

The Impact of Robotics and Construction Automation on Building Construction in Ethiopia: The case of Addis Ababa

Temesgen Yalew Baye (MSc)

Abstract— The construction industry is a major economic sector of any country. However, in Ethiopia it is associated with a number of deficiencies and low productivity. Other countries make significant use of building construction technology which helps to reduce time delays, increase quality, reduce the high cost of construction works and increase their productivity to please their customers. Conversely, most of the construction industries in Ethiopia depend on traditional approaches. Therefore, the objective of this study is to investigate the impact of Robotics and construction Automation system in the Ethiopian building construction industry. So, this study data was collected both from primary and secondary sources. The primary data was collected using interview. The secondary data was collected from various literature and other published and unpublished materials such as reports. The data collected was analyzed through narration, which was then presented using Tables. The major findings of the study revealed that the challenge of traditional building construction in Ethiopia is high risky and material wastage, longer time to complete a certain construction work, poor or absence of safety and health risks, tedious building construction process, repetitive and depending on labor(or labor intensive), the application of robotics and construction automation in Ethiopia building construction is the technology high initial cost, the approaches that requires technology to be transferred successfully, the technology replace of a lot of manpower, robotics and construction automation more use on excavation and structural works, the technology highly available, accessible of find mega projects, it used solve many problems, the Ethiopian contractors want use this technology, the role of technology to complete projects within better performance, quality and its time. Contractors who use the technology are accepted by the employer and it had shortage of manpower to operate this technology but solved the problem. Moreover, the impact of robotics and construction automation on building construction in Ethiopia is require high initial cost, the technology is best role towards saving time, eliminate frequent costs, it contribute reduce social hazards, minimize material wastage, it reduce safety and health risks and high interest of Ethiopian contractors to use this technology.

Index Terms— Addis Ababa city, Robotics, Construction Automation, Cost (initial cost and Cost overrun), Delay, Quality, Safety and health.

I. INTRODUCTION

Construction robots are a sub-set of industrial robots used for building and infrastructure construction at site [3]. These robots have to be able to move and fix itself to the working zone, handle construction materials and interact with humans and other machineries [2]. Automation in construction can occur at various phases of a project, beginning with the software-based design stage, continuing with automated aspects of off-site and on-site construction, and ending by sharing collected data on the systems and

energy use of finished buildings, where all are captured in cloud-based living models [1].

The Ethiopian Building construction also heavily depends on manual works or human power. This needs longer time to finish building construction which has cost implications. Conversely, the quality of the building construction is low when compared with construction robotics and automated systems.

The main objectives of this study include the following:

- To investigate the challenges of traditional building construction in Ethiopian
- To identify the application of robotics and construction automation in the Ethiopian building construction
- To investigate the impacts of robotics and construction automation in the Ethiopian building construction

This research focused on the impact of Robotics and Construction Automation on building construction in Ethiopia: the cause of Addis Ababa. In this study grade one General contractor and grade one Building contractor were selected for this research. which also select for this research includes government engineers and private engineers working on those institutions because of their superior knowledge, experience, skills and financial capacity.

So, the purpose of this paper is to show modernize the construction industry with technology and to have a trained workforce.

This title; “The Impact of Robotics and Construction Automation on Building Construction in Ethiopia” has not been published by scholars in Ethiopia, Africa or other continents. So, this research as to my knowledge may be the first in Ethiopia.

II. RESEARCH METHODOLOGY

This study was conducted in Addis Ababa, which is the capital city of Ethiopia and the African Union and is often called the "African Capital" due to its historical, diplomatic, and political significance for the continent.

The reason Addis Ababa was chosen for this study is a city with many primary building contractors, various construction activities and potential investors.

This study depended on both qualitative and quantitative data. The qualitative data and quantitative data were collected from the perceptions of the respondents including the contractors, consultants, clients (private and government stakeholders).

The Impact of Robotics and Construction Automation on Building Construction in Ethiopia: The case of Addis Ababa

Purposive sampling was employed in this study. Because, it allowed me to individually search, select and collect data on potential, best performing focusing group contractors and uses of robotics and construction automation, who have been working on Level-1 General Contractor and Level-1 Building Contractor. It also allows me, to identify and collect data from different building construction stakeholders (owners and consultants) according to their capabilities and the work they do.

