Enhancement of Road Construction Sector using Automation

Sameer Javed Momin[1], Dr. Jalindar R. Patil[2], Rajesh Ramchandra Nale[3]

[1] Post Graduation Student, Civil Engineering Dept., RMD Sinhgad School of Engineering, Pune, Maharashtra, India

[2] Head of Department, Civil Engineering Dept., RMD Sinhgad School of Engineering, Pune, Maharashtra, India

[3] Post Graduation Student, Civil Engineering Dept., RMD Sinhgad School of Engineering, Pune, Maharashtra, India

---***---

Abstract - *The construction industry is labour intensive and construction work is conducted in risky and dangerous situations. The importance of construction automation has grown rapidly in developed countries. In developing countries, the construction industries need automation technologies such as new machineries, electronic devices etc. The infrastructure project requires more numbers of skilled labour, good quality of work, increased productivity etc. The problems associated with construction work such as decreasing quality of work, labour shortages, safety of labour and working condition of projects. To overcome these problems new innovative technologies such as automation which has the potential to improve the quality, safety, and productivity of the industries must be implemented. Productivity is also a key issue in the construction sector which needs to be increased twice as compared with the present rate. Automation will improve not only the productivity but also take humanity into consideration and be harmless to the global environment. In recent times, the demanding construction requirements and shortage of skilled labours have made automation a viable alternative.*

In developing countries, a lot of work load is dependent on the workers and labours. Also all these labours are not the skilled ones or trained properly, but still the construction activities are carried out by the old traditional ways. So, to mechanize the construction skilled labours with proper work training is necessary. With the help of these skilled labours, the various construction activities may be performed with accuracy. When there are skilled labours, then the automated machineries can be utilized with full extent.

After making a field survey of the ongoing road works, in this paper a proposal of a certain level of automation that needs to be bought will be implemented. This will increase the constructional activities output and lower the labour cost to some level. By implementing gradual automation, there will be a better construction productivity as compared with the current scenario.

It finally concludes that road construction and maintenance tasks have a significant potential for gradual automation due to the repetitiveness and relatively moderate sensory requirements of many tasks. Ultimately, integrated, multitask systems should be feasible once single-purpose automated equipment proves successful.

Key Words: Automation, technology, infrastructure, productivity, etc.

1. INTRODUCTION

Construction is one of the major industries around the world. Construction industry is labor-intensive and construction works performed in dangerous or risky situations because of many problems associated with labours like education, skill, experience, human tendency, strike, etc.[6] Hence, the importance of construction automation has grown rapidly. Applications and activities of automation in this industry started in the early 90s aiming to optimize equipment operations, improve safety, enhance perception of workspace and furthermore, ensure quality environment for construction works.

Construction productivity on large projects, including road construction, has been constant or declining since the 1970s. This has been coupled with a dramatic increase in construction labor cost and shortage in funding for new road construction and maintenance. At the same time, highway construction costs have been increasing, even after correcting for general inflation. [9] One viable solutions is partial or full automation in road construction. [8]

The primary contribution of automation in construction is the development of a comprehensive, multidimensional analysis of costs and benefits associated with a specific automation application. [4] Automation is particularly germane due to the relative simplicity, repetitiveness, and large volume of work involved with roadways. Since, today's construction projects are characterizing by short design and construction period, increased demands of quality and low cost. These

problems can be approached by a flexible automation using robots based on computer assisted planning, engineering and construction management. Especially in high labor cost countries, automated and robotized construction technologies can compensate increasing demand on construction projects. [8]

Automated and robotized construction process lead to a continuous working time through the year. Introduction of robotic technology would result in better working and health conditions, and advanced mechatronics know how and skills. The reduction of construction and repair rehabilitation time would improve cost benefit analysis of construction project or critical maintenance activities likes in roads due to faster availability and return on investment.

In addition to any strictly financial benefits, an expected advantage of automated road construction equipment is improvement in work safety and health. In some instances, laborers will be completely removed from the work loop and thus prevented from being run over by the working machine or other vehicles. In other cases, the health hazards associated with the worker's proximity to carcinogenic materials may be reduced.

