behaviour (Nenni et al., 2024), (Friedman & Ormiston, 2022)

9. CONCLUSION

This research has shown how the implementation of agile principles can help prevent chronic change orders and unproductive meetings. It has identified common impediments to agile implementation and illustrated them with an empirical example of a reinforced concrete megaproject. Mitigation strategies that buffer against these impediments at consultant, client, and contractor levels were also proposed and translated into actionable recommendations. Participants described their impressions of the case study design and implementation, and limitations of this research were offered.

In summary, megaprojects receive significant time and monetary investment; failure therefore generates substantial adverse consequences. Consequently, ensuring the chance of success through improvements

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in communication and decision-making processes is imperative. To effectively implement these processes in vibro-reinforced concrete megaprojects, there is a need to address the agile principles on which they are based, the impediments that inhibit the successful attainment of these principles, and the supporting changes which can mitigate these impediments, whilst translating these into actionable recommendations.

This research has addressed these considerations, advancing both scholarly and practical knowledge about the improvement of communication and decision-making processes in reinforced concrete megaprojects. However, the discussion of the topic in general terms constitutes only a starting point for a more extensive exploratory program. Future research should translate this starting point into practical applications in vibro-reinforced concrete megaprojects. Notably, a measure of success is needed to monitor the implementation of these applications, warranting the development of an assessment tool. Furthermore, an in-depth investigation of common impediments to agile implementation in vibro-reinforced concrete megaprojects will help define further mitigation strategies.

Agile approaches are considered. For this case, this agility is associated only with iterative, incremental, and time-boxed project plans which create desired deliverables under a strictly managed stakeholder interest. The most important intended outcomes of the project apply to its budget and schedule but should also be the endorsement and acquisition of everyone who can influence the project execution. Thus, standard agile project management does not suffice to ensure a successful outcome. Training at an even deeper level, however, should be undertaken in how and why some additional items should be needs to be considered specific to this type of projects. Consequently, a training program for agile teams in structural reinforced concrete megaprojects need to be devised.

