TO ENHANCE THE PRODUCTIVITY AND CONSTRUCTION SPEED USING COBOTIC TECHNOLOGY

[1] Ms. Shreya Bhende, [2]Dr. Ashok More
[1] PG Student, Department of Civil Engineering, D. Y. Patil of College of Engineering, Akurdi, Pune
[2]Asso. Prof., Head of Department of Civil Engineering, D. Y. Patil of College of Engineering, Akurdi, Pune, Maharashtra, India
[1] abmore@dypcoeakurdi.ac.in
[2]shreyabhende1996@gmail.com

Abstract**—** Building has evolved from hand tools to machinery, with an increasing trend toward automation. Automation and robotics can improve construction efficiency, precision, and safety. Structured prefabrication for construction, on the other hand, is gaining popularity globally as a way to increase productivity and reduce environmental impact. The construction industry may benefit from the integration and application of automation and prefabrication technologies. Automation in structural prefabrication and construction: current advancements, issues, and future prospects. The five processes are design, construction management, robotic production, self-driving transportation, and automatic structural assembly. The paper concludes that widespread automation technology is preferable to structural prefabrication for construction, and that connection innovations can help reduce complex operations and thus improve robotic assembly processes.
Thus, in the construction industry, many machines can be used to reduce human effort, lower labour costs, and increase work productivity. Automation in construction should be increased in India where infrastructure development is possible.

I. INTRODUCTION

The construction process of any building includes several stages, ranging from earthworks to structure construction (concreting, frame assembly, walling, and so on) to finishing works. Construction technologies used in these stages have traditionally been recognized as labour intensive and carried out in a variety of hazardous settings. Furthermore, issues such as labour supply volatility and rising labour prices are emerging in the construction industry. It is possible to reduce labour dependency and increase productivity on construction sites by implementing specialized automation. As a result, many researchers have been working hard to find appropriate ways to incorporate automation and robotics into construction sites.
On-site construction is utilizing automation and robotics technologies. Automation and robots provide a number of benefits in construction job execution that may aid in the adoption of these systems.
Objective of the project is, To study the enhancement in work productivity and construction speed using automation and cobotic technology.

Among the most important advantages are:

Less reliance on direct labour – fewer issues with quality and repetitiveness of work performed, as well as costs, may be reduced by reducing labour, whereas the automated system requires fewer operators;

Increased productivity – productivity is improved by removing the operation from the constraints imposed by the human factor; iii. increased occupational safety – automated systems can perform a wide range of tasks;

Improved quality – operations with automated and robotic systems typically have less variability than human workers; v. greater control over the productive process – problems can be detected more easily because each stage of the process is controlled to ensure the correct outcome.
Today, a new branch of construction technology - space construction - is rapidly expanding. In this area of construction work, there are several well-defined schemes that are equally applicable to hazardous construction activities in civilian applications. It is also possible to investigate them for use in specific building applications by selecting the appropriate materials while keeping the desired level of safety, cost, and procurement options in mind. For example, the concept of In-Situ Resource Utilization (ISRU) could be applied to both civilian and military robotics. Consider the lunar concrete scenario to visualize an ISRU concept. According to NASA and other space exploration roadmaps, there are plans to deploy a manned lunar exploration expedition and develop infrastructure on the Moon. This necessitates several steps.

Figure1.1: Human interaction between Cobots

Areas of automation in Construction

- Roads and Runways construction
- Structures
- Buildings construction
- Ports
- Tunnels
- Factories and industries

On-site construction, building maintenance or control after completion, and eventual dismantling or demolition of the building are all possible applications for automation and robotics technologies in construction. Automation and robotics are used in all stages of construction, from design to completion, from cost estimation to project management. The use of automation and robotics in construction varies greatly from project to project.

A reprogrammable multi-functional manipulator designed to move material, parts, tools or specialized devices," says the Robot Industries Association (RIA). A robot is a programmable machine that can process human characteristics like judgment, reasoning, learning, and vision.

