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Adoption of Metaverse in the Indian Construction Industry: An Overview

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ABSTRACT

Technology is being adopted in various sectors worldwide at a significantly faster pace, especially since the COVID-19 pandemic breakdown as well as the subsequent lockdown, which has proved very beneficial in a lot of aspects. The ACE industry (architecture, construction and engineering) is a very labor-intensive industry by its nature and the adoption of technology has been at a slower pace than the other sectors. However, the intervention of technology in the industry is comparatively more unrushed. Construction is one of the longest-standing industries in India. Technology adoption in the construction industry in India has not been to the desired extent. A wider use of the Metaverse technology can be expected in the Indian construction industry if the companies appreciate its benefits. This paper aims to give an overview of the state of adoption of the Metaverse technology in the Indian construction industry. An analysis of the benefits that could be derived from technology adoption and the hindrances that are posing a setback for the adoption were achieved in this study. The benefits of Metaverse adoption are multi-fold with a wide range of activities beginning from design conceptualization, proposals, project planning, coordination, tracking work progress, training and many more.

Keywords: Metaverse; Construction industry; India; Architecture; Construction; Engineering

1. Introduction

The ACE industry in India is one of the oldest industries in the country as well as the largest employment generator, very labor-intensive and one of the prominent forces for economic growth. The con-

struction industry in the Indian market was valued at $609.8 billion in 2021 and is expected to achieve an AAGR of more than 6% during 2023-2026 [1]. India is regarded as a "sleeping giant" by one of the world's leading global construction economists, Graham Robinson. The economist as well predicted that by 2030, India will overtake Japan as the world's third-largest construction market as illustrated in **Figure 1** below. The Indian construction industry stands as the second-largest employer in the country, providing employment opportunities to around 49 million people. This industry is expected to become the world's third-largest construction market by 2025. The multifold population growth is a driving force for increasing demand for residential buildings and other infrastructures in the Indian construction market. Irrespective of such high growth and performance in the industry, companies sail very slowly in terms of technological adaptation [2]. In India, the construction industry consists of about 90% of small and medium enterprises (SMEs) that are deficient in investment in the ICT infrastructure and hence, it stays to be one of the least digitized industries.
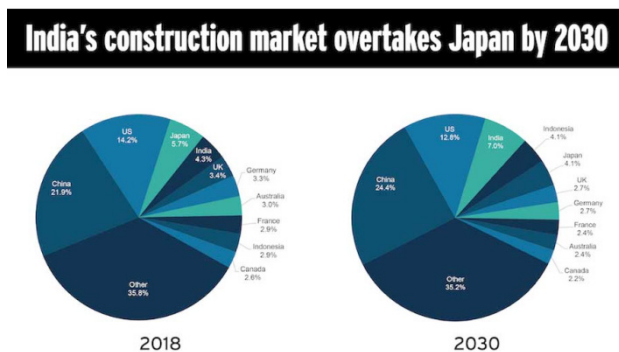

Figure 1. India's construction market overtakes Japan by 2030.

Source: Engineering news record.

Recently, the government of India also highlighted the importance of artificial intelligence (AI) to promote the vision of '**Make AI in India and Make AI Work for India**'. This further braces the need for adopting Metaverse in the construction industry.

The term "Metaverse" refers to a virtual reality space or a collective virtual shared space where users can interact with a computer-generated environment and other users in real time. It is often described as an immersive and interactive digital universe that may encompass virtual worlds, augmented reality, and the internet as a whole. Metaverse uses big technologies like augmented reality (AR), virtual reality (VR), blockchain, Artificial intelligence, the Internet of Things, and 3D reconstruction to enable the digital immersive interactive spaces to mimic the real world.

Metaverse adoption in the ACE Industry is way far behind compared to other industries such as healthcare, retail, etc. If the technology is adopted in the industry on a wider scale, "strong growth" can be witnessed in the next 5 to 10 years. In India, the Metaverse is likely to be a $1.1 trillion market by 2032, making it one of the fastest-growing markets in the world [3]. The global construction sector investment in the Metaverse is only 5%. Comparatively, the investment in India is evidently much lower.

1.1 Definition of AR, VR, MR, and XR

Understanding each of these technologies [4] is important to comprehend the Metaverse technology.

Augmented Reality (AR) enhances the real world by overlaying digital information onto it through a phone or a head-worn device, such as glasses or headsets which use cameras, sensors, and display technologies to blend the real and virtual elements

Virtual Reality (VR) experience is characterized by a sense of presence, where users feel as though they are physically present in the virtual environment. As users move their heads or bodies, the VR system tracks their movements and updates the visuals and audio accordingly to maintain the illusion of immersion.

Mixed Reality (MR) refers to a spectrum or continuum that encompasses both virtual reality (VR) and augmented reality (AR) technologies. It blends the virtual and real worlds, allowing users to interact with both physical and digital elements simultaneously in a merged environment to create a more seamless and integrated experience.