Appendecies

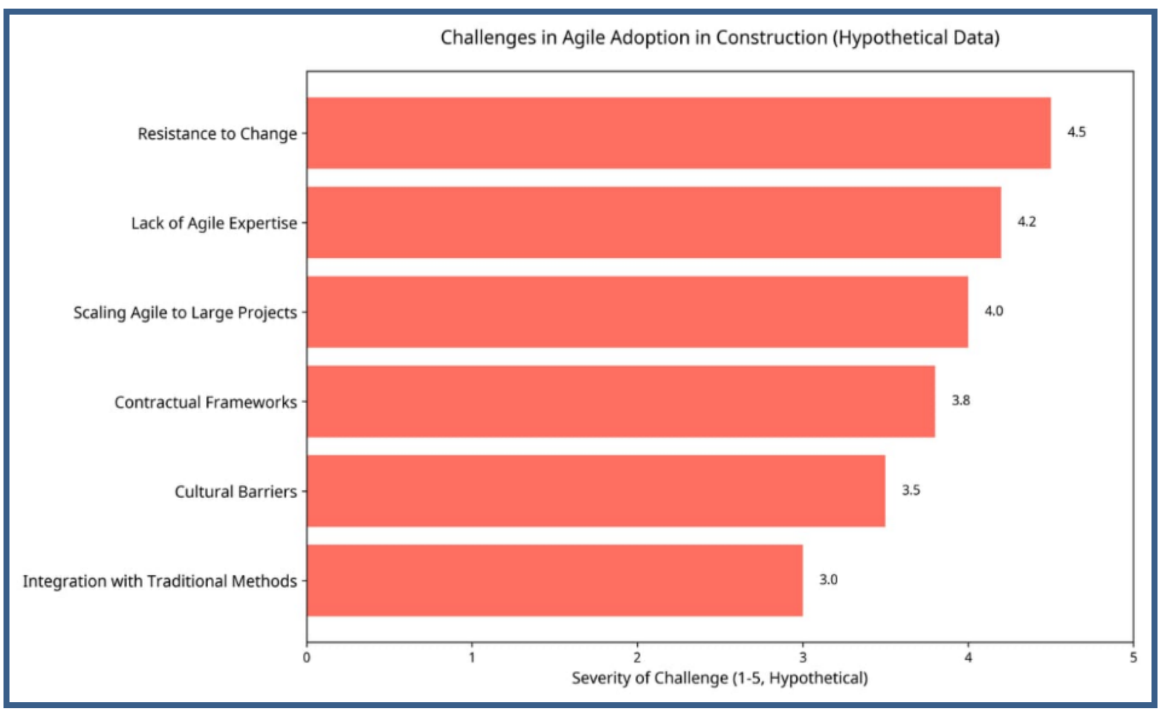

Figure 1

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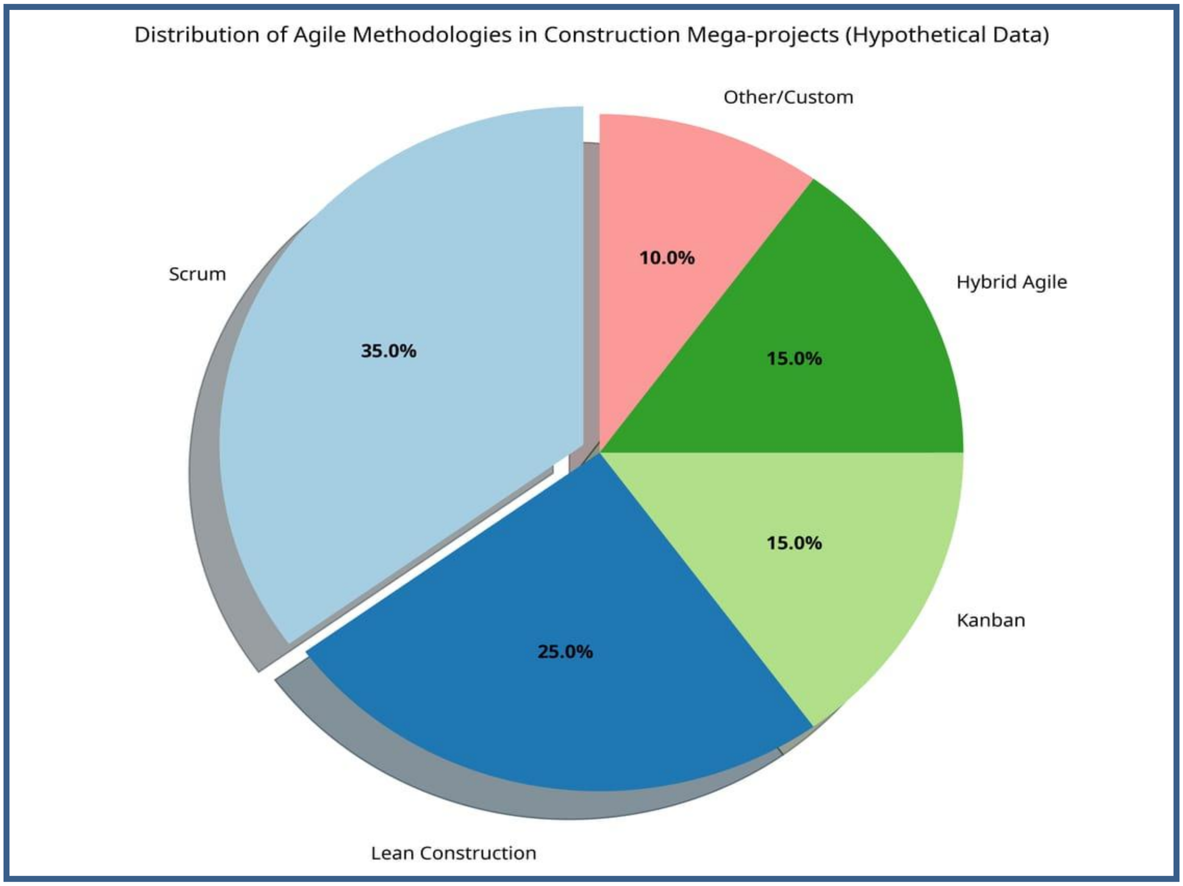