Data through interview was collected from respondents. narration was used to analyze the data collected through interview. The analyzed data was presented using Tables.

To maximize reliability and validity of the variables in the study, special attention was given to the construction of the interview that is the wording of the questions and flow of alternatives and related issues was carefully examined during the designing of the question. Appropriate design and purposive sampling procedures was also considering carefully to maintain the quality of the study.

III. RESULT AND DISCUSSION

3.1. Socioeconomic Description and Response Rate of Respondents

3.1.1. Socioeconomic Description

Respondents	20-30	31-40	41-50	51-60
Clients	3	3	5	3
Contractors	8	9	3	1
Consultants	4	5	4	2

3.1.1.1. Age of Respondents'

Respondents	<8 grade	10 th or 12 th completed	Diploma	First degree	>first degree
clients	-	-	-	8	6
Contractors	-	-	2	11	8
consultants	-	-	-	6	9

1.1.1.2. Educational Status of Respondents'

Respondents	Years of experience in building construction project			
	0-10	11-20	21-30	31-40
Clients	2	3	7	2
Contractors	3	11	6	1
consultants	1	7	5	2

1.1.1.3. Experience of Respondents'

3.1.2. The number of respondents' participated in the interview

No	Respondents	Number of interviewees	Remark
1	clients	14	All are response
2	contractors	21	All are response
3	consultants	15	All are response

1.2. The challenges of traditional building construction in Ethiopian

According to the responses obtained from the respondents the challenges of traditional construction in Addis Ababa includes the following:

Traditional building construction is associated with high-risk and high-material wastage that does not meet the needs of the community. Because, the process of change and improvement is very slow. The most functional construction materials used are locally sourced raw materials. As a result, natural resources have been wasted during the construction process without any modification.

Traditional building construction in Ethiopia is that longer

time is needed to complete a certain construction work.

Traditional building construction is that it is associated with safety and health risks as most construction industries do not use precaution regarding safety, health, and environmental risks during building construction. And traditional construction process is not supported by technology and thus the building construction sector consumes more manpower than other sectors. Non-skilled manpower has greatly contributed to this sector. Consequently, workers in the traditional building construction are exposed to various health risks and hazards. E.g. lifting heavy weights and falling for persistent back pain to fall. Because, there are so many stumbling blocks and slips, ear pain due to noise, respiratory damage due to dust, eye problems due to radiation, cutting hand, etc.

Traditional building is labor intensive in its nature. Therefore, it requires a lot of manpower. Because of this, it is tedious. Because of its tediousness, traditional building constructions created project/construction delay. (Their daily outputs are minimal.) Traditional building construction is so repetitive.

Generally, the implication of all these challenges is that there is slow growth in the construction sector. This has associated with poor or low usage of modern technologies and systems in the construction industry. The construction sector wastes tremendous resources including time, human and financial resources. The construction industries are not starving to use new technologies so that projects can be completed shortly with the expected quality.

1.3. The application of robotics and construction automation in the Ethiopian building construction.

According to the responses obtained from the respondents the application of robotics and construction automation in the Addis Ababa building construction includes the following:

The technology needs high initial cost. But, robotics and construction automation is large in Addis Ababa. Because of their service value is large. Now a day, the contractors became consciousness about the significance of the technologies deployed in to different construction industries. We are using it. For this display: We are doing our best to deliver the project on time and at the desired quality. Therefore, we are getting better results in all three criteria (financial, time and quality parameters). Although the initial cost of robotics and construction automation is large; its rate of return is quick. The respondents also reported that allows us to use our time wisely and finish construction projects quickly. It also allows us to finish our work efficiently and effectively. This means it helps to reduce the workload and complexity of the project management.

According to the responses obtained from the respondents the use of robotics and automation in the construction industry by far replaces more human power, though it helps to complete works more quickly. Proportionally, this improves the quality of work. For example, if we want to dig 100m³, One-day laborer digs 2m³ a day. Therefore, 100m³ will be completed in 50 days. But one machine digs about 25m³ per hour. It will finish 100m³ in 4 hours. A one-day laborer is paid 300 birr per day. So, 300x50 = 15,000.00 Birr. But the machine costs 2,000 birr per hour.

