Chapter 26: Case Studies of Successful Human-Robot Collaboration in Construction

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Introduction

The construction industry is undergoing a transformative shift through the integration of robotics and automation. As projects grow in complexity, scale, and safety requirements, human-robot collaboration (HRC) is emerging as a critical solution to enhance productivity, reduce accidents, and improve project outcomes. Rather than replacing human workers, modern construction robotics are being designed to work *with* humans—combining human adaptability and judgment with robotic precision and endurance.

This chapter explores notable case studies across the globe where HRC has been successfully implemented in civil engineering and construction. These examples illustrate the wide-ranging benefits of collaborative robotics in areas like bricklaying, demolition, concrete finishing, inspection, and 3D printing, among others. Each case study highlights the context, robot type used, nature of collaboration, outcomes, and the key takeaways that are shaping the future of construction.

26.1 Bricklaying: SAM100 by Construction Robotics (USA)

a. Overview

The Semi-Automated Mason (SAM100) is a collaborative robotic system developed by Construction Robotics to assist with bricklaying. It does not fully automate the process but works alongside human masons.

b. Nature of Collaboration

- **Humans** handle setup, alignment, detail work, and quality assurance.
- **Robot** performs repetitive and high-effort tasks like picking bricks, applying mortar, and placing them with precision.

c. Project Example

- Used in multiple projects across the US, including the **Berkeley Building**, New York.
- Achieved 3–5 times faster bricklaying speed.

d. Outcomes

- Reduced physical strain on masons.

- Enhanced consistency in brick placement.
- Optimized use of skilled labor for critical detailing.

26.2 Demolition: Brokk Robotic Demolition Machines (Europe/Worldwide)

a. Overview

Brokk, a Swedish manufacturer, creates demolition robots widely used in tight, hazardous environments like tunnels, nuclear plants, and old buildings.

b. Human-Robot Dynamics

- **Operators** control the robot remotely from a safe distance.
- **Robot** performs demolition with hydraulic hammers, shears, and crushers.

c. Use Case: UK Underground Station Renovation

- Robots used for controlled demolition in London's aging underground systems.

d. Benefits

- Improved worker safety in hazardous demolition zones.
- Precision demolition near sensitive structures.
- Continuous operation in confined spaces where humans cannot work effectively.

26.3 Rebar Placement: TyBOT by Advanced Construction Robotics (USA)

a. Description

TyBOT is an autonomous robot designed to tie rebar intersections, which is a repetitive, labor-intensive job in bridge and highway construction.

b. Collaboration Model

- Human teams place rebar mats manually.
- TyBOT moves along the mats and autonomously identifies and ties rebar intersections.

c. Case: Florida Bridge Construction

- Reduced labor requirements by over 50%.
- Improved job site ergonomics.

d. Key Outcome

- Freed human workers from repetitive strain tasks.
- Ensured speed and uniformity in tying.

26.4 Concrete Finishing: BASF's Doka Concremote and Robot Screeding (Europe)

a. Technology Background

Concremote is a sensor + AI system that works in tandem with screeding robots to determine the ideal time for concrete finishing based on curing data.

b. Human-Robot Interaction

- Humans install sensors and monitor data.
- Screeding robots work autonomously based on sensor feedback.

c. Project Highlight

- Used in **German infrastructure projects** for precision in large slab placements.

d. Advantages

- Avoids premature or delayed finishing.
- Reduces wastage and rework.
- Enhances final surface quality.

26.5 Tunnel Inspection: ROBINSPECT EU Project

a. Context

Tunnel maintenance is crucial for structural safety but poses risks to workers.

b. Robotic System

A mobile robot equipped with sensors, cameras, and AI for detecting cracks, misalignments, and corrosion.

c. Human Involvement

- Human operators define scanning paths and interpret AI-generated defect reports.

d. Use Case: Railway Tunnels in Italy and Spain

- Reduced inspection time by 60%.
- Increased detection accuracy.

e. Safety Impact

- Reduced exposure of workers to confined and dangerous tunnel environments.

