

Assessment of High Rise Building Construction in Addis Ababa City

Amanual Temesgen Mosie

Department of Construction Technology and Management, Institute of Technology, University of Gondar, Gondar, Ethiopia

Email address:

amanauel509@gmail.com

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Abstract: High rise buildings signify an element of the country's economic power and a sign of advantage to the country and also consumes a large number of people with a piece of land. Addis Ababa city is witnessing huge demographic expansion due to migration from surrounding rural areas, leading to urban stretch, housing demand, rise in the cost of land. Given this demand, though high rise structures have become a solution. When accomplishing these complex and huge high rise building structures, many problems affect the construction process. The objectives included an assessment of challenges, identifying the main factors which affect the construction process of high rise building construction. This research involves both qualitative and quantitative approaches for data collection and analysis. To gather quantitative data, survey questionnaires were administered to construction project teams namely; project managers, site Engineers, office Engineers, and resident Engineers. For qualitative approach; in-depth interviews were carried out to purposefully selected respondents. Lastly, data were collected from documents such as policy documents and reports of the Addis Ababa construction bureau. This study identified major challenges of high rise building construction during construction stage. The research result indicates that the major challenges of high rise buildings during construction includes cost overrun, delay, safety risks, and vertical transportation of materials and manpower. The main cause or variables of delay are Design changes, materials shortage, poor labor productivity, inadequate planning, equipment shortage, inaccurate prediction of equipment and craftsmen production rate, skilled labor shortage, and inaccuracy of materials estimate. The major causes of cost overrun of high rise building projects are; materials cost increased by inflation, inaccurate quantity take-off, lack of experience of project type are the major causes of cost overrun of high rise building projects. Safety factors are classified into three categories. Working environment, work at high elevation, and inadequate safety protection are the principal factor of safety at work in high rise building construction. The outcome of study helps the construction stakeholders and as a whole the construction industry to understand the actual factors of high rise building construction.

Keywords: High Rise, Cost Overrun, Delay, Safety, Vertical Transportation

1. Introduction

1.1. General Background

A high rise building is a multi-story structure in which most occupants depend on elevators or lifts to reach their destinations. For a building to qualified as a high rise building its height exceeds 36 m or more than 12 floors and to be qualified as a skyscraper, a height of approximately at least 150 meters are often used as a criterion [1]. A current trend in modern cities all over the world is the development of high-rise buildings, mainly to overcome the challenges of urban over population, for optimal use of scarce land

resources, as status symbol, as tourist attractions and for beautiful skylines [2]. Due to the scarcity of land because of rapid growth of the population, people are unable to reach their demand by which the high rise buildings are being constructed to fulfill the demand of the people. As this high rise buildings are providing the best living facilities for the people with better facility [3]. Ethiopian population is growing fast due to that the demand for housing is increasing; because of this and other reasons construction of high rise buildings in our capital city Addis Ababa is increasing. High rise building is well designed structure which needs a deep investigation, pre-plan, pre-engineering work, final of design and plan, construction and execution. In

this process the other factors, one shouldn't forget to remember is construction time, cost, safety, and quality assurance [4]. This research examines the current trend of high-rise building development its challenges during construction in Ethiopia, taking Addis Ababa the capital city, as a case study. It is a generally accepted fact that one of the greatest challenges facing the Addis Ababa city today is the provision of housing both in quantity and quality. With Ethiopia is being one of having populous nation in Africa, there is a dire need for greater awareness of the opportunities that exist in the use of high-rise buildings and to find out what the situation currently on the ground is and what is needed for improvement [5].

1.2. Statement of the Problem

The importance of housing to national development in general and that of Addis Ababa in particular cannot be overemphasized. In this regard, there exist a number of problems associated with housing. The continued migration of this economic nerve center of the country as well as the rapid growth of Addis Ababa city over the years are casual factors of rapid urbanization. One of the consequences of this rapid urbanization is housing shortages [5]. With more attention shifting towards the development of high-rises in Addis Ababa there is an urgent need to examine the strong influence or impact of this modern structure. High-rise building construction period is long, the work high above the more, the construction difficulty is high, the big workload and complicated technology. As a result, the vertical transport, high safety, fire prevention, communications, water, and the processing of construction waste problems become one of the characteristics of the high-rise building construction. High-rise building construction period is generally long, the huge manpower, material consumption, the staff and the engineering quality put forward higher requirements [6]. High-rise buildings development is known to be problematic and difficult to handle right from conception to the completion and occupation stage. Each stage has its own challenges which requires an independent solutions as it occur or anticipated [7]. Since high rise building construction needs specialized professionals to design, to construct, and to manage; highly mechanized equipment's; and the large amount of budget to perform, most of high rise projects in Addis Ababa city are not completed within the specified time and limited budget.

