International Journal of Innovative Research & Growth
A Peer Reviewed Journal
ISSN: 2455-1848
Journal homepage: http://www.ijirg.com/ijirg/
Volume: 10 Issue: 9, July 2021

Prefabrication and modular coordination and cost reduction in housing construction (a case in Addis Ababa condominiums)

Beimnet Kassaye Beyene[1*] , Rajendra Kunwar[2]
[1]Faculty of Architecture, Arbaminch University, Arbaminch, Ethiopia
[2]Faculty of Architecture, Arbaminch University, Arbaminch, Ethiopia
E-mail: beimnetkassaye@gmail.com, architectkunwar@gmail.com
* Corresponding Author

Article Info
Received 20 May 2021
Received in revised form 05 June 2021
Accepted for publication 20 June 2021
DOI: 10.26671/IJIRG.2021.9.10.101
Citation:
Beyene, B. K., Kunwar, R. (2021). Prefabrication and modular coordination and cost reduction in housing construction (a case in Addis Ababa condominiums). *Int J Innovat Res Growth*, 10, 39-47.

Abstract
The main aim of this study is to investigate the hindrances of IHDP condominium construction focusing on Cost aspects and demonstrate how prefabrication and dimensional coordination could be used as a tool to reduce cost in Ethiopian housing projects. The researcher used both quantitative and qualitative research approaches. The sample design was selected by using a purposive selection technique. Both primary and secondary data sources were utilized in which primary data were gathered from interviews with concerned bodies involved in condominium design and construction authorities, and observation of condominium sites. Secondary data comprises information collected from diverse professional literature and documents which are also presented in addition as a desktop case study. Analysis was made on the current cost reducing strategies mainly the partial prefabricated elements used and their impact in terms of cost reduction. In addition, existing condominium layout plans are also analyzed in terms of modular coordination. Study revealed that, proper implementation of prefabrication leads to incremental advantages. Thus, the following recommendation suggested that basic considerations while redesigning condominium layout for prefabrication with modular coordination are forwarded on the scale of this thesis.
Keywords: - Prefabrication, Modular coordination, Modular construction

1. Introduction

Ethiopia is one of the developing countries and the second most populous country of the African continent. In 2020, 21.7% of the Ethiopian population lives in urban areas. The annual rate of urbanization is estimated with 4.63% for the period 2020 – 2025[1]. This implies that the urban population in Ethiopia is increasing rapidly. The 2007 Ethiopian Population and Housing Census disclosed that at least 15 million residents are living in the urban centers. Also, according to official figures from the Ethiopian Central Statistics Agency, the urban population is projected to nearly triple from 15.2 million in 2012 to 42.3 million in 2037. Addis Ababa, the capital, is still the major urban area with a population of 3.238 million in 2015, but other cities and towns have also grown rapidly[2]. The central challenge for the Ethiopian Government is to ensure that cities are attractive places for working and living. The demands of growing numbers of urban residents are not met in three areas, being the provision of jobs, infrastructure and services, and housing. Ethiopian standards for formal housing are unaffordable for a large segment of the urban population. The lack of sufficient affordable housing, combined with poor quality construction and cost barriers, such as condominium down payments, belong to the major housing challenges[3]. The federal government recognized the significant need to improve housing conditions, and implemented the Integrated Housing Development Program (IHDP) for condominium construction. In the first phase of the IHDP totally 244,436 units were completed. 170,000 were in Addis Ababa. During the current phase of the program, the government plans to build 50,000 units per year in Addis Ababa. The Integrated Housing Development Program, as currently designed, faces challenges to reach the priority population groups[4]. After the first phase, the program was suspended in all cities except Addis Ababa due to high costs. Even in Addis Ababa, the smallest and most subsidized condominiums are unaffordable for low-income households. In Addis Ababa, the unit cost of construction for IHDP condominiums has been steadily rising, from 1000 ETB per square meter in 2005 to over 3000 ETB per square meter in 2014, which keeps uprising continuously[4]. In addition to high cost, also the construction quality of the IHDP condominiums can be defined as

substandard. As stated in the report[4], this results from the urgency to satisfy the pressing housing demand, unprofessional contractors of small & micro enterprises, and poor workmanship, causing wastage of material and financial resources, and delays in construction time. In turn, it contributes to higher cost for the government and future apartment owners, and leads to unsustainable buildings with high maintenance needs during the building's lifecycle.In general, the Ethiopian construction industry is described as shallow, in spite of the rapid and continuous economic growth of the country, and also considered as technologically traditional. Production and execution are still made on site, and new fast and cost-effective alternatives should be utilized, whereby off-site production and on-site assembling is mentioned as a possible tool[5]. How the proper introduction of Prefabrication and the application of Modular Coordination could contribute to construct better quality and cost-efficient buildings will be discussed in this study on the case of IHDP condominium building.