2. OVERVIEW OF AUTOMATION

For rapid construction with less risk and good quality there has been more and more use of machines as well as equipments in the construction industry. Human efforts and risks are reduced by using machines, robots, etc. at appropriate places. Since India has second largest man - power in the world, automation is not replacements of the human-power but is an important supplement that caters to the need of mega-construction and fast-track construction. Nowadays, in India, the human power is replaced by new technologies of automation because of unskilled labours, they do not give good quality work as compared to automation. Automation increases the productivity of the construction project, reduces the duration and laborious work, and increases the construction safety, increases the quality of work as compared to unskilled workers. [3]

The trend of single task automated machines is divided into two streams, one being the low cost tele-operated type. As construction work is less-repetitive, the alternative teach-playback type robot does not fit for construction applications. Another reason is that practically, low cost robots need to be developed. On the other hand, dramatic labour saving cannot be achieved by tele-operated type robots because these require operators.

The second stream is the fully automated system. These machines has laser sensors and a CPU which enables teaching, less operation. The robot measures the portion to be worked on by its laser sensor and then goes on performing the work on its own under the guidance of the operator.

2.1 AUTOMATION IN CONSTRUCTION

The project success from the project management's view point is achieved when the project is completed with the lowest possible cost, the highest quality, no accidents, etc. In other words, success means bringing each of the project performance indicators such as cost, schedule, quality, safety, labor productivity, materials consumption or waste, etc. to an optimum value. Applying automation and robotics in construction is addressed from the perspective of raising projects performance to serve the client and the environment.

Automation and robotics systems in construction industry may achieve the following advantages:

- Uniform quality with higher accuracy than that provided by skilled workers.
- Improving work environment as conventional manual work is reduced to a minimum, so the workers are relieved from uncomfortable work positions.
- Eliminating complaints about noise and dust concerning works such as removal, cleaning or preparation of surfaces.
- Increasing productivity and work efficiency with reduced costs.
- Higher safety for both workers and the public through developing and deploying machines for dangerous jobs.

2.2 METHODOLOGY FOR THE STUDY

The methodology implemented for the present study is as follows:

1. To observe the current methods adopted for the road construction through site survey.
2. To study the lacunas in the traditional methods after the observation.
3. To study the currently used machinery in the road construction works.
4. To study what level of gradual automation can be bought in current working conditions.
5. To implement various new automated machines that will reduce the manual work.
6. To study how the maintenance of the road works can be carried out.
7. To study the effect of automation on maintenance with respect to time, cost and outcome.
8. To identify the various areas where the unwanted manual works can be replaced by the automated works, and thereby reduce the labour costs to some level.

3. FIELD SURVEY

During field survey of the various road works, a lot of lacunas have been found and are discussed as follows:

1. The paver machines used for the laying of the wearing course for the construction of bituminous road was unchecked. Some parts of the machine were not functioning properly. (See Fig.1)

Fig.1: Unchecked Asphalt Paver Machine

2. The string line function in the paver that gives the required layer in millimeters (mm) was not functioning at all.
3. The paver was laying the bituminous concrete on the surface coarse in an uneven manner. (See Fig.2)

Fig.2: Uneven Paving of Surface coarse by Paver Machine

4. The bituminous aggregate was not being supplied to the asphalt paver continuously from the truck containing the material.
5. Due to slow feeding of bituminous aggregate to paver, its temperature was reducing.
6. Workers employed on the site were unskilled.
7. Few numbers of skilled labours of some category (shovelers/rackers/cleaners etc.) were missing from site.
8. Shortage of labours as compared to the minimum labours required for the work.
9. No safety personal protective equipments (PPEs) have been given to the labours.

10. No use of sign boards and barrications installed before the start of work.
11. A lot of people and children were disturbing the constructional work premises by interfering.
12. The excavation work that was being carried out was not done under supervision.