1.3. Objectives

1.3.1. General Objective

The General Objective is to assess the overall practice of high rise building construction in Addis Ababa city.

1.3.2. Specific Objectives

Specific Objectives of the study are:

- 1) To identify the key challenges of high rise building construction;
- 2) To identify the Causes for the key challenges of high rise building construction.

2. Literature Review

Different scholars come up with different definitions of high rise buildings. For this research a high rise building is defined as its height greater than 12 floors or 36 meters above ground level. The history of high rise building starts from at the early with the pyramids of Egypt and the tower of Babel [8]. The modern high rise building started in America in 1931 [9]. High rise buildings have several advantages for one's country by occupying large people in a single building and saving land of a city [10]. The major difficulties or challenges of high rise buildings during construction includes vertical delivery challenges, safety related challenges, construction delay, and cost overrun [11-14]. The use of tower cranes during tall building construction is even more challenging because the increasing height adds problems of visibility, wind load and safety issues for the operator [12]. Even though different local scholars tries to assess the practice of high rise building related with safety, construction time, and construction cost for different projects still a completed and somehow conclusive evaluations of the effectiveness of the construction of high rise buildings especially vertical transportation of materials and man power on the overall performance of the projects need to be assessed.

3. Methodology

This research involves both qualitative and quantitative approaches for data collection and analysis. To gather quantitative data, survey questionnaires were administered to Construction Project teams, namely, Project Managers, Site Engineers, Office engineers, and Resident engineers. For qualitative approach, in-depth interviews were carried out to purposefully selected respondents. In addition, observation was used. Lastly, data were collected from documents such as policy documents and reports of the Addis Ababa construction bureau.

4. Results and Discussion

4.1. Key Challenges of High Rise Building Construction

Table 1 shows that the major challenges of high rise building construction in Addis Ababa City. In this research mean score of greater than 3 (MS greater than 3) are considered as the most common challenges and factors of high rise building construction which have observed by the respondents'. Cost overrun ranks first with the mean of 4.16, delay is the second challenge with a mean of 3.89, safety ranks third with a mean of 3.76 followed by vertical transportation problems with the mean of 3.6.

The major challenges of high rise building construction are cost overrun, delay, safety, and vertical transportation related problems. Since these are the main constraints of any building construction, continuous supervision and improvements must be done. Time delays and cost overruns usually lead to adverse effects on the contractor's performance and investor's profitability, contribute to major

financial losses, and hold back the development of the construction industry. Vertical transportation of manpower

and materials also must be given attention to keep the safety of the employees in the construction of high rise buildings.

Table 1. Challenges of high rise building construction in Addis Ababa City.

No	Challenges of high rise building construction	PM	SE	OE	RE	Average	
		MS	MS	MS	MS	MS	R
1	Delay of a project	4	3.93	3.75	3.88	3.89	2
2	Safety risk factors	3.62	3.86	3.69	3.88	3.76	3
3	Cost overrun	4.15	4.07	4.06	4.35	4.16	1
4	Vertical transportation of material and man power problems	3.46	3.64	3.5	3.94	3.64	4

Note: PM means Project manager; SE- Site Engineer; OE- Office Engineer; RE- Resident Engineer; MS- Mean square and R is rank.

4.2. Causes for the Key Challenges of High Rise Building Construction

4.2.1. Causes of Time and Cost Overruns in High Rise Building Construction

Since cost overrun and delay are the major challenges of the construction of high rise buildings, identify the main causes are very essential. Therefore the following causes of cost overrun and delay of high rise building projects in Addis Ababa city are identified. Table 2 shows the major causes of cost overrun of high rise building projects; materials cost increased by inflation, inaccurate quantity take-off, and lack of experience of project type, are the major causes of cost overrun of high rise building projects.

Materials cost increased by inflation: - inflation as a general rise in the price level in an area over a certain period of time. The construction of high rise buildings needs much time, which leads the fluctuation or inflation of construction materials. The cost of construction materials is

higher relative to other parts of high rise buildings. Therefore the inflation of construction materials highly affects the cost of the building.