2. Problem Statement

Ethiopia is challenged with a huge housing need and the government is trying to meet the demand with the implementation of the integrated housing development program (IHDP). Thousands of condominiums are already constructed all over the country during the first phase of the program; the current phase will only be realized in Addis Ababa. This is because the IHDP, as currently implemented, faces challenges to reach the target groups, and was suspended in all other cities due to high costs and slow take-up[3][4]. Increasing costs makes housing unaffordable for the majority of the population. Poor construction quality, leads to higher lifecycle cost, more maintenance and material demand. High material wastage, due to traditional construction technology and unskilled labor, result in increased material consumption, which means more material needs to be produced and transported, and the huge amount of construction waste needs to be disposed to landfills. Both, high material consumption and increased construction waste, are affecting the environment and contributing to climate change. The construction of IHDP has failed to fully integrate technologies and processes that can contribute to an improvement in performance and productivity by reducing cost. Though there are some innovative practices, such as construction with the mix of in-situ and pre-cast reinforced concrete frame structure with masonry infill walls and usage of standard size of materials throughout the project, their impact is very negligible compared to the scale of housing constructed [4]. The growing awareness of environmental, social and economic problems, associated with conventional construction technology, led across the world to the search and adaption of more sustainable building practices. Prefabrication is recognized as such tool with the potential to promote sustainable building construction, but it is currently unclear what would be the critical success factor to let prefabrication succeed in the Addis Ababa condominium housing construction projects.

3. Research Questions

1. What characterizes the cost reduction strategies of condominium housing constructions in Addis Ababa, Ethiopia?
2. What are the advantages and drawbacks of the partial-prefabricated elements used in the condominium housing projects?
3. How can prefabrication and dimensional coordination be implemented to reduce cost in Addis Ababa condominium housing construction Projects?

4. Objective

To investigate the hindrances of IHDP condominium construction focusing on cost aspects and demonstrate how prefabrication and dimensional coordination could be used as a tool to reduce cost in Ethiopian housing projects.

5. Literature Review

Approaches aimed at achieving housing affordability can be seen with two categories. The first one is cost reducing strategies, which are basically attained through the reduction of standards, use of indigenous technologies and materials, adopting self-help modes and delivery, and addressing market imperfection whereas the second one deals with non-cost reducing approach aims at improving the economic status of low-income groups by implementing measures that reduce household expenditure and/or boost their incomes[6].To improve construction efficiency and reduce costs of IHDP condominiums, the Ethiopian government is currently investigating alternative building technology and systems, focusing on the use of local construction techniques and materials. Researchers are being conducted to find an alternative material to cement, for the partition wall of the building to avoid the delay it currently causes and to reduce costs [4].
Prefabrication is closely linked with Modular or Dimensional Coordination, which is a standardization system for sizing building components and placing them within a reference system. It is based on a three-dimensional grid as reference and the basic unit is the module. The prefabrication and industrialized production systems use this dimensional coordination system to optimize the number of different sizes, to reduce on-site modification and waste, and to simplify the interchangeability of components [7]. Prefabrication/Modularization is becoming more widely recognized as a resource-efficient and greener construction process [8].

6. Data Type and Data Collection Techniques

The data is collected from primary and secondary sources. The primary data is collected through official's interview and participant observation. The secondary data is collected from journal articles, books, published and unpublished reports, and also reports from Addis Ababa housing project development office are used to support the discussion.

7. Current Construction Practice's Impact on Housing Delivery and Affordability

The current construction trend in Ethiopia comprises both conventional and modern or technological system of construction. The Modern systems by themselves are classified as fully prefabricated modular houses, composite system of the prefab and cast-in-situ systems said Engineer Wondimu Getahun, an interview respondent from Construction works and Technology Corporation of Ethiopia, Kality branch. The construction of IHDP condominiums envisaged creation of positive impact on the construction industry especially in terms of technology transfer and advancement in searching for a possible reduced cost construction system. Currently partial prefabrication system of construction is at work.

