International Journal of Advance Research in Science and Engineering
Vol. No.6, Issue No. 10, October 2017
www.ijarse.com
IJARSE
ISSN 2319 - 8354

ROBOTICS IN CONSTRUCTION TECHNOLOGY

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ABSTRACT

Robot system used in building construction sites can efficiently reduce construction time and increase safety by replacing human in dangerous operations. Construction robots are defined as field robots and while operating in dynamic environment. Robotic systems have become common in many manufacturing and production operations because they have proven to be more robust, safe, efficient, accurate and productive .There are specific areas of application in which robots could benefit the industry. Feasibility of using robots in building construction is determined from comparison of robotic versus manual performance of pertinent building tasks. The following study presents a quantitative assessment of two aspects of robotic feasibility: saving in in human labour and its impact on costs. This paper compares the traditional and human operated systems with autonomous systems and provides a set of guidelines for developing future equipment more economically.

Keywords: Construction robots, safety, building works, reduce labours.

I. INTRODUCTION

The construction industry employs a large labour force, next only to agriculture. Development of the construction industry in our country like other industries is very slow and less systematic till 19th century. The construction industry in India as undergone the large scale mechanisation with rapid changes and advancements in construction practices as well as in the management of construction works.

Shimizu Corporation of Japan began its research and development of robotics in 1975 to advance innovation in construction production.

The following section summarizes the company’s progress in R&D in various areas in building construction.

1. Fire proofing spray robot (SSR-3)
2. Ceiling-panel positioning robot (CFR-1)
3. Concrete-floor finishing robot (FLATKN)
4. Wall-finishing robot (OSR-1)

Construction automation and robotics have been generating much interest in the construction community for the last decades. Early development onsite robotised concepts started to emerge and even been tested over 15years ago. Atomization and Robotization of the industry was started in 1980's in Japan. The first ISARC (International symposium on automation and robotics in construction)

II. OBJECTIVES

The general objective is to determine the scope of application of robotics in building construction. In more specific terms the objectives of are:

- To review the literature for implementation of robotics in building construction.
- To identify the feasibility of using robots in building construction.
- To reduce time and save cost in building construction using robotic applications.
- To draw conclusions regarding the extent of success of building robots.

III. NEED FOR ROBOTS:

Fast changing, field-based, project-oriented industries like construction are severely handicapped by their lack of accurate, timely and systematic technical, cost and production data from ongoing operations. Meanwhile, technologies have evolved that can not only monitor the ongoing operation of manufacturing facilities and collect operational and passenger volume data from transit systems, but can monitor vehicle operations characteristics, transit high resolution video images.

The conventional process of executing the construction work requires highly skilled workmen in order to achieve sufficient and consistent quality. This labour-intensive construction process results in relatively high cost. To achieve higher rationalization and humanization, different methods have been tested. For example, one of the approaches, which are used by the sand-lime brick and cellular concrete industry, is the enlargement of the size of the building blocks. The enlarged dimensions of these blocks, however, coincide with their increased physical weight up to 300 kg. Due to their larger dimensions and heavier weights, these building blocks are not ergonomically desirable and, therefore, various mechanical aid devices such as hydraulic balancers or mini cranes with counterweights are used for the assembly. The conventional process of executing the construction work requires highly skilled workmen in order to achieve sufficient and consistent quality. This labour-intensive construction Process results in relatively high cost. To achieve higher rationalization and humanization, different methods have been tested. For example, one of the approaches, which are used by the sand-lime brick and cellular concrete industry, is the enlargement of the size of the building blocks. The enlarged dimensions of these blocks, however, coincide with their increased physical weight up to 300 kg. Due to their larger dimensions and heavier weights, these building blocks are not ergonomically desirable and, therefore, various mechanical aid devices such as hydraulic balancers or mini cranes with counterweights are used for the assembly.

IV. COST OF ROBOTIZED WORK

The total cost per unit of robotized execution of a building task is composed of the following:

• Direct cost of robotized work. This cost depends on the direct cost of time input per work unit and the cost of the robotized system per hour.

• Cost of materials per unit, in robotized work. • Cost of auxiliary manual labour, such labor may need for the materials handling, work area preparation, and some improvements or additions to the robots work. Its cost depends on the required time input of manual work and its cost per hour.

• Cost of the robots movement between workstations. This cost depends upon the distance the robot has to travel, its speed of movement and the cost of the robotized system per hour.

• Cost of robots positioning at each workstation. This cost depends upon the time setup and the cost of the robotized per hour.

• Cost of robots transfers between different work areas on site. This cost depends upon the number of transfers, the time required per transfer, the cost of the robotized system per hour, the cost of the other resources involved in the transfer.