Inaccurate quantity take-off: - The construction stakeholders must understand and make an appropriate estimation of all the activities in terms of time and cost before taking part in the tender process. This ensures a proper estimation of the costs and requirements for the materials and will also give an indication of the labor costs involved in the installment or construction materials. If the estimator fails to do the accurate take off, the actual cost of the building will be increased.

Lack of experience of project type: - high rise building construction in Ethiopia is an infant stage. The construction firms didn't have experience in the construction of high rise buildings which needs sophisticated equipments and highly experienced man powers. Lack of experience in high rise building construction leads to incur additional costs without the plan of the project.

Table 2. Causes of cost overrun in high rise building construction.

No	Variables/causes of cost overruns	PM	SE	OE	RE	Average	
		MS	MS	MS	MS	MS	R
1	Unpredictable weather conditions	1.85	2.86	1.94	2.76	2.35	6
2	Materials cost increased by inflation	4.69	4.43	4.63	4.41	4.54	1
3	Inaccurate quantity take-off	3.08	3.50	3.19	3.71	3.37	2
4	Lack of experience of project location	2.69	3.03	2.75	3.21	2.92	4
5	Lack of experience of project type	2.77	3.43	2.94	3.47	3.15	3
6	Lack of experience of local regulation	2.67	2.78	2.88	3.08	2.85	5

Table 3 shows the major causes of delay of high rise building projects. Design changes, materials shortage, poor labor productivity, inadequate planning, equipment shortage, inaccurate prediction of equipment and craftsmen production rate, skilled labor shortage, and inaccuracy of materials estimate constituents the major causes of delay of high rise building projects.

Design changes: - Design changes caused rework in construction projects while rework is the prevailing cause of loss in productivity. Design changes inevitably lead to variation in original cost/time programs [14]. This condition is also becoming a trend in Addis Ababa construction projects which leads delay of the construction projects.

Inadequate planning: - Planning is the basis for the project execution. Good planning will ensure that the resources are ideally utilized. Improper planning will result in the

assignment of redundant tasks, thus increasing the cost and time taken to complete a project.

Equipment shortage: - high rise building construction needs highly advanced and sophisticated equipments and machineries. These equipments are essential for the timely completion of these huge projects. Most of the construction projects in Addis Ababa are more labor intensive rather than equipment. This highly affects the duration of a project.

Inaccurate prediction of equipment and craftsmen production rate: - understand the accurate productivity rate of construction equipment and craftsmen is vital for the estimation of the construction schedule. The total schedule of a project is determined by the duration of each activity which is accomplished by different construction equipments and craftsmen. Therefore the production rate of these equipments and man powers affects the total duration of the project.

Skilled labor shortage: - Due to the lack of skilled laborers on job sites, it's taking more time for structures to be completed. One way that firms are trying to optimize their construction schedules is by offering overtime hours to their employees.

Inaccuracy of materials estimate: - The appropriate type, number, and quality of the construction material shall determine within the specified time. If this is not done before the projects started the project faces delay due to additional material delivery.

Table 3. Delay causes in high rise building construction.

No	Variables/causes of delays	PM	SE	OE	RE	Average	
		MS	MS	MS	MS	MS	R
1	Unpredictable weather conditions	2.00	3.07	2.25	2.65	2.49	8
2	Inaccuracy of materials estimate	3.00	3.43	3.13	3.53	3.27	6
3	Inaccurate predictions of equipment and craftsmen production rate	3.23	3.36	3.31	3.53	3.36	4
4	Equipment shortage	3.38	3.93	3.44	3.71	3.61	3
5	Skilled labour shortage	3.31	3.36	3.31	3.35	3.33	5
6	Locational restrictions of the project	2.92	2.79	2.81	2.88	2.85	7
7	Inadequate planning	3.69	3.64	3.75	3.71	3.70	2
8	Design changes	4.38	4.07	4.19	3.71	4.09	1

4.2.2. Safety Problems in Construction of High-Rise Buildings

The following table's shows safety factors of high rise buildings. These safety factors are classified into three categories. Working environment, work at high elevation, and inadequate safety protection are the principal factor of safety at work in high rise building construction. Table 4 indicates the first principal factor that is working environment factors which affect the safety of construction workers in high rise building construction. Heavy objects fall from height, inadequate site lighting and ventilation, strong wind when work at height, and Emotional stress, fear and anxiety are the major safety factors with the mean of 3.42, 3.37, 3.10, and 3.03 respectively.

Heavy objects fall from a tall stack of materials: - Objects have the potential to fall onto or hit people in the workplace or adjoining areas if precautions are not taken. Adjoining areas could include a public footpath, road, square or the yard of a dwelling or other building beside a workplace.