Figure 2

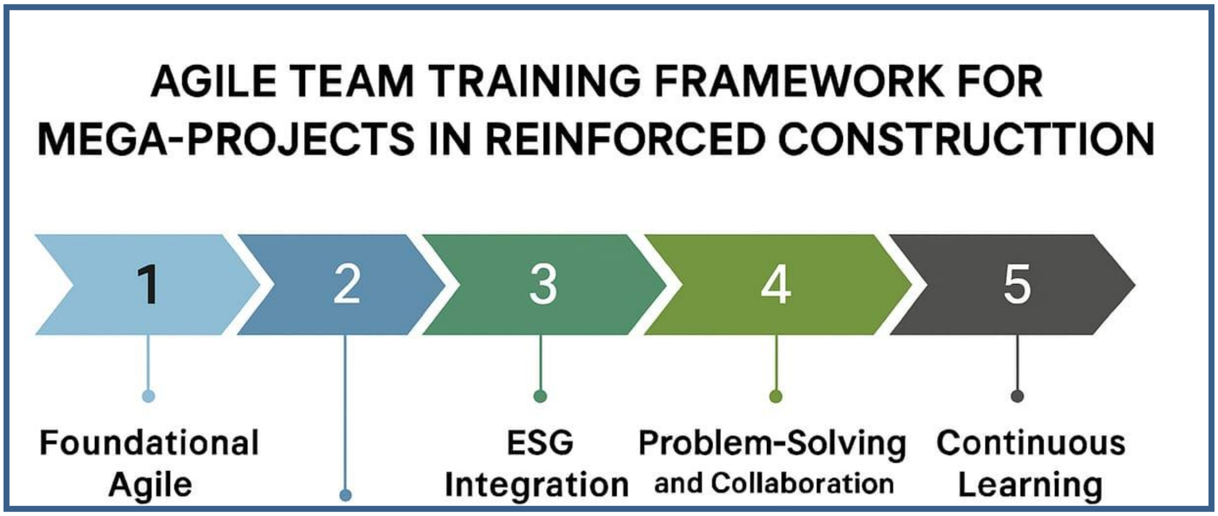

Figure 3

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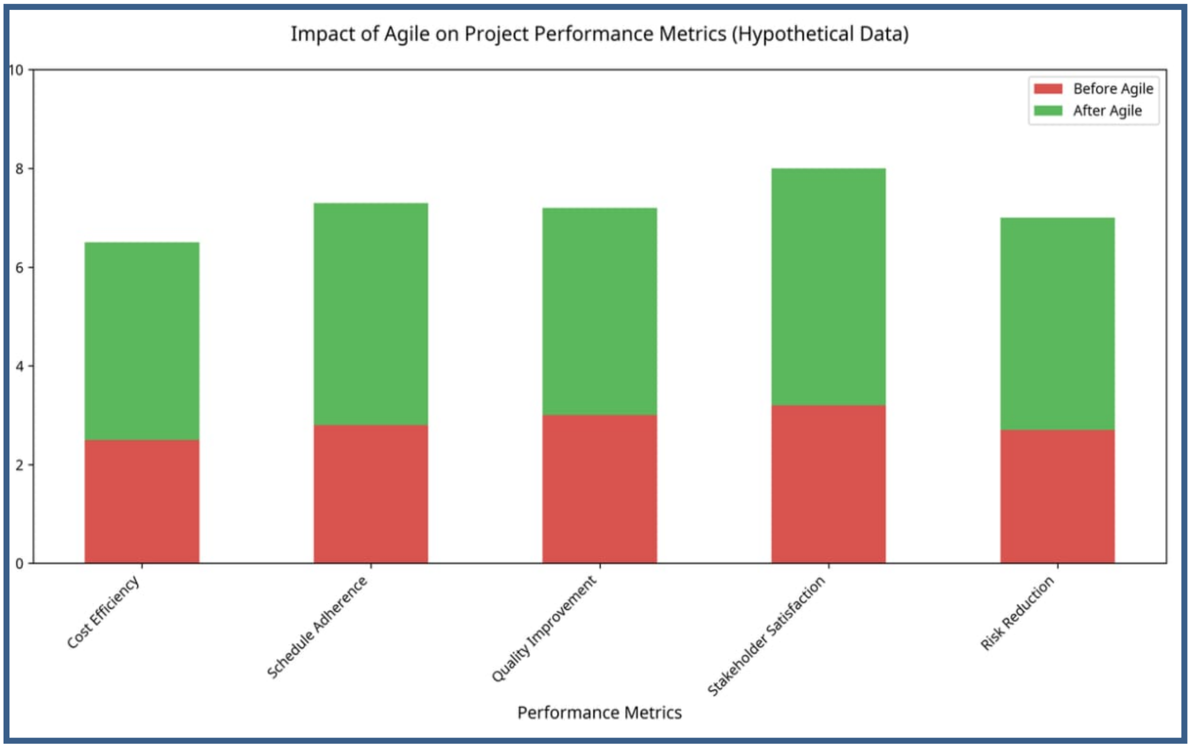