Extended Reality (XR) is a wholesome term that

is a combination of virtual reality (VR), augmented reality (AR), and mixed reality (MR). It refers to the combination of these immersive technologies and the spectrum of experiences they offer, including fully virtual environments, augmented environments, and blended virtual-real environments. It enables a range of experiences that span from complete immersion in virtual environments to overlaying digital content onto the real world and seamlessly integrating virtual objects with the physical environment.

1.2 The Metaverse

The term Metaverse was coined by Neal Stephenson in his cyberpunk novel, "Snow Crash" (1992). In the novel, he indicates a three-dimensional universe parallel to the real world, as well as mimicking individual movement, and interaction.

Extended reality (XR) refers to a combination of virtual reality (VR), augmented reality (AR), and mixed reality (MR). Metaverse technology refers to the ecosystem revolving around XR for a rich user experience. In simple terms, Metaverse is a collective combination of the virtual reality worlds, augmented reality, and the internet. It is a virtual setting empowering communication and interactions, and carrying out a variety of tasks among people (users), exactly mimicking the real world.

By 2025, the global Metaverse market could reach between $390 billion and $800 billion by 2025. By 2032, Metaverse could be a $1.1 trillion market in India. With this, it is predicted that the Indian Metaverse market is set to be one of the fastest-growing in the world [3].

Though the term Metaverse is gaining popularity these days, the relevant companies are constantly developing the technology as well as evolving the devices and the wearables making them much more lighter and sturdier. This technology is already being integrated with the construction industry to achieve a wider scope of benefits. Attempts are also being made to integrate this technology with construction software.

1.3 Technology and devices for the immersive experience of Metaverse

Metaverse immersion occurs through hardware [5]. Mobile and wearable devices such as AR glasses, headsets, VR viewers, controllers and smartphones have been the most widely adopted interfaces. A sizeable number of devices with various features are available for use. The main specifications which determine the performance the immersive devices are:

- **FOV and frame rate:** The field of view (FOV) and the frame rate are directly proportional to each other. The higher the aspect, the better the VR viewer devices.
- **Degrees of freedom:** This is related to the freedom of movement in the immersive experience. It is ideal to have three or six degrees of freedom (3dof or 6dof).
- **Movement tracking:** This refers to the technologies in the Metaverse that enable the 6dof. Movement tracking refers to outside-in tracking and inside-out tracking. When sensors are placed inside the room where the virtual reality experience is to be enjoyed is referred to as outside-in tracking. External sensors are not used for inside-out tracking.
- **Wired or standalone:** Wired viewers cannot operate on their own and need a computer to which the virtual reality experience is processed and delegated. Standalone VR viewers independently function and possess all the computational power for the immersive experience.
- **Controllers:** The VR viewers can also be paired with one or two physical controllers to immerse within the virtual space. Cameras or infrared sensors also can be used allowing direct use of the hands (hand tracking) to interact with virtual reality.

1.4 Applications and benefits of Metaverse in the construction industry

Though already widely adopted in various domains, organizations are still exploring Metaverse to

analyse its assistive technology.

The various benefits of Metaverse in the construction industry range from design conceptualization to finished project demonstration [6]. It can be used in almost all aspects of the construction project. Consider the following few use cases:

- **Project presentation:** Design conceptualization, proposals, 3D models or walkthroughs, Metaverse enables stakeholders can get a better understanding of the project with a complete immersive experience.
- **Progress capture:** Metaverse can be used to track and document the project progress with high efficiency and accuracy. This can enable the stakeholders to understand the project status even from a remote location.
- **Better collaboration:** This technology allows seamless collaboration in remote environments by letting stakeholders share 3D images and videos of great precision with the team members, be it on-site or off-site collaboration.
- **Design Development and Prototyping:** 3D models and walkthroughs of the proposals in the Metaverse build a physical mockup. These mockups result in being very efficient in terms of time, money, and materials.
- **Enhanced safety:** The devices (like glasses or mobile devices) can be provided with scan tags or labels placed in specific areas which can communicate by popping up text or even 3D models indicating safety or hazard information on the site.
- **Construction training:** The immersive environment can benefit the workers being trained in the various construction activities before heading to the site. The workers can also be exposed to various health and safety practices by avoiding exposure to real hazardous scenarios.

2. Literature review

A study was carried out to understand the implications of Metaverse or the digital built environment on architecture and heritage [7]. Research in the ca-

pacity of an architect and scenographer has been undertaken as part of the study. The virtual world is regarded as an extension of our real world, also consisting of physical appearance, cultural and social interaction, and aesthetic and philosophical arguments. The COVID-19 pandemic further accelerated the development and usage of this technology which is tangible, completely immersive and a 3D replica of the real world. The researcher hints at the Metaverse technology as possible futuristic evolution of the 'new normal' and encourages architects to support this digital spatial technology that could create a revolution.