Equipment, material, tools and debris that can fall or be released sideways or upwards are also considered as falling objects.

Inadequate site lighting and ventilation: - Ventilation is one of the most important engineering controls available for maintaining the quality of the air in the occupational work environment. The absence of adequate light in the working areas will expose to an accident. Therefore, inadequate light and ventilation in high rise building constructions is the cause for safety risks.

Strong wind when work at height: - The power of wind loads becomes increase when the height of the building increases. If the employees of the project are working at the height of the building during wind actions may happen in an accident.

Emotional stress, fear and anxiety: - Working at higher elevation makes discomfort for employees, especially when all the personal protective equipments are not fulfilled. Therefore the workers can't work fully with their full confidence and their productivity rate becomes decreased.

Table 4. Working environment factors.

No	Safety risk factors due to environment	PM	SE	OE	RE	Average	
		MS	MS	MS	MS	MS	R
1	Ladder propped against a wall	2.83	2.86	3.00	2.94	2.91	5
2	Emotional stress, fear and anxiety	3.00	3.00	3.13	3.00	3.03	4
3	Strong winds when work at height	3.00	3.14	3.20	3.06	3.10	3
4	Exposed electrical wires	3.17	2.57	3.27	2.59	2.90	6
5	Excessive noise from equipment and machineries	2.67	2.57	2.73	2.76	2.68	9
6	Dust from soil, stone or concrete	3.25	2.36	3.20	2.47	2.82	7
7	Work with loose materials at height	3.08	2.43	3.13	2.24	2.72	8
8	Heavy objects fall from a tall stack of materials	3.50	3.36	3.60	3.24	3.42	1
9	Inadequate site lighting and ventilation	3.25	3.36	3.27	3.59	3.37	2

Table 5 shows safety factors that have arisen from work at high elevation. The major safety factors from this principal factor includes; improper safety-net system, failure to secure heavy materials during lifting, and fall from height respectively with their mean value.

Improper safety-net system: -Safety net systems are provided in the construction of high rise buildings in order to prevent people in the construction site as well as the neighbor

of the building projects. Literatures found that fall from height is among the predominant accident cases in high rise building construction [15]. This analysis suggests that sufficient and proper safety net system is very crucial to ensure no chance of objects falling off the perimeter of building.

Failure to secure heavy materials during lifting: - Lifting operations in construction occur during transportation of

material from the storage place to the place where it is being processed, and during the processing of materials. A load includes any material or people that are lifted or lowered by lifting equipment. During this operation materials shall be secured appropriately in order to keep their position until it reaches its final position.

Fall from height: - falls from height are a leading cause of death and serious injury in the construction industry. Temporary structures which support the construction employees and materials shall be provided properly and the workers also shall wear personal protective equipments including safety harness in order to keep themselves from falling.

Table 5. Safety factors due to working at high elevation.

No	Safety risk factors due to work at high elevation	PM	SE	OE	RE	Average	
		MS	MS	MS	MS	MS	R
1	Structural collapse	2.15	1.57	2.31	1.82	1.96	4
2	Fall from height	3.54	2.93	3.56	2.94	3.24	3
3	Improper safety-net system	3.62	3.64	3.69	3.59	3.63	1
4	Failure to secure heavy materials during lifting	3.46	3.64	3.56	3.71	3.59	2

Table 6 shows safety factors which arise from inadequate safety protection. The major safety factors for this principal factor are; unprotected shaft or hole, unprotected outside edge of a slab or balcony, fix scaffold without adequate fall protection, and exposed sharp edge of a reinforcing bar or mesh respectively with their mean value.

Unprotected shaft or hole: - Unprotected openings in floors and shafts are serious hazards and put employees at risk of injury from falling. A building shaft is a continuous vertical space substantially enclosed on all sides that extends to two or more floors, and includes elevator shafts, ventilation shafts, stairwells and service shafts.

Unprotected outside edge of a slab or balcony: - Unprotected outside edges, slabs and openings pose a serious safety hazard. Edges, holes and openings shall be protected

by covering or the installation of guardrails that will physically restrain personnel near the opening.

Fixed scaffold without adequate fall protection: - According to OSHA, employers must provide fall protection for each employee on a scaffold more than 3.1 meters above a lower level. A competent person must determine the feasibility and safety of providing fall protection for employees erecting or dismantling supported scaffolds.