Even if different strategies are applied in practice their impact is quite negligible. For this reason, the construction practice of condominium construction is characterized by cost overruns backed by time delay, poor quality output and plenty of wastage creation which is not properly disposed creating an environmental pollution and from all missing the initial objective the program became a good platform to exercise deep corruption in different stages. The reasons why the aforementioned problems are occurred are summarized below from different interview respondents.

7.1 Cost Increase

Engineer Zewdu, an architect working in AAHDPO mentioned the reason for increase in cost for condominium house construction is that the MSEs (Micro and Small-Scale Enterprises) which are hired to execute the task with nearly zero years of experience, with no one to supervise, and this leads to total increase of cost in construction due to wastage of materials, inaccuracy of execution, and other related factors.

Another interview respondent from AAHDPO said that the initial estimated cost increases in double amount: there are various reasons for this

- Primarily the initial estimate was incorrect, for this the main reason is that the cost is produced for an unfinished design, which leads to repetitive modification and finally huge cost overruns happen.
- Delay in construction leads to an increase in construction raw materials, which again creates a mismatch between the estimation and actual cost.
- Shortage of construction raw materials
- Delay in construction modification approval due to lack of organized office system.

7.2 Time Delay

Delay in construction of condominium houses is due to low capacity of contractors hired, problems in the supply of material from the government and delay in releasing the budget required in time said Engineer Zewdu, an architect working in AAHDPO.

7.3 Poor Quality Output

Quality of condominium houses is very poor said Engineer Zewdu. This is due to poor workmanship, carelessness of the contractors and lack of supervision. For instance, in the construction of ribbed slabs shortage of precast beams and HCBs, poor quality production of those elements leads to breaking of HCBs after casting of concrete this makes refilling very challenging. The figures below are taken from field observation from the actual site.

Figure-1 Poor execution of ribbed slab and Poor quality of columns which is due to less vibration and formation of cracks on a plastered surface. (Source: Touristsite condominium, Megenagna).

7.4 Wastage Creation and Environmental Pollution

In condominium sites plenty of wastes are occurred with various reasons. The main reasons are not feeling responsible for the environmental pollution, lack of skill this leads to higher wastage due to trial-and-error work, and dimensional inaccuracies which leads to cutting of HCBs, or provision of in executable designs with odd numbers in dimensioning says Engineer Zewdu, from AAHDPO and also Mr Tesfaye Kibru, a contractor in the construction of IHDP condominiums.

Figure-2 Wastes created on conventional construction system on condominium site. (Source: Tourist site condominium, Megenagna)

A senior building construction supervision officer Engineer Dawit Yayeh from AAHDPO, summarizing the reasons for the aforementioned challenges as

- Poor capacity and capability of contractor
- Poor methods of material supply schedule
- Poor methods of contract administration and management practices
- Lack of innovative approach in construction practice modification.

All the above challenges became a bottle neck for the success of IHDP condominium in terms of construction practice to be a potential solution as a housing supply tool. The created gap between demand and supply is increasing widely through time. This shows there is a rapid need of change of construction practice.

Table-1 Summary of characteristics of condominium construction

	Ministry of construction	Construction works and technology corporation	AAHDPO	Micro and Small-scale enterprises	Contractor in IHDP
1. Cost increase	√	√	√	√	√
2. Time delay	--	√	√	√	√
3. Poor quality	--	--	√	√	√
4. Env't pollution & waste	--	√	√	√	--

8. Cost Reducing Strategies Used in Condominium Housing Projects

The condominium housing construction did envisage of being a potential influence in the construction sector. Though the achievements cannot be denied, but in terms of cost reduction especially by the adaptation industrial system of construction the improvement is so poor. In the article written by Kamte[6]unit cost of housing is a summation of land acquisition, Infrastructure, Planning, designing, administration, community facilities, and others related to financing of the project; interest rate, amortization period, subsidy, etc. In IHDP Condominium houses also the unit cost is a summation of the aforementioned individual components. Since it is a government owned project the individual components provision or administration is handled by different stakeholders which are assigned by the government as presented in Table 2.