Intelligent robots respond to changes in their environment via sensors linked to their controller. Human safety is a major consideration when using a robot in the workplace.
A robot with sensors that detect an obstacle or a human worker in its workspace could automatically shut down to protect itself and/or the human worker.

How can cobots be used?
Cobot is small, light, and easy to assemble. The Cobot can work in small spaces and is mobile.
You could, for example, mount this collaborative robot on a mobile workbench and move it around, but a robot can also stay in one place for longer.

Who are COBOT?
Traditional industrial robots are built and programmed to do a single task away from human workers. They are often used to process large batches of single items: welding, drilling, spray application (paint, adhesive), transporting items across an area, loading and unloading heavy items. They are large, heavy, fast, and strong, making them dangerous to humans and requiring fencing or other barriers. Traditional industrial robots work in parallel, not in collaboration, with humans.
The task performed is less important than the features of the robot that make it safe and useful for working alongside humans. In a work cell, station, or bench, a machine and a person can work on the same task, assembly, object, or activity.
There are several "off-the-shelf" collaborative robot options to suit a variety of needs. Accessories and tools like vision cameras, suction cup grippers, and welding tips can be added to most cobots (check out this example from Universal Robots on the right). No longer is it necessary to build a large, dedicated machine from scratch to use a robotic arm.

Unlike older-style caged robots, collaborative models can be mobile multi-takers. They are portable and can be moved around the factory floor or facility. Operators can quickly switch between tasks once they arrive at their new location. Many models can be programmed to perform new tasks by hand-guiding the arm through the steps. For small and medium-sized manufacturers, especially in high-mix/low-volume and JIT environments, this flexibility is vital.
Cobots also have built-in controls for safe operation. Included are programmable speed zones, collision avoidance, and sensors that stop the machine when a hand or other object enters an unexpected area.
A Cobot assistant can help with safety and ergonomics. Worker ageing, dexterity loss, and effects of standing, lifting, or twisting earlier in a shift are relevant. It also allows users to perform tasks while seated, programme the robotic arm to do a task, and adjust settings based on computer data. Then you can expand your manufacturing workforce.
Rather than completely replacing human workers, cobots usually integrate into repetitive or dull processes where errors or injuries can occur.

- Pick and place
- Packaging and palletizing
- Process tasks, when equipped with end effector tools (e.g. drilling, welding)
- Finishing (sand, polish, trim)
- Quality inspection, when equipped with a vision camera
- Assembly
- Dispensing (e.g. adhesive, lubricant, sealant)
- Painting, coating, dipping

Constructing, operating, and maintaining buildings and engineering structures is all part of the construction automation life cycle. Computer science and robotics advancements have aided in the development of new construction technologies. Japanese robotics and automation innovations have helped the construction industry reduce human labour, lower construction costs, and shorten project timelines while increasing productivity.

II. LITERATURE REVIEW

"Success factors for introducing industrial human-robot interaction in practice: an empirically driven framework", Tobias Kopp & Marco Baumgartner & Steffen Kinkel, The International Journal of Advanced Manufacturing Technology, 9 December 2021[1]
In recent decades, automation employing industrial robots has been a driving force in businesses, resulting in an ever-increasing number of robots being implemented in factories. However, the research agenda in the past view years has focused on developing smaller lightweight robots which enable direct interaction with without the requirement for physical separation between humans
Research that focuses on practically relevant factors to guide HRI (Human Robot Interaction) research, inform cobot development, and support companies in overcoming apparent barriers.
Keywords: Industrial human-robot interaction, Collaborative robots, Success factors, Human-robot collaboration, Empirical research, Framework

“"A study of Cobot manufacturing investment in the manufacturing industry", SANDRA AUDO, School of Innovation, Design, and Engineering, 2021[2]
A collaborative robot is something of growing interest for companies in the manufacturing industries to implement. However, a collaborative robot is quite new in today's market. An issue that there is currently no process for implementing collaborative robots.exists today, as well as no requirement guide for skills, as well as actors, has been defined.
To examine how an implementation process of collaborative robots in manufacturing companies could look like. Focusing on charting the integration process steps of a collaborative robot, and identifying the actors as well as skills needed for successful Cobot integration, with the aim achieve the goal
Keywords: Collaborative robot, cobot, Human-robot interaction, Human-Robot Collaboration, Development strategies, Automation, Industry 4.0