A study followed by analysis was conducted to understand the extent of acceptance and penetration of virtual and augmented reality in the ACE industry as well as estimate future performance predictions [8]. The study also aimed to identify the shortfalls within the industry which could be a reason for the setback of wider adoption. To identify the prospects of AR/VR in the ACE industry, applications were examined on the applications of the technology in other domains such as retail sector, education, healthcare and the mining industries. Among these other domains, the technology usage has shown amplified benefits in terms of enhanced human behavior, learning enhancement, and revenues. With this, it was also inferred that the adoption of the technology in the ACE industry would benefit in terms of enhanced revenues and performance. The technology can benefit the ACE industry with enhanced safety training, BIM visualization and communication, energy savings, and understanding of users' preferences. As part of the study, a real-time VR model which enabled the stakeholders to visualize/customize the walls, floors, and other components in terms of materials as well as price impacts instantaneously was used. This experiment led to the conclusion that estimators can benefit greatly by linking cost estimations to AR/VR. A cloud-based VR system called CoVR was also introduced to enhance multiuser interactive virtual environment for improved communication among the stakeholders in a construction project. The study identified that the CoVR is able to import BIM data

and visualize it in the interactive virtual environment by multi users. Also, it was comprehended that for the next 5 to 10 years, industry experts could identify a surge in the usage of the technology. The research survey identified the factors—deficit investment budget, incomprehensive upper management, ignorant design team members about the technology and inadequate analysis of cost-benefit criteria; as posing a hindrance to the adoption of this technology in the ACE industry.

The real estate businesses have increased and had expressed the following facts about the Metaverse technology in relation to real estate [9]. Globally, the real estate sales in Metaverse have reached $501 million in 2021 and $1 billion by the end of 2022 and the compounded annual growth rate (CAGR) of 45.2 percent is expected to be achieved between 2020 and 2025 in this segment. The author [9] also identified that the global Metaverse market is predicted to be increased at 39.8 percent CAGR to $996 billion in 2030. However, Metaverse for real estate in India is still in the germinal phase, as the developers are innocent of the technology. The technology integration is only going with the people who are skilled in its usage.

An intervention to identify the various startups, their contributions to the industry and the government's encouragement of the technology [10]. Our country has close to 70 start-ups related to the VR space. Also, a lot of these companies have been able to raise seed capital from venture funds. The government has been playing its part to encourage the spread of the technology through various funding opportunities. In 2018, the government provided a lot of funding and incubation opportunities for virtual reality, with the aim of promoting VR/AR start-ups. This resulted in Indian-based companies like GridRaster, Chymera VR, SmartVixz, etc. receiving funding from investors and enhancing themselves to offer high-quality immersive technology. This start-up is associated with real estate players like Asian Paints. Infurnia, another Metaverse company contributes to the development of immersive tools for interior designers. However, various Indian organi-

zations are still at the nascent stages of VR and AR adoption. ROI justification and deficient hardware components have been the key criteria hindering the faster up-scale of Indian start-ups in this field.

3. Objectives of the study

- To what extent has the Metaverse technology penetrated the construction industry?
- Factors that are a setback to the adoption of Metaverse in the study area of the industry.

4. Methodology

The research methodology is carried out to identify some of the important factors that can be used for the analysis of the adoption of Metaverse in the Indian Construction Industry and the benefits arising from it.

A questionnaire was circulated among the leading players in the construction industry (architects, engineers, contractors, real estate personnel, builders, modelers, PMC, consultants, and academia; with their operations in the cities of Bangalore, Bhubaneswar, West Bengal, Delhi, Gulbarga, Hyderabad, Mumbai, Vijayawada), to assess the adaptability of Metaverse. The survey was conducted to understand the acceptance of Metaverse amongst the key industry players as well as to assess what factors are the criteria for not adopting the technology and what could be the benefits that could be achieved if the technology is adopted by the industry.

The survey also made an attempt to draw benefits that the industry could achieve if the technology is adopted pertaining to design development, enhanced design presentation, enhanced profits, better team coordination, staff/employee training, enhance site safety, progress capture, and property showcases.

5. Results of survey

The survey inferences are as follows:
- 20% respondents of the survey are not aware of the Metaverse technology.
- 15% of the survey respondents believe

Metaverse to be a game changer in the Indian construction Industry.