Table-2 Cost of Housing summary

Cost of Housing			
No.	**Unit cost of a house summations**	**How in IHDP condominiums**	**Cost reduction strategy applied**
1.	Land acquisition	Provided by government	
2.	Infrastructure	Partially government	
3.	Planning	Municipality and IHDP office	Specifying the types of blocks and adaptation of design in different sites
4.	Designing	GTZ, MH Engineering consultants, IHDP,	
5.	Construction	IHDP office, Contractors, Micro and small-scale enterprises	Prefabricated elements (Ribbed slab, agrostone partition wall and door leaf, some stair elements)
6.	Administration	IHDP office, until handing over	

7.	Community facilities	Government (IHDP office)	
8.	Others (related to financing of the project; interest rate, amortization period, subsidy, etc.)	Government finances the project, lottery system and established saving scheme	

Even with the application of Prefabrication, the cost of condominium housing is escalating rapidly.

9. Evaluation of Cost-Reduction Strategies in Existing IHDP

Currently the IHDP condominium housing projects are applying the prefabrication technology in two specific components of the buildings. The precast-slab and interior partition walls are the main ones. Even if they brought some advantages to the construction system, but they did fail in major dimensions.

9.1 Ribbed Slabs

This pre-cast ribbed slab has a big problem in water resisting capacity. For this reason, all wet core areas of the condominium are built with a solid slab. But peoples are still complaining about water leakage and take their own measures from adding extra waterproof layer to increasing the thickness of the slab. For all this defect, the problems are rising following poor workmanship, carelessness of the contractors and lack of supervision. The reason behind the poor-quality output is the cost incurred for the contractors which can be said very low, not enough to finish the houses even. For this reason, unskilled contractors with nearly zero experience of working in construction activities will be hired for the job, finally producing such an unpleasant and low qualified work.

Another problem related to ribbed slab construction is production of prefab components namely prefab beams and HCB. For instance, as seen in the figure, in the manufacturing of HCB there are various dimension difference. This means for same size of elements the width are 4.8, 5.0 and 5,1 cm each but the element is the same this variation is occurred due to lack of regular standards and still the production in handled by manual compression system. Therefore, because of this some HCBs fall short and some will not fit to the interlocking spacing plus some will get broken after the concrete is poured on the top which makes it difficult to cover or refill.

9.2 Agrostone Partition Wall

The production of Agrostone partition walls unlike the ribbed slab components is manufactured in a well monitored factory environment. The factory produces a partition wall, door leaf and other ornamentation sculptures from the design up to final delivery with trained and skilled peoples but when it comes to erection of the partition walls unskilled peoples hired by contractors are working on it this creates a gap and unpleasant finishes leading to poor outcome. For this reason, the social acceptance of the agrostone partition wall is declining is said by MrSisayTamiru Agrostone manufacturing factory supervisor.

In addition to the above problem one big issue is that lack of integration the design of the condominium dimension and manufactured panel dimension. For instance, the room height of condominium is 2.8m or 2.7m in some floors, but the standard agrostone partition wall is 3m height with 0.6m width. So, to fit the partition walls the top part of the panel will be trimmed for 2.7m height. This makes the partition panel vulnerable to water penetration meaning it reduces the performance of it. For this reason, people are forced to invest extra cost and replace the panel with 10cm HCB partition wall after they start living in the house.

Therefore, from the above description it is clear that the applied cost reducing strategies are not fulfilling the expected output. The forecasted cost gain is missed due to improper application. For the reasons are crystal clear, a systematic design tool is required to get the best out of those partial prefab elements.

Table-3. Summary of Cost reduction strategies performance

Parameter *Increase* = ∧ *Decrease* = ∨ *Unknown* = -	Contractor (AAHDPO)		AAHDPO Interview respondent		AAHDPO MSEs		Agrostone factory		(CWTCE)	
Ribbed slab	∨	∧	∧	∧	∨	∨	-	-	-	-
Agrostone wall	∨	∧	∨	∨	∧	∧	∨	∨	-	-
Modular designing (planning)	-	-	-	-	-	-	∨	∨	∨	∨

10. Advantages and Disadvantages of Partial Prefabricated Elements Used In the Condominium Housing Projects

Table 10.1. Advantages and disadvantages of prefabricated building elements in condominium houses

