International Journal of Enhanced Research in Science, Technology & Engineering
ISSN: 2319-7463, Vol. 15 Issue 3, March-2026

Drones in Surveying Inspection and Construction Monitoring

Miss. Snehal S. Tarade[1], Miss. Shagun Rajendra Jadhav[2], Mr. Onkar R. Misal[3]

[1,2]Student Civil Engineering Department, Karmaveer Bhaurao Patil Polytechnic Satara, India
[3]Lecturer Civil Engineering Department, Karmaveer Bhaurao Patil Polytechnic Satara, India

ABSTRACT

The integration of unmanned aerial vehicles(UAVs) into the civil engineering domain represents a transformative technological paradigm shift fundamentally altering the methodologies employed for surveying, structural health monitoring (SHM) and construction progress management. this research paper provides and exhaustive and critical examination of the current state of UAV technology, evaluating it's efficacy against traditional terrestrial methods such as Total Station surveying and manual visual inspection. The study dissects the technological evaluation of drone platforms - from multirotor systems optimized for vertical structure inspection to fixed - wing and VTOL hybrid air craft designed for large-scale corridor. Rigorous comparative analysis of Structure-from-Motion (SfM) photogrammetry and Light Detection and Ranging (LiDAR) is presented, supported by quantitative accuracy metrics, operational work flows, and economic impact assessments. Further more, this paper explores the advanced applications of UAVs in detecting structurals pathologies, detailing the use of thermal imaging and AI-driben crack detection algorithms capable of identifying sub-milimeter defects in critical infrastructure. The integration of aerial data into Building Information Modeling (BIM) environments, known as “Scan-to-BIM,” is analysed to demonstrate the potential for automated, real-time progress monitoring. Special emphasis is placed on the Indian context, providing a detailed review of the regulatory frame work established by the Directorate General of Civil Aviation (DGCA) and analyzing adoption strategies by major entities like the National Highway Authority of India (NHAI). The findings indicate that UAVs not only achieve centimetre- level accuracy comparable to traditional instruments but also reduce operational timelines by upto 90% , thereby of a ring significant return on investment and enhanced safety profiles for large-scale engineering projects.

Keywords- Unmanned Aerial Vehicles (UAVs), Structural Health Monitoring (SHM), Structure-from-motion (SFM), Light Detection and Ranging (LiDAR), Building Information Modeling (BIM), Directorate General of Civil Aviation (DGCA), National Highway Authority of India (NHAI

INTRODUCTION

The architectural, engineering, and construction (AEC) sector has long grappled with a persistent productivity gap, where project delivery timelines and cost efficiencies have failed to match the rapid advancements seen in manufacturing or logistics. Conventional land surveying involves the use of Total Stations and Global Navigation Satellite System (GNSS) rovers,which, while offering high precision, required human surveyors to physically traverse rugged and potentially hazardous terrain, often taking days or weeks to cover large scale sites.

The emergence of unmanned aerial vehicles (UAVs), commonly known as drones, has provided this solution by delivering a scalable, high-resolution “birds-eye view” of construction environments. Done facilitate the rapid capture of aerial imagery and laser scanning data, transforming how site assessments are conducted. When equipped with specialized sensors, this platforms can generate high-precision topographic maps, 3D point clouds, and volumetric calculations with a speed that traditional methods cannot replicate. For instance, where a traditional survey crew might map 10 acres in a single day, an RTK-enabled drone can cover over 100 acers in less than an hour, representing a significant leap in operational throughput. The true transformative power of drone technology, however, lies in its integration with Artificial Intelligence (AI). AI- powered computer vision and deep learning algorithms enable the automated processing of thousands of images to identify structural defects, moniter worker safety, an track project progress against planned schedules. This automation moves the industry away from reactive inspections toward proactive, data- driven decision-making. Moreover, the synergy between drones and emerging technologies such as Building Information Modeling (BIM), Geographic Information Systems (GIS), and Digital Twins creates a unified digital thread that persists throughout the project lifecycle. This “Living Models” provide a single source of truth for all stakeholders, reducing miscommunication and preventing expensive rework. In India, the Directorate General of Civil Aviation (DGCA) is transitioning from the Drone Rules 2021 towards the more robust Civil Drone (Promotion and Regulation) Bill 2025. By 2025 the market capacity for civilian drones is projected to triple, with the sector for civil infrastructure applications estimated to rich USD 45 billion.