"Modeling and Control of Collaborative Robot System using Haptic Feedback" Vivekananda Shanmuganatha, Lad Pranav Pratap, Pawar Mansi Shailendra singh, Advances in Science, Technology and Engineering Systems Journal, 2017[3]
New research inquiries in human-robot collaboration. We have created a system capable of independent tracking and table-best protest object manipulation with humans and we have actualized two different activity models to trigger robot activities. The idea here is to explore collaborative systems and to build up a plan for them to work in a collaborative environment which has many benefits to a single more complex system
In the paper, two robots that cooperate among themselves are constructed. The participation linking the two robotic arms, the torque required and parameters are analyzed. Thus the purpose of this paper is to demonstrate a modular robot system which can serve as a base on aspects of robotics in collaborative robots using haptics.

Keywords: Multi Robot Systems Collaborative Robot Systems Kinematics Dexterous manipulation Haptics Telerobotics Human-Machine Interaction

"Cobot Programming for Collaborative Industrial Tasks: An Overview" Shirine El Zaataria , Mohamed Mareia , Weidong Lia , Zahid Usman, Robotics and Autonomous Systems, Research Article, June 2019[4]
In this paper, an overview of collaborative industrial scenarios and programming requirements for cobots to implement effective collaboration is given. Then, detailed reviews on cobot programming, which are categorized into communication, optimization, and learning, are conducted. Furthermore, a considerable gap between cobot programming used in industry and research is observed, and research aimed at closing the gap is identified. Finally, prospective extensions and improvements of cobots for industrial collaborative settings are discussed. **Keywords**: Human-Robot Collaboration, Intuitive Programming, Human-awareness, Cobot

"Safety Design Method for Interactive Manufacturing System" TSUKIYAMA Kazunari and TAKETA Saori, Omron Technics, 2021[5]
The usefulness of a new strategy for efficient safety design of an interactive manufacturing system is investigated in this research. First, applications of the interactive manufacturing systems were analyzed and a new concept of consecutive application was created. The approach for selecting the most relevant safety criterion as a basis for safety design was then established using this concept. Furthermore, the efficiency of a method for systematic hazard identification and calculation of the requirement for risk reduction was investigated.
Research of these methods, designers can demonstrate safety of the interactive manufacturing system that adequate cost and user-friendly system.
Keywords: Safety, Risk, Cost, user-friendly

"Collaborative manufacturing with physical human-robot interaction" Andrea Cherubini, Robin Passama, Andr´e Crosnier, Antoine Lasnier, Philippe Fraisse, Open Science 2017[6]
The results of a combined human-robot production cell for homo-kinetic joint assembly are presented. The robot alternates active and passive behaviour during assembly, to lighten the burden on the operator in the first case, and to comply to his/her needs in the latter. Our method successfully manages direct physical contact between the robot and the person, as well as between the robot and the surroundings. The results of a combined human-robot production cell for homo-kinetic joint assembly are presented. The robot alternates active and passive behaviour during assembly, to lighten the burden on the operator in the first case, and to comply with his/her needs in the latter.
Keywords: Cobots, Industrial robotics, Human-Robot Interaction, Reactive and Sensor-based Control

"Cobot Studio VR: A Virtual Reality Game Environment for Trans-disciplinary Research on Interpretability and Trust in Human-Robot Collaboration", Martina Mara, Kathrin Meyer, et.al., Research Article, 2021[7]
This paper describes the Cobot Studio research environment's features and system architecture, shows an initial application, and analyses the methodological merits of using immersive VR games for human-robot collaboration research.
Human-robot collaboration, industry, virtual reality, interpretability, intention signalling, trust, multimodal communication, and digital twins are some of the terms used in this paper.