Agrostone wall panels	
Advantages	**Disadvantages**
Cost reduction advantage especially with those applied in dry area of the rooms	Users are forced to invest extra money for the replacement of the partition walls which are damaged by water penetration
Potential of good practice of factory monitored standard building elements prefabrication	Lack of skills in the installation procedure reduces the performance of the panels in use
Superior quality achieved by the factory-based construction process and predelivery checks.	Some practical defects are experienced by the users which were not expected in the first place due to this the social acceptance of the boards is still on doubt.
Needs less time in production/manufacturing as well as installation	
Flexible and light weight which gives extra advantage	
Unlike block construction, the material doesn't require much water during construction, which is good to shift from wet to dry construction	
Unlike bricks and HCB, the partition boards don't require plastering for finishing surfaces.	
The raw materials are light weight mineral fillers and agricultural wastes which reduces the usage of wastage by an alternative building material	
Reduced environmental impact due to factory monitored production and possibility of wastage recycling.	
Ability to dismantle of the standard sized panels can be used for other applications	
Ribbed slab	
Advantages	**Disadvantage**
Compared to the solid slab around 15% cost reduction is achievable	Water leakage in some areas due to defects in construction
Needs less formwork, minimum numbers of reinforcement bars and concrete usage reduction which makes less waste to be created	Reduced quality of HCB leads to breakage after curing of the concrete which in turn leads to work and cost.
less self-weight achieved due to the hollow section in the blocks which reduces over all load of the structure	Lack of standards reduced the best performance of the slab system
Greater quality will be achieved with a proper manufacturing and installation of every component	
Less time is required for the curing of the concrete compared to the solid slab construction due to this it has time reduction advantages as well.	

11. Analysis of Existing Condominium Design

As mentioned in the objective of the research the result of the research is going to be interpreted in the redesigning of the existing condominium floor plan. To do this first analyzing the plans is the first condition.