26.6 3D Printing in Construction: Apis Cor (Russia/USA)

a. Description

Apis Cor uses mobile 3D printers for on-site house construction using cementitious material.

b. Human-Robot Workflow

- **Humans** design the digital model, manage material supply, and perform electrical/plumbing work.
- **Robot** autonomously prints structural walls layer by layer.

c. Highlight: Dubai Municipality Office

- World's largest 3D-printed building using one robotic arm.

d. Impact

- Cost-effective, sustainable housing.
- Minimal waste and labor cost.
- Faster project turnaround.

26.7 Exoskeletons for Worker Augmentation: Ekso Bionics (USA)

a. Concept

Exoskeletons are wearable robotic suits that support the human musculoskeletal system, reducing fatigue and injury during heavy lifting.

b. Use Case: Skanska Construction Sites (UK)

- Used by workers performing repetitive overhead tasks.

c. Human-Robot Symbiosis

- **Robot suit** assists movement without replacing human control.
- **Humans** remain in full command but with reduced exertion.

d. Benefits

- Increased work duration without strain.
- Fewer musculoskeletal disorders.
- Improved productivity.

26.8 Modular Construction Automation: Autodesk + Factory_OS (USA)

a. Overview

Factory_OS combines modular construction with robotic systems in a factory setting to build housing units rapidly.

b. HRC Integration

- Robots handle module framing and material handling.
- Humans perform electrical, plumbing, and finish work.

c. Output

- Entire apartment units completed in weeks instead of months.
- Better quality control due to factory setting.

d. Example Project: Bay Area Affordable Housing Initiative

- Created hundreds of units at reduced cost and time.

26.9 Autonomous Surveying: Spot by Boston Dynamics + Trimble (Worldwide)

a. Robot Introduction

Spot, a quadruped robot, is used in surveying and inspection tasks, equipped with Trimble laser scanners and GPS systems.

b. Human-Robot Integration

- Surveyors plan paths and define data needs.
- Spot navigates terrain and collects accurate 3D scans.

c. Case: Large-Scale Construction Sites

- Sites in Singapore and Japan using Spot for daily progress monitoring.

d. Results

- Reduced need for rework due to accurate and consistent progress data.
- Improved communication among stakeholders.

26.10 Robotic Drywall Installation: Canvas Robotics (USA)

a. Background

Canvas Robotics developed a robot to assist in drywall finishing—an essential but tedious part of interior construction.

b. Collaboration

- Human workers prepare walls and materials.
- Robot applies compound, sands surfaces, and ensures evenness.

c. Deployment: Commercial Offices in California

- Completed jobs in half the usual time.
- Reduced physical wear on drywall workers.

26.11 Robotic Rebar Fabrication: Jaibot by Hilti (Global)

a. Overview

Jaibot is a semi-autonomous drilling robot designed to perform overhead MEP (Mechanical, Electrical, and Plumbing) tasks, such as marking and drilling holes for installations on ceilings and slabs.

b. Human-Robot Collaboration

- **Humans** load design data (BIM) and supervise the robot's positioning.
- **Jaibot** performs precise drilling based on the data input, guided by cloud-based planning.

c. Application Site: High-rise Commercial Project, Germany

- Jaibot executed thousands of drilling tasks across multiple floors.

d. Advantages

- Improved accuracy by eliminating manual layout errors.
- Enhanced safety by reducing ladder and scaffolding work.
- Reduced fatigue for human workers.

26.12 Road Construction Assistance: Autonomous Paving Systems by Volvo CE (Sweden)

a. Project Overview

Volvo Construction Equipment has developed autonomous and semi-autonomous asphalt pavers and rollers for road construction.

b. Collaboration Model

- **Engineers** program paving routes and supervise quality control.
- **Machines** pave roads using sensor fusion and GPS control with minimal human intervention.

c. Case: Smart Road Projects in Sweden and Norway

- Conducted trials in extreme weather and terrain conditions.

d. Key Benefits

- Enhanced uniformity in paving thickness and compaction.
- Reduced human fatigue in long-haul paving tasks.
- Significant gains in operational efficiency.