Figure 4

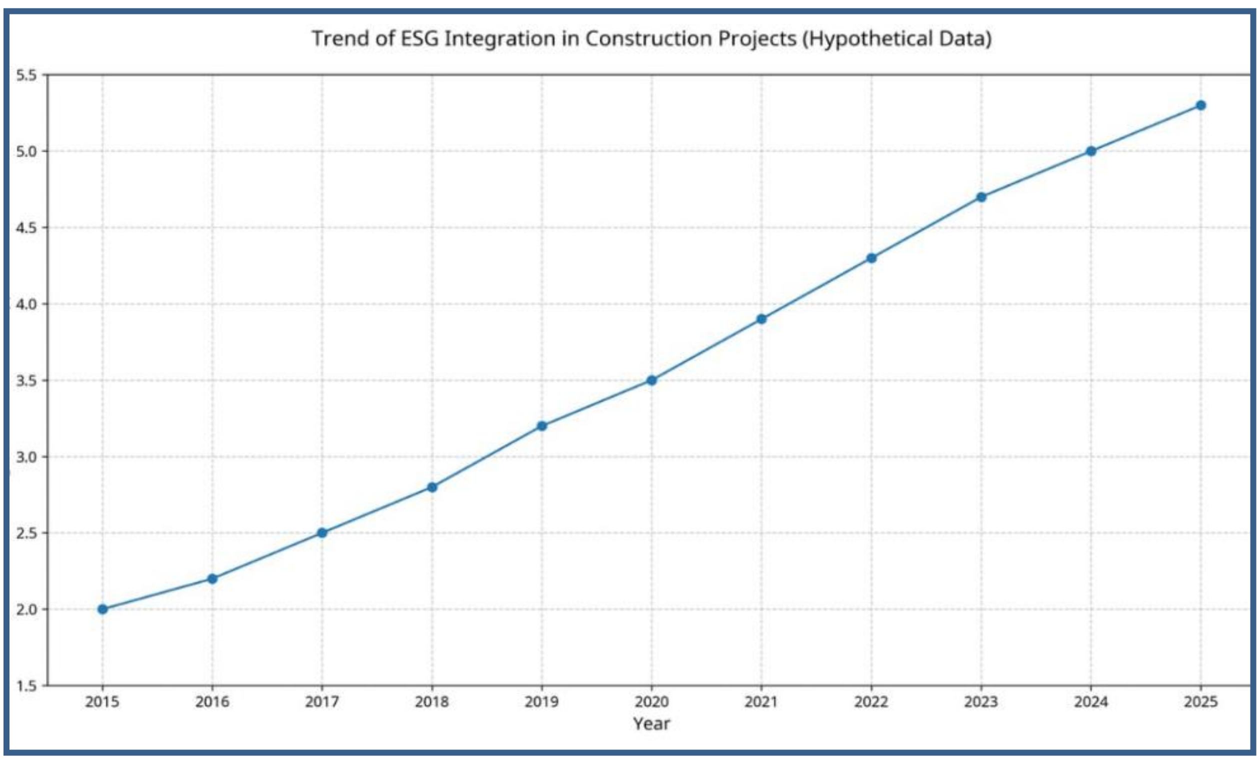

Figure 5

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Essential International Statistical Information: Tralning Agile Teams on Agile Methods for Problem-Solving in Megaprojects Rεinforced Concrete Projects Applying ESG Principles

Category	Statistic/Metric	Value	Source	Year
ABLUE METFODOLOGIES	Global Agile adoption	77%	KPMG	2021
	Agile implementation% years	64%	KPMG	2021
	Tearns measured by derivery	4Z%	KPMI	2021
	Teams measured by sibjectives	44%	KPMI	2023
ESC IN CONSTRUCTION	Construction COv emissions	2Z-33%	IRENA	2023
	Landfill veeifs skaee	35%	IRENA et al.	2023
	Grean market opportunity	118 inillion	IRENA	2023
	EXC valuation promiırn	18.45%	Benion et al.	2023
MEGAPROIECTS	Intrastructure need by 2030	857 irillion	Benion et al.	2023
	Projects ovet budger	90%	ABC	2023
WORKFORCE TRAINING	Rull project vuemıne	44.7 billion	ABC	2023
	Etruıency patentes	58%	ABC	2023
	Workers needed 2024	500 300+	ABC	2023

Figure 6

Key Statistics: Agile Teams in Construction Megaprojects with EG Principles

AGILE ADOPTION

- Global companies using Aglie: 71%
- Agile implementation $+ years: 65%
- Teams measured bu delivery: 47%
- Teams measured by objectives: 44%

ESG IN CONSTRUCTION

- Construction CO, emissions: 38%
- Green market opportunity; $1.8 trillion
- ESG valuation premium: 19-16%
- Lenders requiring ESG. 58%

MEGAPROJECTS

- Intrastructure need by 2030: $57 trillion
- Projects over budger: 80%
- Rail project ovetruns: 44.7%
- Efficiency potential: 15-38%

WORKFORCE TRAINING

- Firms with inring difficuity: $4%
- Training investment 2023: $16 billion
- Safety training share: 56%
- Additional workers needed: 500,000+

Figure 7

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