13. As shown in Fig.3, the backhoe loader (local name - JCB) excavated the road and also cut the wirelines of various domestic utilities.

Fig.3: Wirelines/Electricity cables cut off due to improper excavation by Backhoe Loader (JCB)

14. The blueprint showing the various internal pipelines, gas lines and wirelines were not checked from the competent authorities before starting the road works.
15. The excavation work is done improperly and hastily.

Fig.4: Improper levelling (dressing) at the subgrade layer

16. While laying of base and sub-base layers, the amount of material laid is less than determined design to reduce the construction cost.
17. The compactor is not rolled for the designed number of times, thereby reducing the strength of the road.

4. SUGGESTED AUTOMATION CONCEPTS

The above lacunas can be overcome in the near future in developing countries like India, by adopting Automation used in the developing countries, as discussed below:

- The Earthwork machines such as excavator, grader, asphalt paver, etc. should consist of the Laser – based sensor systems installed on it. By using this system, we get the required field data with the help of the laser sensors which acts alongside the working of machines. The field data is then displayed on the LCD screen to the operator, with the help of which he can make necessary adjustments in the machine before commencement of work.
- The earthwork machines used for the construction of bituminous roads should be fully equipped with required features and should be fully functional. (See Fig.5)
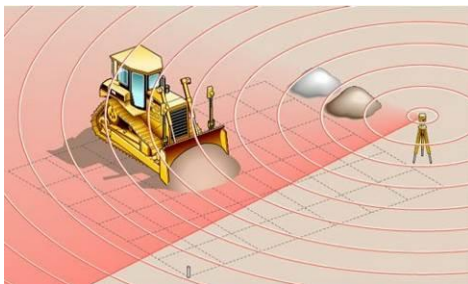

Fig.5: Laser – based systems that can be used in Earthwork Applications

- The asphalt paver machine should have the depth adjustment knob working, with the help of which the required depth of the asphalt layer to be laid on the road can be adjusted.

Fig.6: Laser based system used for road construction in Asphalt paver machine used in developed countries

- Laying of tack coat/prime coat should be done using the machines such as Bitumen Pressure Distributor. (See Fig. 7)

Fig.7: Bitumen Pressure Distributor

- Power broom machine or the Road sweeper should be used for the road cleaning before the laying of tack coat and prime coat, which will remove all the unwanted waste materials from the construction site.
- Paver should regulate the grade and the cross slope of the pavement.
- To know the underground profile before excavation, Ground Penetrating Radar System (GPRS) should be used to avoid cutting of live wire cables and pipelines if any. Using this machine, we get to know the underground profile of the area. Then the excavation work can be done easily without disturbing other things.

Fig.8: Ground Penetrating Radar System (GPRS)

- Releasing agents should be used in machines before using them to avoid sticking up of bitumen.
- There are machines like Mobile Hot Mix Plant and Mobile Concrete Plant, which can make availability of the fresh material on site.
- With the help of Mobile Hot Mix Plant, the bituminous concrete used on the site will be fresh without any contamination and will be maintained at required temperature till laying is complete.
- With the help of Mobile Concrete Plant, fresh concrete will be produced having less segregation and also the transportation cost and time will be reduced.
- Another machine, Pothole Repairing Machine, can be used to repair the potholes to maintain the road conditions.
- Fuel and oil leaks are also a major problem. Spot checks should be performed before paving.

5. CONCLUSIONS

The importance of implementing automation technologies is the need of today's infrastructure project and construction firms in order to increase the productivity and good quality of work. Both small and medium size firms require automation technologies partly or fully to implement in different sectors such as design, planning, on site construction etc.

It is important to maintain the correct relationship between the speed of processing and the speed of material delivery, which is essential for automation in construction industry. Although the robotic technology can benefit construction industry in many ways, it is not cheap, especially for application in the rugged outdoor environment.

The existing construction procedure is observed & concerned drawbacks & lacunas in existing construction procedure have been outlined. To achieve satisfactory road construction work with necessary quality and safety, we must follow the automation adopted by developed countries.