The cost per hour is identified using the following formula

C = (P X Pr (I, N) + Cm) / H + Co

Where;

P is investment in the robot (including the cost of carriage, effectors, sensors & other adoptions).

Pr (I, N) is the capital recovery factor (depreciation and interest factor, assuming annual interest I and economic life in years).

Cm: Cost of repairs and high level maintenance of the robot per year.

Co: Operating costs (including some effected parts) per hour and

H: number of robot employment hours per year.

V. ROBOTS USED IN CONSTRUCTION INDUSTRY

Robotics and automation are expected to play an increasingly important role in the construction industry in the next decade. Due to the dynamic and unstructured nature of the construction environment research and development (R & D) in the application of high technology is needed. Recent progress of robotics in the other industrial fields has shown a great possibility to promote the automation of the complicated construction processes.

Shimizu Corporation of Japan began its R & D of robotics in 1975 to advance innovation in construction production. The company’s rationalization for R & D in construction is to increase productivity, improve quality, reduce cost, increase efficiency, obtain new markets and improve safety of the construction work environment. The ultimate goal is to create a flexible and integrated environment of the construction projects. The company has focused on both of these areas, automating traditional construction sites and new construction fields.

The following section summarizes the company’s progress in R & D in various areas:

1. Fireproofing spray robot (SSR-3).
2. Steel-beam positioning manipulator
3. Ceiling-panel positioning robot (CFR-1).
4. Wall-finishing robot (OSR-1).
5. Spray-coating robot (SB-Multi Coater).

5.1. Fire Proofing Spray Robot (SSR-3) Rock wool spray work for fireproofing steel structural members is a hazardous construction job. The SSR-3 was developed to provide a safer work environment for spray workers. While spraying, the SSR-3 moves parallel to a steel beam at a constant distance measured with a pair of ultrasonic sensors.

5.2. Steel-Beam Positioning Manipulator:

Steel-Beam erection work is one of the most dangerous tasks on the construction to be robotized. Steel-Beam positioning manipulator lifts two or three steel beams and sets them in the correct position by teleportation. While setting beams, the manipulator grasps the top of the columns and there is no need to be lifted by a tower crane. This means that the tower crane can be used for the other jobs while the manipulator is working. It weighs a total of 1,900 kg with a hanging load capacity of 2,100 kg and one degree of freedom.

5.3. Ceiling-Panel Positioning Robot (CFR-1)

Ceiling construction for office buildings, hostels and other commercial buildings is accomplished by using plaster-board panels, which are made of plaster and covered with paper. A typical midsize office building, for example, with eight floors and 5,000 sq m requires 400 panels for each door. The procedure for ceiling construction requires temporary scaffolding to be erected over the floor and then cleared away for next procedure. The workers must raise heavy, large panels over their heads for placement against the hanging ceiling flat bars. Repetition of this work over a long period of time exhausts workers.

5.4. Wall-Finishing Robot (OSR-1):

OSR-1 (Ohi Saikaihatsu Robot) is an automatic spray-painting system for the high-rise residential buildings. Conventional painting work has resulted in accidents when objects fall from high scaffolding. The OSR-1 is developed to decrease such accidents and to realize uniform spray quality using robot. Moving along the handrail on the wall, the OSR-1 extends its multi axis arm. A spray nozzle moves up and down on the end member of the arm. The arm avoids obstacles, such as pipes located along the wall and moves its spray nozzle parallel to them.

5.5. Spray-Coating Robot (SB Multi-Coater)

The SB Multi-Coater is an automatic sprayer for exterior wall painting, which can perform spray coating on exterior walls of medium and multistory buildings. Their main purposes are sealer coating, material spraying and top coating. It needs only one operator on the ground and provides an enhanced production rate about five times that of conventional methods. It gives an excellent finish comparable to skilled workers. The SB Multi-Coater provides a smooth, evenly sprayed surface. It performs spraying by moving right and left with one or two spraying guns rotating at high speed in a uniform pattern during the main material spraying process. There are five types of basic patterns in wall finishing. Suitable patterns are selected according to the materials to be coated. The SB Multi-Coater can spray the main elastic coating material at approximately 400 sq m per day as opposed to the daily production rate of the conventional methods, approximately 80 sq m per day

VI. ROBOTS USED IN CIVIL WORKS

6.1 Semi Autonomous Robot:

Navigation and tele operation are the special features in this mobile robot prototype. This can be used for indoor and outdoor works. The Semi Autonomous Robot is shown in figure