Keywords: Human-robot collaboration, industry, virtual reality, interpretability, intention signaling, trust, multimodal communication, digital twin

"Collaborative or Simply Uncaged, Understanding Human-Cobot Interactions in Automation" Joseph E Michaelis, Amanda Siebert-Evenstone, David Williamson Shaffer, Bilge Mutlu, CHI 2020, April 25–30, 2020, Honolulu, HI, USA, 2020[8]
Our thematic analysis revealed that, contrary to the envisioned use, experts described most Cobot applications as only low-level interactions with little flexible deployment, and experts felt traditional robotics skills were required for collaborative and adaptable cobot interaction
Finally, we offer design suggestions for future robots, including programming and interface designs, as well as instructional systems to facilitate collaborative use.
Keywords: Human-robot interaction (HRI); human-robot collaboration; collaborative robots; end-user programming; educational technology; technology adoption

"Design Guidelines for Collaborative Industrial Robot User Interfaces" Helena Anna Frijns, Christina Schmidbauer, Research Article, August 2021[9]
Author proposes a set of design guidelines for cobots based on existing literature on heuristics and cobot UI design. The guidelines were further developed on the basis of modified heuristic evaluations by researchers with robotics expertise, as well as interviews with cobot Experience design experts. The resulting design guidelines are intended for identification of usability problems during heuristic evaluation of the UI (User Interfacing) design of cobot systems.
The design of robots and accompanying user interfaces for collaborative industrial robot systems (cobots) is the subject of this study. Cobots are systems that are intended for collaborative operation, i.e. the concurrent execution of tasks by human and robot in the collaborative workspace
Keywords: Human-Robot Interaction, Human-Robot Collaboration, Collaborative Robots, Design Guidelines, Heuristic Evaluation, User Interface Design

"Human–Robot Collaboration in Manufacturing Applications: A Review" Eloise Matheson, Riccardo Minto, Emanuele G. G. Zampieri, Robotics, MDPI 6 December 2019[10]
The study begins with an overview of human–robot collaboration, including standards and operational modes. An detailed review of publications published in this field is conducted, with special attention paid to the principal industrial application instances. The report continues with an analysis of the authors' predictions for future trends in human–robot collaboration.
Keywords: Cobots; human–robot interaction; literature study; collaborative robotics

"Teaming with industrial cobots: A socio-technical perspective on safety analysis" A. Adriaensen, F. Costantino, G. Di Gravio, R. Patriarca, Human Factors and Ergonomics in Manufacturing & Service Industries, 5 September 2021[11]
The goal of this paper is to look at current approaches to Cobot safety and illustrate how they might benefit from systems thinking methods as well.
This exploratory research component is designed to overcome an unduly restricted view of safety issues, anticipating the obstacles that would arise in increasingly complex Cobot applications.
Cobot applications can only be operated safely if the design, training, and operation of the apps are all in sync.

Each of these strategies adds value to the traditional understanding of risk that is required by present and future industrial Cobot implementations. Systemic solutions have the potential to make cobot operations safer and more efficient in revealing the distributed and emergent result from joint actions and overcoming the reductionist view from individual failures or single agent responsibilities.
Keywords: collaborative robots, cobots, EAST, FRAM, functional allocation, levels of automation, socio- technical systems,

"Human-centered Design of an Interactive Industrial Robot System through Participative Simulations: Application to a Pyrotechnic Tank Cleaning Workstation" David Bitonneau, Théo Moulieres-Seban, Julie Dumora, Research Article, 26 Dec 2017[12]
We propose a humancentered approach to improve the introduction of collaborative robots in the industry. Safran and Airbus Safran Launchers are researching a variety of industrial uses. The first application of our work on a pyrotechnic tank cleaning workstation is presented in this study. The design of a solution is demonstrated via numerous simulation processes involving the workstation's operators. Our approach is illustrated with the design of a solution through several simulation steps involving the workstation's operators. In particular, the current design of a prototype based on a tele-operated robot is introduced.
Industrials are starting to deploy collaborative robots as new solutions to improve workstations
Keywords: Quality, Operations, Performance, Human-being, Workstations