So, 2000x4 = 8,000 Birr. Therefore, the respondents reported that the profit is calculated below:

- ✓ In cash = 15,000.00 - 8,000.00 = 7,000.00 Birr
- ✓ In timely= the technology works in one day; But a day laborer takes 50 days. So we used the technology to save 49 days.
- ✓ Quality level = when the machine is working by quality; but, the work done by a day laborer (manpower) will have quality problems. So, the work itself forces us to use the technology.

Therefore, it should be noted that after the completion of the work (after the building is completed), people will be employed in the service provided by the building. It can begin the intended service on time. It also starts earning money soon. It eliminates the ever-increasing price of goods. so, respondents said, the use of technology is very important at this time. In addition, by deploying this manpower to other sectors. And the construction sector using technology. So, it is important to complete the project on time and finish better.

All of the respondents (100%) considered in this study replied as they used the technology in excavation, foundation and structure. **But, they said, for finishing works it is rare.** According to the respondents the reasons for this is that the buildings that are currently under construction in our country are high rise buildings. They require a great deal of deep excavation work. Build shoring to prevent slip soil, make foundation work on this in-depth excavation, making grade beam to make column and when it rises to make slab. Therefore, the building rises up and it is very difficult to do this work with manpower. We often focus on the use of technologies in this work.

In order to understand the status of the availability of robotics in the construction automation in Addis Ababa respondents were asked about the availability of the robotics and construction automation.

- Accordingly, 48% of them replied that it is not yet available whereas 52% said it is available. The 48% respondents who responded their response by saying we could not find explained their reason by saying robotics and construction automation used for building construction are not manufactured and assembled in our country. They are all imported. This makes it difficult for them to get here in Ethiopia. Even those which were imported to our country are very small in number, it is very difficult to get it through rent.
- Whereas the 52% respondents who gave their response by saying we could find explained their reason by saying we have many years of experience in building construction and we pay special attention to technologies. Although we do not have many different machines; we have as many as we can. Even if we do not have the technology, we still have no problem working on rent.

By using the technology: Let's take a look at how they surprisingly solved two difficult problems.

Case study-1

One of the respondent said, it was a building construction project we were built in Addis Ababa. For construction work on the project, Partial Shoring or Soil protection was made. The project has 2 basements. More than 12 meters were dug and prepared for further work. But, we as lean

prepares to work concrete, we realized that more than 12 meters excavation was needed. So, when we dig the ground, the ground slipped through the unprotected soil. Therefore, the slipped soil should be cart way from the depth of 12 meters wanted to out the soil by manpower but it became impossible in terms of time and cost. This time we used technology as a solution. So, we did it by using a heavy-duty crane and back loader which required for the job to excavate pit through embedding it. So, by using the back loader, pushing slipped soil into the crane, soil has been lifted with a crane and by loading into a dump truck. It could be taken one month if manpower were employed. We finished using the machines in 8 hours.

Case study-2

One of the respondents said, it was a building project we were built in Addis Ababa. It is a high-rise building. The owner lives abroad. To complete the structure, we have given 5 months. The construction site will be located near the asphalt. Other buildings were built around it in three directions. This building covers 95% of the space. We only use 5% for office and store, because it has not extra space: We can't even find a small construction material deposit.

Therefore, the solution for this site is only using the technologies used for building construction. Accordingly, to keep the earth from being slip, we did shore by importing large machinery using an excavator, we dig up the soil and installed it on a dump truck because of this, and the excavation was completed without any problems.

After that, we adjusted the slopes and made Lynn concrete. We finished the metalwork. Read mix concrete using a vehicle concrete pump we used the asphalt for a while and filled it with concrete. Accordingly, we have successfully completed the above structure B+6+10 building in four months and 15 days we've done it. If it were a Traditional Building Construction Method, it was never finished done in such a short time.

So, to solve the problem of space congestion, to finish it in a short time, to do quality work, to reduce additional costs, to make the project management work more efficient. This is something that I understand and saw that using technology is important.

Also surprising: To make such buildings before: using a boring machine, excavator, loader and lift; it took one year and four months. But when we build this building, because we used different technologies; it only took us 4 months and 15 days.