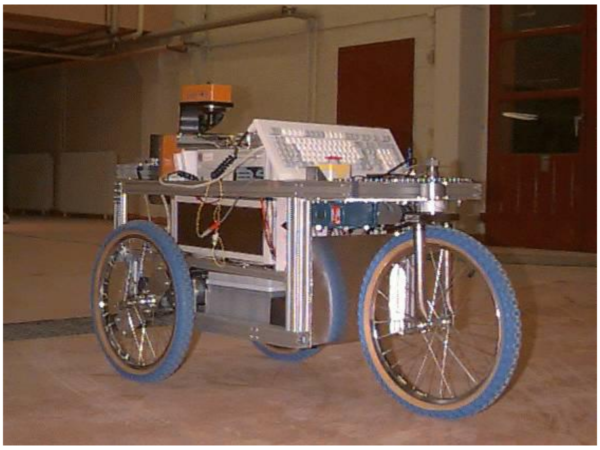

Fig 1 Semi Autonomous Robot

6.2 Concrete Crusher:

It is faster and quieter robot to demolish the concrete. Adjoining work can often continue uninterrupted and emollition can even take place at night. The Concrete Crusher is shown in the figure 2.

Fig.2 Concrete Crusher Robot

6.3 Demolition Robot:

It is used in the confined space and selective demolition works. The precise control enables demolition needed sections, while leaving the remaining sections un scattered. The Demolition Robot is shown in the figure 3.

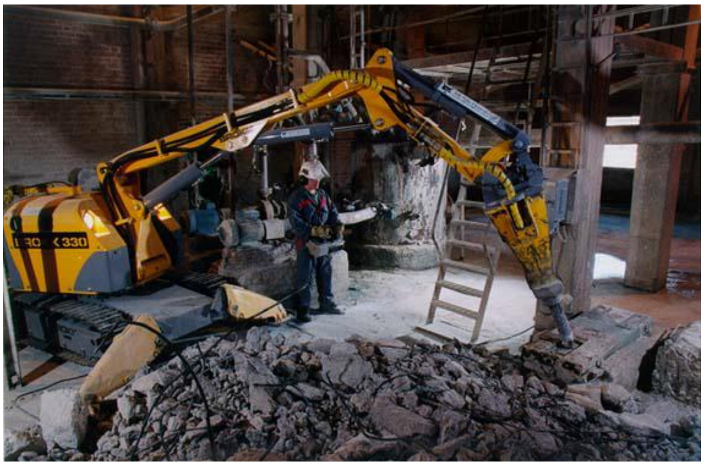

Fig 3. Demolition Robot

6.4 Robot for All Jobs:

It is employed for chiseling up-channels in the floors to allow the replacements of the drains, removing tiles and clinker and it is shown in the figure 4.

Fig 4. Robot for All Jobs

VII. CHALLENGES FACING AUTOMATION AND ROBOTICS IN CONSTRUCTION

The primary contribution of automation in construction is the development of a comprehensive, multidimensional analysis of costs and benefits associated with a specific robotic application. It is quite important to analyse success through the technical and economic feasibility. The technical feasibility is determined by an ergonomic evaluation of individual steps taken to accomplish the given work task, and by analysis of the requirements for robot control and process monitoring. The economic feasibility, which is perceived to be the decisive factor in the market success of the proposed robotic systems, is determined by the analysis of the costs and benefits associated with their development and field implementation. Specific technologically challenging process and characteristic of robot construction applications include:

- Performance in a harsh work site environment, or undefined and sometimes hostile conditions such as:

- Difficult climatic conditions
- Exposure to dust
- Calibration in relation to environment
- Adjustment to changing surface conditions
- Complexity of the working environment
- Some changes in the nature of the robotized work process versus the traditional, human- performed work process.
- Real-time "Sense-and-Act" operation for mobile construction robots to perform accurate and/or delicate tasks
- Identification of various types of objects in natural environment conditions
- Interactivity between sensors and end-tools.

VIII. CONCLUSIONS

It is important to maintain the correct relationship between the speed of processing
and the speed of material delivery is essential for automation in construction industry. Use of robots will directly or indirectly save builder/contractor/owner to face legal problem and also the given tasks can be completed at a faster rate. Although the robotic technology can benefit construction industry in many ways, it is not cheap, especially for application in the rugged outdoor environment.

• The economy of robot use requires a sufficient volume of appropriate work for their continuous employment.

• The main justification for such employment will probably be scarcity of local labor and the explicit and the hidden cost of importing foreign labour.

• At present the robots can be economically employed in the construction of repetitive buildings designed with due regard for robotics constraints, in sophisticated and high precision tasks and in dirty and dangerous building chores.

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