Robots and COVID-19: Challenges in integrating robots for collaborative automation, ALI AHMAD MALIK[2020[13]
As the pandemic of COVID-19 started to surface the manufacturers went under pressure to address demand challenges. Because of the social distancing measure, fewer people were available to work. Robots were aimed at in such instances to assist people in addressing supply shortages. An important activity where humans are needed in a manufacturing value chain is assembly. HRC assembly systems are supposed to safeguard coexisting humans, perform a range of actions and often need to be reconfigured to handle product variety. During their operating life, they must be durable and adaptive to numerous configurations. Besides the potential advantages of using robots the challenges of using them in industrial assembly are enormous.
The current state of human-robot collaboration for assembly applications is discussed, as well as important contemporary problems for researchers and practitioners.
Keywords: Robot; Human-robot collaboration; Assembly; Challenges; COVID-19

Sensor-Based Control for Collaborative Robots: Fundamentals, Challenges, and Opportunities Andrea Cherubini and David Navarro-Alarcon, Open Access, January 2021[14]
This presentation will give a thorough evaluation of existing sensor-based control approaches for applications involving direct interaction between humans and robots, such as physical collaboration or safe coexistence. To that goal, we'll go over the basic formulation of the sensor-servo problem before presenting the most typical solutions: Vision-based, touch-based, audio-based, and distance-based control are all options.
Keywords: Control systems (CS), visual servoing, human-robot collaboration (HRC), human-robot interaction (HRI), robotics (VS)

Physical Ergonomic Improvement and Safe Design of an Assembly Workstation through Collaborative Robotics Ana Colim, Carlos Faria, Robotics Safety 2021[15]
The framework is divided into four sections: I characterisation of the initial situation, (ii) risk assessment, (iii) formulation of requirements for a safe design, and (iv) conceptualization of the hybrid workstation, including all normative implications. This methodology was applied to a case study in a furniture manufacturing company's assembly workstation. The findings suggest that the methodology used provides a solid foundation for faster design and development of new human-centered collaborative robotic workstations.
Keywords: human–robot collaboration; safe design; risk assessment; safety standardization; physical ergonomics; work-related musculoskeletal disorders; manufacturing.

A new generation of collaborative robots for material handling Ernesto Gambao, Miguel Hernando, Unpaid 2021[16]
As a demonstration of the suggested next generation of material handling methodology, a modular flexible collaborative robot prototype has been conceived and developed. This technology supposes a break with traditional paradigms regarding flexibility, cost, accessibility and applicability of high-tech handling solutions as well as conventional human-machine interaction. The architecture of the control system is hierarchical order control blocks. Because a collaborative robot is defined by genuine collaboration between human employees and intelligent assist devices, a comprehensive safety system has been established.
Keywords: Material handling, collaborative robots, modular robots, and construction robots are all keywords.

Automation in Construction, Elsevier, 2021[17]
The first part of this issue presents three review articles. Montero et al. discuss the past, present, and future of robotic tunnel inspection. who, after a comprehensive survey on robotic tunnel inspection, describe current efforts and outline future trends towards fully autonomous tunnel inspection. Bock in the second review foreshadows the future of construction automation, conceptualized in robot-oriented design, robot industrialization, construction robots, site automation and ambient robotics

Automation in construction industry it's application and barriers to implementation on construction site, Smit Rangani1, Jayraj solanki "International Research Journal of Engineering and Technology (IRJET), June 2020[18]
To study the how much amount of Automation is utilized in current construction industry and its future trends , and study which barriers are highly affect to apply in construction and how it can be minimized. To maximise resource value, intelligent and integrated control over all building activities is required. To develop and achieve the best possible construction quality, safety, profitability, and productivity.

Learning to share - Teaching the impact of flexible task allocation in human-cobot teams Titanilla Komenda, Christina Schmidbauer, David Kames, 11th Conference on Learning Factories, CLF 2021[19]
Cobots (collaborative robots) are essential for agile industrial manufacturing concepts and are seen as flexible and low-cost automation solutions. As a result, handling using Cobot technology, their industrial applications, and safety ideas are becoming increasingly important in factory designs. Thus, working with and evaluating the demonstrators hands-on, not only students and professionals, but also children, teenagers and the general public are able to explore the potential benefits, consequences and necessary preconditions within potential use cases.
Keywords: Task Allocation; Collaborative Robot; Flexible Task Sharing; Hybrid Manufacturing; Teaching Concept.