26.13 Human-Robot Collaboration in Prefabricated Construction: KUKA Robotics with Skanska

a. Project Summary

KUKA robotic arms were deployed in Skanska's prefabrication facilities for cutting, welding, and assembling steel components for modular structures.

b. Human-Robot Division

- **Humans** provide inputs, material logistics, and supervise error handling.
- **KUKA robots** carry out repetitive high-precision tasks.

c. Site Application: Modular Hospital Units During COVID-19

- Rapid construction of hospital modules with high precision.

d. Outcomes

- 40% reduction in fabrication errors.
- Improved speed-to-market for urgent infrastructure needs.
- Enhanced worker safety in factory environments.

26.14 Robotic Painting and Surface Coating: Okibo Painting Robot (Israel)

a. Technology Overview

Okibo is an autonomous robot designed to paint walls and ceilings on construction sites.

b. Human-Robot Interaction

- Workers outline the painting area and upload the building's model.
- The robot handles spray painting and adjusts its movements based on surface contours using computer vision.

c. Pilot Project: Residential Towers in Tel Aviv

- Delivered consistent coating with reduced material wastage.

d. Value Addition

- Freed skilled painters for detail work.
- Reduced respiratory hazards.
- Faster coverage with minimal supervision.

26.15 Bridge Inspection Robots: BEAR (Bridge Evaluation and Assessment Robot)

a. Description

BEAR is a climbing and crawling robot used to inspect the undersides of bridges, often unreachable by humans.

b. Collaboration Setup

- **Operators** control the robot remotely, interpret scan results, and manage data analysis.

- **Robot** captures real-time visual and sensor data of steel structures and concrete surfaces.

c. Deployment: US Federal Bridge Inspection Program

- Used on aged infrastructure in New York and Michigan.

d. Benefits

- Detected microcracks earlier than traditional inspection methods.
- Safer inspections without the need for hanging platforms or divers.
- Enabled predictive maintenance strategies.

26.16 Robotics in Hazardous Materials Handling: Demobot with Radiation Shielding

a. Background

Demobot is designed for decommissioning old industrial sites with radioactive or chemical hazards.

b. Human-Robot Teaming

- **Humans** operate from shielded control rooms or use telepresence.
- **Robot** handles cutting, sampling, and material disposal.

c. Site Case: Former Uranium Plant Dismantling (USA)

- Successfully removed 80+ tons of contaminated concrete.

d. Significance

- Eliminated the need for direct human exposure.
- Complied with environmental and health regulations.
- Enabled faster site clearance.

26.17 Digital Twin Integration with Robots: Autodesk Forge + Spot

a. Technology Synergy

Construction robots are being used to update digital twins in real-time. Robots like Spot, equipped with 360° cameras and LiDAR, continuously feed data into platforms like Autodesk Forge.

b. Human Role

- Engineers define monitoring parameters.
- Site managers interpret the evolving model for decision-making.

c. Use Case: Data Center Construction, Singapore

- Monitored progress, material stock, and alignment against BIM.

d. Results

- Reduced clashes and rework through early detection.
- Created dynamic as-built documentation.
- Enhanced coordination among remote stakeholders.

26.18 Safety Monitoring Robots: Smart Robotics Surveillance Units

a. System Overview

Autonomous wheeled or aerial robots equipped with thermal cameras, object detection, and gas sensors are deployed to monitor real-time safety on construction sites.

b. Human Interface

- Safety officers define patrol routes and hazard triggers.
- Robots autonomously patrol, detect violations, and report back via dashboards.

c. Implementation: Smart City Site in Dubai

- Detected over 300 safety violations in a month, preventing injuries.

d. Impacts

- Improved site discipline.
- Enabled 24/7 monitoring with minimal human fatigue.
- Automated hazard identification in real-time.