I. EASE OF USE

Easy to deploy and operate with minimal manpower, Quick data collection over large and difficult areas, Reduces need for physical site access improving safety, Simple flight planning using mobile apps and software, provides real-time images and videos for instant review

Generate accurate maps 3D models measurements automatically, Saves time and cost compare to traditional methods, Easy integration with GIS, BIM, and reporting tools, Minimal training required for basic operation, Can be operated in confined or hazardous area safely, Enable Frequent site visits without extra logistics

Easy data storage and sharing in digital format, Provide consistent and repeatable data collection, Reduces dependency on heavy surveying instruments allows fast progress comparison with past site data, Works in remote and in accessible locations.

Improves documentation with high-resolution visuals supports automated processing through software tools, Reduce human error in measurements, Enhanced communication among engineers,contractors and clients.

II. DRONE TECHNOLOGY OVERVIEW

Classification of UAV platform
In the context of civil engineering, drone selection is determined by a trade-off between flight endurance, payload capacity, and the required spatial resolution. 3 primary architectures dominate the field.

1.Multi-rotor Drone: These are the most common platforms for construction monitoring and structural inspection characterized by multiple rotors (quadcopters) hexacopters, they offer vertical take off and landing (VTOL) capabilities and the ability to hover in place. This makes them ideal for close up visual inspection of bridges, facades, and confined spaces. Platforms like the DJI Matrice 350 RTK are designed for durability in industrial environment, supporting high-precision payloads.

2. Fixed- wing Drones: unlike multi-rotors, fixed wing Drones utilised a wing to generate lift, allowing them to travel much further on a single battery charge. They are the preferred tool for large scale topographic survey and corridor mapping, such as for highways or railways. The Robota Eclipse 2.0, for instance, can cover expansive areas at speeds and durations ata multi-rotors cannot achieve.

3. Hybrid (VTOL) Drones: These systems combined the take off flexibility of a multi-rotor with the long range efficiency of a fixed wing. They are particularly useful for surveying remote infrastructure projects where traditional runways for fixed wing launch are unavailable.

Sensor Systems and Data Acquisition-

The technical depth of a drone survey is primarily define by its sensor suites. Advanced payloads allow for the capture of diverse data types:-

•High resolution RGB Cameras: Used for photogrammetry, these cameras capture overlapping optical images that are processed into 2D ortho mosaic and 3D textured meshes. The resolution is measured by Ground Sample Distance (GSD) which defines the real world size of a single pixel.

•LiDAR (Light Detection and Ranging) : LiDAR sensors emit thousands of laser pulses per sec, measuring the time it takes for the light to return after reflecting of a surface. This create high-density 3D point clouds. LiDAR is superior for penetration of vegetation and for capturing the complex geometry of structural elements like steel trusses.

•Thermal Infrared Sensors: These sensors capture heat signature rather than light. They are in valuable for identifying moisture traps in roofs, Heat law in insulation, and electrical “hotspots” in substations or equipment.

•Multispectral sensors: By capturing data across narrow bands of the electromagnetic spectrum these sensors allow engineers to monitor environmental impact, such as changes in local vegetation or water quality near a construction site.

AI and Emerging Technologies in Drones -
Deep learning and computer vision for defect detection: Artificial intelligence act as the analytical engine for drone data. In structural health monitoring (SHM) , deep learning models automate the detections of issues that would otherwise require manual , subjective human review.

Integration with IoT and Digital Twins -
Drones are increasingly viewed as mobile sensors within the Internet of Thing (IoT) ecosystem.While static sensor (e.g., Train guages, Moisture sensor) provide continuous points data , drones provide the spatial and visual context for those readings.

III. APPLICATION IN SURVEYING, INSPECTION, AND CONSTRUCTION MONITORING

Topographic Surveying and volumetric analysis -

Drone-based surveying has revolutionized the "pre-construction" and "earthwork" phases of civil engineering projects. By utilizing RTK-enabled platforms, surveyors can generate highly accurate Digital Elevation Models (DEMs) and topographic maps without the need for extensive ground-based measurements.