A Novel Integrated Industrial Approach with Cobots in the Age of Industry 4.0 through Conversational Interaction and Computer Vision Andrea Pazienza and Nicola Macchiarulo and Felice Vitulano, Science Direct 2019[20]

Robotic automation is undergoing a new trend that poses a substantial challenge for component manufacturers, ranging from robots that replace employees to robots that assist them. The contribution is the result of a unique vision that envisions a deeper collaboration between Cobots, which can perform a specific physical task with precision, and the AI world, which can perform a variety of tasks and provide information to aid decision-making, as well as the man who is capable of having a strategic vision of the future.

III. RESEARCH METHODOLOGY

In the dissertation following methodology has been decided to measure and manage the

- ✓ By operating advance technology (Application Of COBOT) at construction project reduce delay in transporting of material and increase efficiency of work that ultimately reflect of time and cost in construction Sector
- ✓ From literature found that because of frequent change of project managers, Appointment of staffs in the site who are not experienced and also Non sequential progress of works and that Work was not followed as per procedure instead it was followed as per availability of resources caused delays in construction project on pandemic situation
- ✓ Unavailability of adequately trained health workers and lack of experience in managing an unprecedented emergency; the pandemic and the confinement measures created a psychosocial burden for the population and, especially, the wellbeing of the health workforce.
- ✓ The construction industry is the vehicle through which physical development is achieved, and this is truly the locomotive of the national economy. The more resources, engineering know-how, labor, materials, equipment, capital, and market exchange provided from within the national economy, the higher the extent of self-reliance. The increasing complexity of infrastructure projects and the environment, within which they are constructed, place greater demands on construction managers to deliver projects on time, within the planned budget and with high quality.
- ✓ Therefore, improving construction efficiency by means of cost-effectiveness and timeliness would certainly contribute to cost savings for the country as a whole. Efforts directed to cost and time effectiveness were associated with managing time and cost.
- ✓ It also aims to identify the main factors that lead to project delays and to suggest recommendations on how to overcome or mitigate effects of the problem. Data is gathered from responses from questionnaire survey and interviews with those involved in automation construction project.

Step 1
- Literature Review
- Problem Statement
- Objectives

Step 2
- Actual Case study
- Primary Data Collection

Step 3
- Preparation of Questionnaire
- Data Collection
- Prepare Benefit cost & Time analysis for particular case study

Step 4
- Analysis of Data with SPSS Software
- Find Factor using RII method

Step 5
- Result and Discussion

Step 6
- Recommendations

Step 7
- Paper Presentation and report writing.

Step 8
- Submission and Approval of Dissertation

Figure1.2: Flowchart of Methodology

- ✓ The surveys and research findings indicate that delay incidents and Accidents occur mainly during the construction phase of a project and one or more parties usually contribute to delay. This paper highlights the importance of having more experienced and capable construction managers as well as skilled labourers to enable the industry to develop at a faster rate either nationally or internationally.
- ✓ A questionnaire and personal interviews have formed the basis of this research. Factor analysis and regression modelling were used to examine the significance of the delay factors. From the factor analysis, most critical factors of construction delay were identified.

IV. DATA COLLECTION

Cobot in Construction: Why Design it?

They are often described as "inherently safe." These are built-in safety features that make collaborative robots safer than traditional factory robots. The emphasis is on using these robots without cages or fencing, and with rounded edges and corners.

ISO 10218 provides general guidelines for robot designers and manufacturers to create human-friendly robots. ISO Technical Specification 15066 provides more specific guidelines and was updated in 2016 to reflect current technology. To ensure human safety, ISO/TS 15066 defines four major capabilities of a collaborative robot:

Stopped for safety (i.e., when the robot's safety parameters are triggered, it stops until explicitly restarted.)