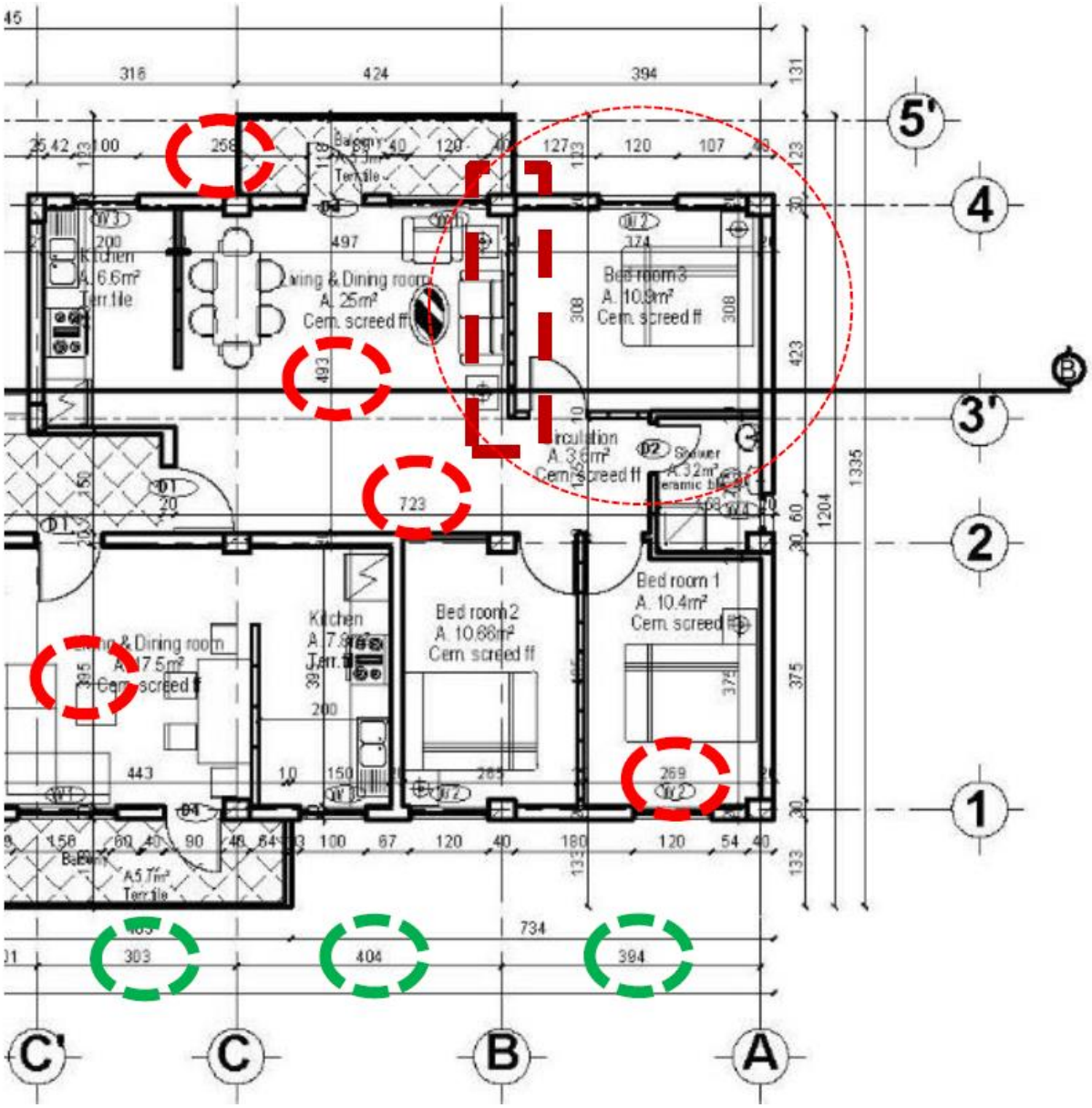

Figure-3 Condominium sample Floor Plan Detail

As we see in the above figure (Figure-3) the structural grid dimensions vary with very small amount of distance this is due to lack of standard forwarded to guide this dimensioning. The dimensions between A&B, B&C, and C&C' are 394, 404, 303 respectively. For example, in between as it is external wall, we expect the wall to be made from hollow concrete blocks this implies for different grid size at the end we will cut the HCB in different sizes to complete the wall to fill from one axis to the other. This implies lots of HCBs are wasted in the process. But if such grid dimensions became smashed and came in to one or two modular size this will highly control the production of wastes from the designing stage and result in reduction of cost at the end.

As mentioned earlier for interior partitions one of the prefabricated elements is Agrostone board. The board is manufactured in regular size of 60cm width, 10 cm thick and 260cm height. Installation of the system is with tongue and groove system of connection. In this case the selected wall is a bed room and living room partition wall. It has 308 cm width. When we calculate it with regular size of the board it doesn't fit. It fits 5 panels and left with opening of half size of the panel which is 30cm. Therefore, to fit this gap in construction all of the constructors will cut the panel into half and fill the gap in between without covering the cut part of the Agrostone panel with some mechanism. This in the long run poses a problem as the material is poor in water resisting the open left part of it makes it prone to moisture absorption and will deteriorate after certain period of time. This is the problem of designing as the size of the panels are known then it was possible to make the partition width in such a way that no cutting and adding is required.

The other thing is the size of the room which is 308x374cm in to in dimension. Seeing the room size according to modularization, Basic module is 1M=100mm, or 10cm.

So, dividing the dimensions in to this basic module, we get;

- 308cm is equal to 30.8M but there is nothing called 0.8 modules. To be sub module it needs to be division of 2 or 4… this shows the room size is modular just simply without any guide dimensions are given.

 The second dimension is 374cm which is equal to 37M and have extra 0.4M which cannot be given like this, it is all because of complexity in construction.

For manufacturing of prefabricated components, we need to give big concentration to the dimensions that we are going to give. The above Agrostone can be a good example for what will happen if not considered properly.

In the above figure the dimension of some internal and external wall is highlighted. These dimensions are 151,139,444,615,446,594,133, and 133. All this dimension led to cutting of HCBs. But it was possible to make the dimensions an even number. They only create inaccuracy in execution. Finally, the outcome will be low quality work with lots of wastage production which have negative impact on the environment and unnecessary costs are also incurred.

12. Results

The construction of IHDP condominium is characterized by cost overrun, time delay and quality problems which indirectly or directly affects the project's cost as the research indicates. The applied cost reduction strategies are also not successful to achieve their initial goals. Partial prefabrication was applied to the construction of condominiums in the hopes of being a potential tool for cost reduction and an approach to practice a new way of alternative construction system. Even though there are some advantages experienced by the application of those techniques, but holistically they fail to have a cost reduction advantage. There can be various reasons to be mentioned for that. The main reasons which are raised by respective stakeholders interviewed by this research is summarized as follows.