- Only 5% of respondents of the survey use Metaverse in their organizations.
- The survey concluded the benefits of using Metaverse in construction as follows in **Figure 2** below:
- The survey identified the factors behind the non-penetration of Metaverse in the industry as illustrated in **Figure 3** below:
- The respondent organizations were also surveyed to understand when the organizations are planning to invest in the Metaverse technology. The response is as follows in **Figure 4** below:

6. Conclusions

The Metaverse technology in the construction industry is very progressive and aimed to benefit the industry substantially [11]. The technology can enable the faster and safer realization of construction projects in the industry which is growing at a very fast pace. As per the research findings, conducted through a market survey, the adoption of the Metaverse tech-
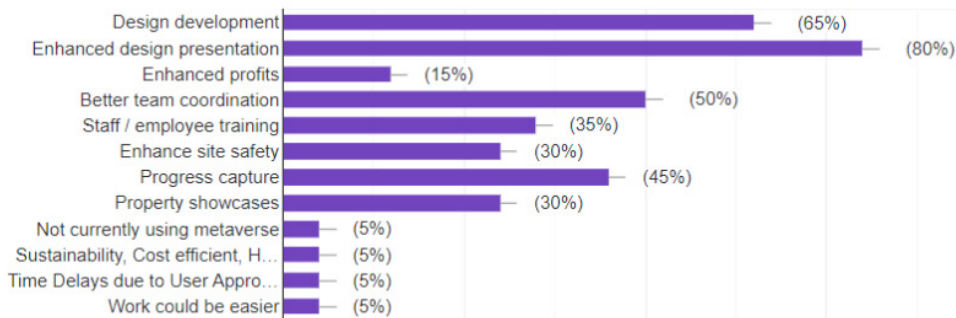

Figure 2. Benefits that could be achieved in the construction industry if Metaverse is used or adopted.

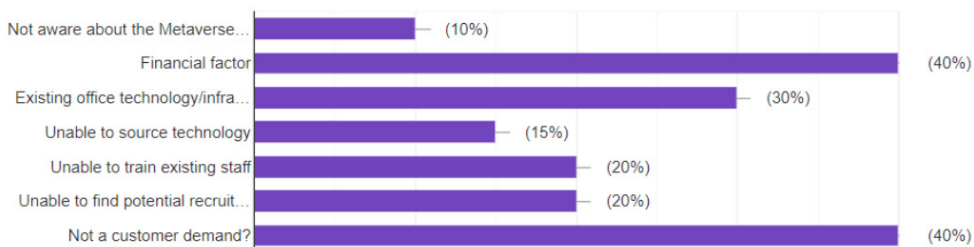Source: Authors' questionnaire survey response.

Figure 3. Benefits that could be achieved in the construction industry if Metaverse is used or adopted.

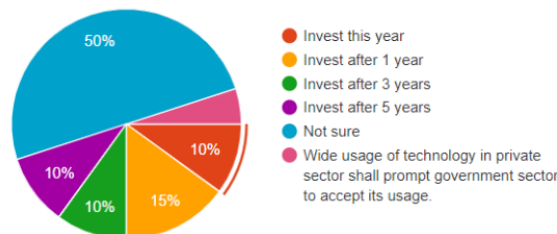Source: Authors' questionnaire survey response.

Figure 4. Organization plans to invest in Metaverse technology.

Source: Authors' questionnaire survey response.

nology will definitely contribute to the organizations of the construction industry in terms of:

- Design development;
- Enhanced design presentation and efficient working;
- Enhanced sales and profits;
- Better team (stakeholder) coordination;
- Efficient staff training;
- Enhancing site safety;
- Progress capture of the project;
- Property showcases;
- Cost efficient hassle-free project execution which could also be a sustainable work practice;
- Mitigating time delays in the approval processes of the projects;
- Customer satisfaction, enhanced sales, better stakeholder collaboration, better safety, health, and staff training, and property showcase.

The extensive adaptation of the technology in the private sector shall prompt the government sector to accept and encourage its usage.

The survey findings also indicate the various factors that are reasons for the static growth of the Metaverse technology adoption in the Indian construction industry:

- Financial constraints in terms of deficient budget to invest in the technology and unsuitable ROI justification.
- Not being aware of the Metaverse technology itself.
- Unsuitable existing office infrastructure not completely suitable for the Metaverse. Unable to source the technology due to various reasons like budget deficiency, unable to locate the procurement sources, unavailable skilled personnel to operate the technology, and not having the right sources to train the staff to work on the technology.
- The technology in itself is not a customer demand yet. It still takes a wide penetration of the technology among the masses so that the customers demand projects to be showcased in the Metaverse.

The study establishes the demand for the adoption of Metaverse in the construction industry. The construction segment is usually a very labor-intensive segment and a strong driving force are needed for the companies to adopt technology that could transform the traditional construction work culture into a smart and skilled branch of activity. The wider adoption of the Metaverse technology can be propelled by two things, the acceptance of the construction players to go through the digital transformation and the further maturity of the Metaverse technology more effortless for the industry.

Conflict of Interest

There is no conflict of interest.

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