Hand-guiding for "teaching" a step sequence When the robot is stopped, speed and force limits are set, and the operator selects hand guiding mode, positive confirmation is required.
Scanners for speed and (i.e. sensors are installed to track where a human is, and safety zones can be programmed so the robot operates at a certain speed within each zone)
Weaknesses of power and (including sensors that reduce the speed and force applied if a potential collision or force overload is detected; also design elements like rounded corners to dissipate forces on impact and ways to add sensors to robotic arm joints)
According to an article on risk assessment from Engineering.com, "One of the central ideas behind ISO/TS 15066 is that if robot-human contact is allowed, it must not cause pain or injury." Determining pain and injury, safe maximum operating speeds, and core robot capabilities to avoid contact are all part of this.

Solution
Automation is possible when working with industrial robots and using Cobot in construction. Notables include:
timing (material heating, parts queuing, etc.) – especially when an operator could be working elsewhere; Quality issues, such as frequent scrapping or rework, or operator inconsistency Human-only tasks vs. wasted labour Backups and bottlenecks Heavy tools or parts work slows workers throughout the shift. If-then logic (sorting) Processes that begin once paint/adhesive is dry to the touch. Jobs or areas in your facility with a history of mishaps; Activities involving repetitive motion and ergonomic issues, especially over time Tasks requiring sustained concentration or shifting attention.

A cobotization plan

End-to-end testing use cases require collaborative robots with visual, audio, and sensor capabilities. To help companies understand how to integrate cobot-based testing into a verification and validation ecosystem,

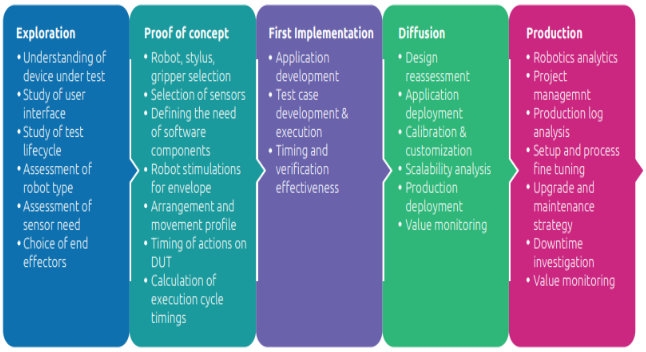

Figure1.3: Roadmap of Cobotization

Sources and Methods

We used open-ended questions to allow participants to elaborate on ideas generated during conversations. Interviews were sometimes conducted in pairs or groups of three to foster meaningful discussion. There were two interviews with the same company: one with engineers and the other with implementers.
There was also a three-person interview with an engineer, a worker, and the implementer who had installed and programmed the cobot at that company. As part of a Grounded Theory approach, the researchers reviewed and discussed each interview after each participant visit to refine and inform future interviews and compare potential themes. After six interviews, the authors agreed that saturation had been reached. A Reflexive Thematic Analysis was used to code each interview.
After familiarizing themselves with the interview data, the first two authors began generating codes based on the data. These two major themes emerged from iterative discussions: (1) cobots are used as uncaged traditional robots, and (2) experts believe worker training should focus on traditional robotics skills. The findings are organized around these themes.

VI. CONCLUSION

This research seeks to discover how automation is now used in construction and on-site labour. And the biggest road blocks to automation in the construction industry?
Literature reviews and case studies uncover barriers-related factors. Then survey questionnaires are created and data is analyzed using frequency analysis.
According to the Frequency analysis technique, the most significant barriers to automation in construction are high costs, firm size, and difficult to maintain technology. Workers' lack of technological understanding and difficulty using technology are among the lowest-scoring barriers.
The amount of site automation was found to be strongly related to the firm size, project size, and staff limit.
The study concludes that developing technologies that are easier to use and understand, as well as training programmes for workers and employees, will reduce barriers, while making technology more affordable to maintain and update will reduce barriers.
The use of automation technology in construction improved job quality, saved time, improved working conditions, increased safety, and increased productivity.
Due to the high complexity, nature of the development process, and technological advancements in development, a long-term plan is required. Modelers, specialists, and other members of the development team must work together in this technique. Short- and long-term automation will be improved and tailored to each application.
One of the benefits of implementing automation technologies is the need to increase productivity, worker safety, and job quality. Small and medium-sized businesses need automation in many areas.