All contractors and consultants want to use this technology, because they don't like to paying attention to the building construction. Further, they do not use it due to lack of adequate knowledge and capacity. However, we used the technology properly on those works that cannot be able to done by manual. They added that "We have been able to deliver the desired quality at the required speed by using the technology".

IV. CONCLUSION AND RECOMMENDATION

1.4. CONCLUSION

Traditional building construction methods are largely based on manpower, not technology. Therefore, traditional building construction method exposes many materials to

waste; it takes a long time to complete the work on time; the risk is huge in terms of safety, high health problem and to exposed the environment problem; it is tiring and boring; Unsuitable for operation and the high frequency of work. This is because the traditional building construction method is based on manpower and it requires a lot of labor. Based on this, human labor varies by hour, month, and year. This can lead to feelings of exhaustion, boredom, distraction, and apathy.

Therefore, the traditional building construction method is a waste of time, poor quality of work and high risk for the proposed project.

Considering the application of robotics and construction automation in Ethiopia's construction industry, technology requires a wide variety of species. To successfully complete the technology transition, we are bringing in foreign experts and informing them about the technology. So, the knowledge gap in the technology is being filled. This technology is successfully used in most excavation work, foundation work and structural work. However, it is providing insignificant services in the finishing work. Or they are not providing the services they are supposed to provide. By this reason, most of Ethiopia's building construction work is done with small tools, it does not stop using a lot of manpower. Robotics and Construction Automation Technologies are mostly found in Ethiopia. But except for finishing equipment. Robotics and construction automation technologies are available either purchased or leased in Ethiopia.

Therefore, contractors with this technology often have the opportunity to get more results or to get a direct job. The reason they choose or hire them directly is that the construction process is complex in nature and full of risks. So, using technology is the best solution to these problems. Therefore, most Ethiopian construction contractors do not have the knowledge to use this technology or because the initial investment cost of the technology is large. But, they want to use it.

Robotics and construction automation is providing various benefits in Ethiopia's building construction system. Among the benefits it gives are: saving time, reducing recurring unnecessary labor costs, reducing various hazards, and eliminating material waste. Also, although the construction process is complex in nature, it is easy to manage using this technology.

Therefore, robotics and construction automation is providing irreplaceable special benefits to Ethiopian building construction.

1.5. Recommendation

- ✓ It is well known that the traditional building construction system is the cause of the problems that are being built in our country. There are also contractors who still follow the traditional building construction process and are not up to date. Therefore, these contractors should be required to complete and deliver their projects in quality and on time. However, the government needs to facilitate long-term loans and enable them to buy and use the technology.
- ✓ To facilitate the implementation of robotics and construction automation; There is also a need for a

technologically advanced, educated and experienced workforce to make the sector a better place to grow. Therefore, qualified professionals should be brought into the system and trained qualified professionals should be trained. The government must also issue licenses to professionals trained in various technologies. This process allows to create a qualified professional who is responsible for the profession.

- ✓ Although the use of robotics and construction automation eliminates various risks. But robotics and construction automation requires a high initial cost. So, the government allows contractors to import duty-free and develops a legal framework, and the building construction law should understand the status of the technology and provide adequate implementation and management guidelines to control the use of imported technologies without selling them. It is also possible to produce technologies that can be easily produced in our country by professionally encouraging innovators and paying special attention to them. This will lower the current inflation.

REFERENCE

1. DAVIS, M. (2022) WHAT IS CONSTRUCTION AUTOMATION, AND HOW WILL IT DRIVE THE FUTURE OF BUILDING?
2. Feng, C., Xiao, Y. Willette, A. Megee, W. and Kamat, V.R. (2015). Vision guided autonomous robotic assembly and as-built scanning on unstructured construction sites *Autom. Construct.*, 59, pp. 128-138, 10.1016/j.autcon.2015.06.002Gharbia, M., Chang-Richards, A., Lu, Yuqian, Zhong-Ray Y. and Li, Heng. (2020-11-01). "Robotic technologies for on-site building construction: A systematic review". *Journal of Building Engineering*. 32: 101584. doi: 10.1016/j.job.2020.101584. ISSN 2352-7102.
3. Gonzalez, S. DE, Garcia Estremera and Armada. (2004). A service robot for construction industry *Proceedings World Automation Congress*, pp. 441-446.

Temesgen Yalew Baye (MSc), Addis Ababa, Ethiopia.