Exposed sharp edge of a reinforcing bar or mesh: - exposed sharp edges of reinforcement bars or meshes causes accidents like piercing and cutting off employees during construction or transportation.

This sharp edges must be covered with materials which prevent any accident to the workers of the construction.

Table 6. Safety factors due to inadequate safety protection.

No	Safety risk factors due to Inadequate safety protection	PM	SE	OE	RE	Average	
		MS	MS	MS	MS	MS	R
1	Unprotected outside edge of a slab or balcony	3.62	3.79	3.69	3.82	3.73	2
2	Moving construction equipment and machineries	2.77	2.85	2.95	3.00	2.89	5
3	Exposed sharp edge of a reinforcing bar or mesh	3.38	3.14	3.50	3.29	3.33	4
4	Fixed scaffold without adequate fall protection	3.46	3.43	3.50	3.71	3.53	3
5	Unprotected shafts or hole	3.46	3.93	3.50	4.06	3.74	1

4.2.3. Vertical Delivery Challenges in High Rise Building Construction

The main factors which affect the transportation of construction materials and that of manpower are identified in table 7. The major factors which affect the construction process of high rise buildings are communication difficulties at the height of the building, insufficient space to fix tower cranes, Concrete pump line blockage due to the pipeline itself with a mean of 3.63, 3.33, and 3.21 respectively.

Difficult to communicate from the top of the building to the ground: - since the height of the buildings is high, the communication means is by using electronic media. These Medias may include radios and telephones. In Most high rise building construction projects in Addis Ababa the way of communication is very backward and difficult to accomplish activities within the time and specified quality. Messages sent through a piece of paper from the height of a building to the

ground and vice versa during construction.

Insufficient space to fix tower cranes: - High rise building projects in Addis Ababa are much congested which makes difficult to fix heavy equipments especially tower cranes. Tower cranes needs much space in order to install with a suitable position. Some of the construction projects in Addis Ababa installed tower cranes in public roads which obstacles the traffic of the city.

Concrete pump line blockage due to the pipeline itself: - One of the major problems of vertical transportation is blockage of pipe lines during casting of concrete. From site observation and interview the pumping machines which are used in Addis Ababa construction projects had less horse power capacity which makes difficult to reach concrete at higher elevations. And the way of cleaning of pipelines is not efficient to clean the whole parts which may cause to harden concrete inside the pipes and finally makes blockages during concrete casting.

Table 7. Factors of vertical transportation of materials and manpower.

No	Factors of vertical transportation	PM	SE	OE	RE	Average	
		MS	MS	MS	MS	MS	R
1	Concrete pump line blockage due to wrong mix	2.77	2.64	2.69	2.71	2.70	4
2	Concrete pump line blockage due to the pipeline itself	3.11	3.21	3.81	2.71	3.21	3
3	Concrete pump line blockage due to operator error	2.54	2.64	2.50	2.71	2.60	5
4	Slump loss of concrete	2.08	2.93	2.19	2.71	2.48	6
5	Insufficient space to fix tower cranes	3.54	3.41	3.44	2.94	3.33	2
6	Difficult to communicate from the top of the building to the ground	3.77	3.64	3.56	3.53	3.63	1

5. Conclusion

The major challenges of high rise building construction include cost overrun, delay, safety risks, and vertical transportation of materials and manpower. The main cause or variables of delay are Design changes, materials shortage, poor labor productivity, inadequate planning, equipment shortage, inaccurate prediction of equipment and craftsmen production rate, skilled labor shortage, and inaccuracy of materials estimate. The major causes of cost overrun of high rise building projects are; materials cost increased by inflation, inaccurate quantity take-off, lack of experience of project type are the major causes of cost overrun of high rise building projects. Safety factors are classified into three categories. Working environment, work at high elevation, and inadequate safety protection are the principal factor of safety at work in high rise building construction. Safety risk factors due to working environment include; heavy objects fall from height, inadequate site lighting and ventilation, strong wind when work at height, and Emotional stress, fear and anxiety are the major safety factors. Safety risk factors due to work at high elevation include; improper safety-net system, failure to secure heavy materials during lifting, and fall from height. And safety risk factors due to inadequate safety protection include; unprotected shaft or hole, unprotected outside edge of a slab or balcony, fix scaffold without adequate fall protection, and exposed sharp edge of a reinforcing bar or mesh. The main factors which affect the transportation of construction materials and that of manpower are communication difficulties at the height of the building, insufficient space to fix tower cranes, and concrete pump line blockage due to the pipeline itself.

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