REFERENCES

[1] "Success factors for introducing industrial human-robot interaction in practice: an empirically driven framework", Tobias Kopp & Marco Baumgartner & Steffen Kinkel, The International Journal of Advanced Manufacturing Technology, 9 December 2020.
[2] "A study on Cobot investment in the manufacturing industry", SANDRA AUDO, School of Innovation, Design, and Engineering, 2021.
[3] "Modeling and Control of Collaborative Robot System using Haptic Feedback" Vivekananda Shanmuganatha, Lad Pranav Pratap, Pawar Mansi Shailendra singh, Advances in Science, Technology and Engineering Systems Journal 2017
[4] "Cobot Programming for Collaborative Industrial Tasks: An Overview" Shirine El Zaataria , Mohamed Mareia , Weidong Lia , Zahid Usman, Robotics and Autonomous Systems, Research Article, June 2019

[5] "Safety Design Method for Interactive Manufacturing System" TSUKIYAMA Kazunari and TAKETA Saori, Omron Technics, 2021
[6] "Collaborative manufacturing with physical human-robot interaction" Andrea Cherubini, Robin Passama, Andr´e Crosnier, Antoine Lasnier, Philippe Fraisse, Open Science 2017
[7] "Cobot Studio VR: A Virtual Reality Game Environment for Trans-disciplinary Research on Interpretability and Trust in Human-Robot Collaboration", Martina Mara, Kathrin Meyer, et.al., Research Article, 2021
[8] "Collaborative or Simply Uncaged, Understanding Human-Cobot Interactions in Automation" Joseph E Michaelis, Amanda Siebert-Evenstone, David Williamson Shaffer, Bilge Mutlu, CHI 2020, April 25–30, 2020, Honolulu, HI, USA
[9] "Design Guidelines for Collaborative Industrial Robot User Interfaces" Helena Anna Frijns, Christina Schmidbauer, Research Article, August 2021
[10] "Human–Robot Collaboration in Manufacturing Applications: A Review" Eloise Matheson, Riccardo Minto, Emanuele G. G. Zampieri, Robotics, MDPI 6 December 2019
[11] "Teaming with industrial cobots: A socio-technical perspective on safety analysis" A. Adriaensen, F. Costantino, G. Di Gravio, R. Patriarca, Human Factors and Ergonomics in Manufacturing & Service Industries, 5 September 2021
[12] "Human-centered Design of an Interactive Industrial Robot System through Participative Simulations: Application to a Pyrotechnic Tank Cleaning Workstation" David Bitonneau, Théo Moulieres-Seban, Julie Dumora, Research Article, 26 Dec 2017
[13] Robots and COVID-19: Challenges in integrating robots for collaborative automation, ALI AHMAD MALIK,2020
[14] Sensor-Based Control for Collaborative Robots: Fundamentals, Challenges, and Opportunities Andrea Cherubini and David Navarro-Alarcon, Open Access, January 2021
[15] Physical Ergonomic Improvement and Safe Design of an Assembly Workstation through Collaborative Robotics Ana Colim, Carlos Faria, Robotics Safety 2021
[16] A new generation of collaborative robots for material handling Ernesto Gambao, Miguel Hernando, Unpaid 2021
[17] Automation in Construction, Elsevier, 2021
[18] Automation in construction industry it's application and barriers to implementation on construction site, Smit Rangani1, Jayraj solanki "International Research Journal of Engineering and Technology (IRJET), June 2020
[19] Learning to share - Teaching the impact of flexible task allocation in human-cobot teams Titanilla Komenda, Christina Schmidbauer, David Kames, 11th Conference on Learning Factories, CLF2021
[20] A Novel Integrated Industrial Approach with Cobots in the Age of Industry 4.0 through Conversational Interaction and Computer Vision Andrea Pazienza and Nicola Macchiarulo and Felice Vitulano, Science Direct 2019