- Due to the minor attention given to the technology advancement by the government the success of the prefabricated elements is unattainable.
- Lack of monitoring and inspection in production and construction leads to unwanted results
- Quality is mostly affected by micro and small enterprises seeking to make additional profit by using cheaper substandard materials like rebar, and the low levels of construction skills and capacity.
- To get the most out of prefabrication, as seen in most countries experience, the elements should be manufactured in a controlled environment/factory.
- In executable design dimensions are also the other factors leading to the failure of prefab, so new strategy should be developed that will go in line with prefabrication.

13. Conclusion

The partial prefabricated elements are applied in the condominium construction as an innovative practice to improve the construction performance plus as a means of cost reduction. But due to an improper application strategy, the success of prefabrication system applied could not attain the expected objective. Most of the literatures and interview respondents in the higher and other level of government officials presented that the construction of IHDP condominium did face a lot of challenges to make housing supply affordable to the peoples. From those challenges the ever-increasing cost of housing is the major one. On the launch of the program, application of ribbed slab and agrostone partition wall panels were introduced to reduce cost and have a positive influence in the construction industry. But in the long run the workability of those systems came in to question. This makes the current construction of condominium housing very expensive.

14. Recommendation

For such huge scale mass housing projects, to improve the performance and remove those hindrances, rapid shift of construction practice is mandatory to modularized industrial system of construction. For the realization of modularized prefabrication, the government should pay attention and invest a lot to enhance the existing prefab plants and focus on adaptation of new technologies. The need to enhance the construction industry will never be achieved by using only the conventional method of construction.

The system of execution of houses starting from planning stage to construction must be shifted to a modern system of construction in order to achieve the objective of influencing the construction industry and providing affordable housing.

For the implementation of modular prefabrication in the mass housing construction, the initial cost will be higher. For this the government must provide a large budget. This will be returned in the long run by the application of the system with various advantages. Apart from financial investment various infrastructure developments is also mandatory, like horizontal infrastructures/roads.

Alternatively, a possibility of temporary prefab-plants could be established in each respective sites where the condominiums are planned to be constructed. Which could mostly use to manufacture selected elements of the buildings? After completion those mobile plants can be shifted to another new site for another production. With this it is possible to implement a hybrid system of modular construction.

The success of a modular construction/Prefabrication approach is dependent on how well information is shared between the various parties involved, especially the design team, the modular manufacturer, and the on-site construction management team. So, a well-established coordinated structure should be formulated.

Finally, the focus of this study is on the cost implication of partial prefabricated elements applied in the condominium projects. For a rapid shift, and creation of visible change it is recommended that a holistic study is required on the issues beside construction practice related things. Which may include social aspects and some technical and legal issues as well.

Centeral_Intellegence_Agency, "World fact book," CIA, USA, 2016.

Conflict of Interest

The Author declares that no conflict of interest in this manuscript.

References

i. Centeral_Intellegence_Agency, "World fact book," CIA, USA, 2016.
ii. Centeral_statistical_authority, "2007 Population and housing census of Ethiopia," Centeral Statistical authority, Addis Ababa, 2012.
iii. O. Ozlu et.al., Ethiopia-Urbanization review: urban institutions for a middle-income Ethiopia. The World Bank, UK, 2013.
iv. U. N. H. S. P. UN-HABITAT, "The Ethiopia Case of Condominium Housing: The Integrated Housing Development Programme.," UNON, Publishing Services Section, Nirobi, 2010.
v. Y. Robel, Ethiopia: Transforming the Construction Industry, Addis Ababa: The Ethiopian herald, February 2016.
vi. A. Y. Kamte. (2001).The Quest for affordable urban housing, a study of approaches and results in Harare, Zimbabwe. *Developmnet South Africa*, 18, 1-14.
vii. I. M. S. Bhd, "Modular coordination in construction industry," 18 May 2017. http://ibsmodular.blogspot.com/2007/05/modular-coordination-in-construction.html.
viii. Bernistein, H. M.(2011).Prefabrication and Modularization: Increasing Productivity in the Construction industry," Mc Graw Hill Construction Smart Market Reports, North America.