Volumetric calculation is a standout application. In traditional surveying, a surveyor would take a limited number of spot elevations on a stockpile, leading to approximations. A drone captures millions of points, creating a high-fidelity 3D mesh of the stockpile. This allows for the calculation of volumes for excavations and material reserves with a high degree of precision, facilitating better project logistics and financial reconciliation.

Construction Progress and Safety Tracking -
During the construction phase, drones act as the "eyes of the project manager." Scheduled daily or weekly flights provide a repeatable, objective record of progress

CONCLUSION

Drones have emerged and a powerful tool in Surveying, Inspection, and Construction Monitoring by providing fast, accurate, and cost effective data collection. They improve safety by reducing the need for manual site inspection and enable real-time progress tracking with high-quality aerial imagery.The use of drones enhances decision -making , minimizes error , and increases overall project efficiency. As technology continuous to advance, drones will play an increasingly important role in modern civil engineering practices, making construction project smarter, safer, and more sustainable.

The Future of AI- enabled drones in civil engineering lise in “full autonomy” and “Swarm intelligence” where multiple drones work in coordination to monitor large scale infrastructure projects with minimal human intervention. As these technologies continue to mature, they will not only improve the productivity of the Construction sector but also ensure that our built environment is safer, more sustainable, and more resilient.

They also support better planning, quality control, and timely problem detection on construction sites. Integration with GIS, BIM, and AI further improves data analysis and project management. Overall, Drone technology represents a measure step toward digital and automated construction practices.

ACKNOWLEDGMENT

The authors would like to acknowledge the Civil Engineering Department of Karmaveer Bhaurao Patil Polytechnic Satara, for there support in providing access to technical resources. We also extend our gratitude to the Directorate General of Civil Aviation (DGCA) and the academic researcher whose primary data and finding formed the basis of this technical analysis.

REFERENCES

1. A. Colomina and P. Molina, “Unmanned aerial systems for photogrammetry and remote sensing: A review,” ISPRS J. Photogramm. Remote Sens., vol. 92, pp. 79–97, June 2014.
2. C. Eisenbeiss, UAV Photogrammetry, Ph.D. dissertation, ETH Zurich, Zurich, Switzerland, 2009.
3. S. Siebert and J. Teizer, “Mobile 3D mapping for surveying earthwork projects using an unmanned aerial vehicle (UAV) system,” Autom. Constr., vol. 41, pp. 1–14, May 2014.
4. J. Irizarry and M. Costa, “Exploratory study of potential applications of unmanned aerial systems for construction management tasks,” J. Manage. Eng., vol. 32, no. 3, pp. 1–10, May 2016.
5. M. H. Kim, S. Y. Kim, and S. J. Kim, “Unmanned aerial vehicle-based inspection of civil infrastructure: A review,” Struct. Infrastruct. Eng., vol. 15, no. 7, pp. 1–15, July 2019.

6. T. Rakha and A. Gorodetsky, "Review of unmanned aerial system applications in the built environment: Remote sensing, inspection, and monitoring," J. Constr. Eng. Manage., vol. 144, no. 2, pp. 1–13, Feb. 2018.
7. A. Nex and F. Remondino, "UAV for 3D mapping applications: A review," Appl. Geomatics, vol. 6, no. 1, pp. 1–15, Mar. 2014.
8. J. Teizer, "Status quo and open challenges in vision-based sensing and tracking of temporary resources on infrastructure construction sites," Adv. Eng. Inform., vol. 29, no. 2, pp. 225–238, Apr. 2015.
9. Y. Ham, K. K. Han, J. J. Lin, and M. Golparvar-Fard, "Visual monitoring of civil infrastructure systems via camera-equipped unmanned aerial vehicles," Autom. Constr., vol. 36, pp. 1–10, Dec. 2013.
10. F. Chiabrando, F. Nex, D. Piatti, and F. Rinaudo, "UAV and RPV systems for photogrammetric surveys in archaeological areas: Two tests in the Piedmont region (Italy)," J. Archaeol. Sci., vol. 38, no. 3, pp. 697–710, Mar. 2011.
11. M. Golparvar-Fard, J. Bohn, J. Teizer, S. Savarese, and F. Peña-Mora, "Evaluation of image-based modeling and laser scanning accuracy for emerging automated performance monitoring techniques," Autom. Constr., vol. 20, no. 8, pp. 1143–1155, Dec. 2011.