- As the machines used for construction work are not up to mark, they need to be upgraded with the newer machines with all the extra features in it.
- The work procedure, materials used, standard of quality etc. all should be done according to the recommended design.
- There should be a different committee for stricter supervision on the constructional works by their higher authorities to avoid use of inferior quality materials, inefficient machines, improper work procedures etc. all that are being followed nowadays.
- The operators shall be mandatorily trained under renowned construction companies (like VOLVO, CATERPILLAR, JCB, etc.) to gain proper knowledge and increase skills. They give information and training to the labour/operators/workers etc. to operate these automated machines and follow various techniques for speedy construction work.
- Necessary diversions, pathways, proper barrications and sign boards should be used before starting the work for safety purposes.
- All labours/operators/workers need to be fully equipped with Personal Protective Equipments (PPEs) before the commencement of any constructional activity.

There is a wider scope for automation in construction sector and its utilization of automation is growing rapidly since last decades.

REFERENCES

[1] Balaguer Carlos and Mohamed Abderrahim (2008), "Trends in Robotics and Automation in Construction", Robotics and Automation in Construction, Carlos Balaguer and Mohamed Abderrahim (Ed.), ISBN: 978-953-7619-13-8, InTech

[2] Bock Thomas (2007), "Hybrid Construction Automation And Robotics", 24th International Symposium on Automation & Robotics in Construction (ISARC 2007) Construction Automation Group, I.I.T. Madras

[3] Chaitanya Goyal (2012), "Automation and Robotics in Construction: Applications, Advances and Challenges", The Masterbuilder www.masterbuilder.co.in

[4] Elattar S.M.S. (2008) "Automation and Robotics in Construction, Opportunities and Challenges", Emirates Journal for Engineering Research, Vol. 13(2),p. 21-26

[5] Nashwan Dawood and Serafim Castro (2009), "Automating Road Construction Planning With A specific-Domain Simulation System" Journal of Information Technology in Construction - ISSN 1874-4753   www.itcon.org

[6] Ramanathan Mohan (2007), "Concept to Position and Enhance Automation Technologies in Emerging Construction Markets", 24th International Symposium on Automation & Robotics in Construction (ISARC 2007) Construction Automation Group, I.I.T. Madras

[7] Russell Jeffrey S. and Kim Sung-Keun (2003), "Construction Automation", by CRC Press LLC

[8] Sonjoy Deb (2013), "Automation and Robotics Based Technologies for Road Construction, Maintenance and Operations", The Masterbuilder www.masterbuilder.co.in

[9] Skibniewski Miroslaw and Hendrickson Chris (1990), "Automation and Robotics for Road Construction and Maintainance", Journal of Transportation Engineering, Vol. 116, No. 3,May/June, 1990. ©ASCE

BIOGRAPHIES

Mr. SAMEER JAVED MOMIN

B.E. (V.P.C.O.E., Baramati, Pune), Pursuing M. E. in Construction and Management, (RMD Sinhgad School of Engineering, Warje, Pune)
Email ID:
samu_050590@yahoo.co.in

Dr. JALINDAR R. PATIL

B.E., M.E., Ph.D. (Engg.: Civil-Geotechnical, National Institute of Technology, Warangal), MISSMGE, FIGS, MIRC, MISTE, MISRMTT, Professor of Civil Engineering, RMD Sinhgad School of Engineering, S.No.111/1, Warje, PUNE, 411058 M.S. INDIA, Teaching and Administrative Experience of 24 years and 3.5 years of experience of Research, Published more than 35 international/national papers in journal and conference, Received 3 merits and awards at national level.
Email ID:
jalindarrpatil@gmail.com

Mr. RAJESH RAMCHANDRA NALE

B.E. (R.I.T., Sakharale, Islampur, Sangli), Pursuing M. E. in Construction and Management, (RMD Sinhgad School of Engineering, Warje, Pune)
Email ID:
rajeshnale000111@gmail.com