International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 5 Issue 5 ǁ May. 2017 ǁ PP.73-79

Performance Evaluation of Cost Saving Towards Sustainability in Traditional Construction Using Prefabrication Technique

Muhammad Afzal[1,*], Sohail Maqsood[2], and Sumra Yousaf[3]
[1](*Architectural/Civil Engineer (Branch Manager), OKAZ Consultant Engineering, Jeddah - Kingdom of Saudi Arabia)*
[2](*Lab Engineer, Department of Civil Engineering, Muslim Youth University, Islamabad - Pakistan)*
[3](*PhD Scholar at UM Malaysia, Assistant Professor at UCE&T Bahauddin Zakariya University, Multan - Pakistan)*

Abstract:*It is most significant to achieve environment protection in construction industry for which prefabrication construction technique is considered to be most efficient sustainable construction method. The importance of prefabrication is based on the influence of different activities elaborate such a waste management, adaptation of material reuses and recycles. This research paper includes a dynamic design approach to evaluate the cost performance of construction project using prefabrication construction method along with applying the subsequent waste treatment activities to accomplish waste management. The construction cost of duplex villathrough traditional construction has been carried out. The construction cost of the same project has then been calculated by the present prefabricated assembly market prices. After critical comparison between construction costs of traditional and prefabrication methods, a significant cost saving has been noticed. The day by day increasing public awareness about the environmental impacts of construction waste has been resulted in including waste management as a major function of construction project management by some construction organizations. Although, some of methods have been developed for construction waste management it is still of much importance that no research has been done so far in this topic to introduce waste minimization through necessary waste treatment activities. This research paper emphasis on the identification of supreme horizons of prefabrication techniques and methods in construction industry by converging on the aggressive need of suitable training and skills for workplace.*

Keywords: *Cost saving, Environment protection, Prefabrication, Sustainable construction, Waste reduction, Traditional construction*

I. Introduction

It is, no doubt, not negotiable to reduce the negative impact of building production on the environment. The techniques in prefabrication construction are developing the platform to improve the building construction, waste reduction as well as cost performance as prefabrication is well known key element in construction.The unfriendly behavior of construction with environment is not negotiable although. Construction industry have evolved in creating construction waste in the form of many challenges like carbon emission, resource consumption, use of high energy and lack of technical advancement to environmental and human life. Construction industry is currently facing lack of improvement in research and development being a major issue. Although there has been a prominent improvement in this regards during the last few years back, but still require a tremendous improvement. Noticeable research developments in sustainability in construction industry have been carried out in more recent times.

It is already stated that environmental pollution is increasing day by day due the result of increasing construction activities and which creates the overwhelming condition like threat to humans by humans. Since the 18^{th} century, particularly 1750, the concentration levels of GHG specially carbon dioxide (CO_2) as an atmospheric pollutant have increased considerably.It is calculated that the 75% ofincrement in atmospheric carbon dioxide (CO_2) have been resulted due to the CO_2 emissions both from the manufacturing process of cement (a core construction constituent) and the combustion of fossil fuels.A considerable rise in global warming has come into front when CO_2 calculation data stated the mean monthly increase in CO_2 concentrations from 315.71 to 396.18 in 1958 to the date. Hence, it has become intense crucial priority to conserve energy against the GHG encountered with the buildings and that of carbon dioxide consequential emissions.The energy consumption and creation in environmental impacts would continue as long as the construction production continue. The choice of construction technology and construction materials are the main factors influencing over the carbon emissions. The energy is somehow too associated with the construction waste.The concisely revised use of buildings and sufficient efficiency of construction is top tier important in order to address energy embodied problems.Construction waste (can be defined as the excess material removed from the industrial, construction, demolition workspace, building sites, renovation, civil engineering

structureand human activities with no further worth) has been considered to be one of the major environmental pollutant so far. Construction waste can be identified with two main classes as structure waste and finishing waste. Abandoned concrete fragments, reinforced bars and timber plates etc. generated during the construction phase can be referred as structure waste. Non-technical labor, insufficient technology, inappropriate construction techniques, improper material management, errors in equipment handling, design inaccuracy and procurement etc. are considered the main sources of construction waste. It is said that 17% (70 million tone) of the total extracted waste per year in the world is the result of demolition and construction activities which solely names the construction industry as larger producer of controlled waste in the world.To finally extent, construction industry is in fierce need of sufficient improvements towards sustainable development to overcome environmental impacts. The improvements and developments must contain the criteria to minimize the environmental impacts as well as maximize the socio-economic benefits. Thus, efficient waste management, sequential resources, enhancement in material use, energy demand reduction and appropriate stabilization of carbon and GHG emissions strategies can only be found in sustainable building construction making it a best construction choice in all periods.

Prefabrication Technology

In the present research purpose, prefabrication is considered as the term used in reference to the modern construction methods as it was believed that prefabrication existed as a construction technique on its own in the previous research. Due to the term of reference, prefabrication and its definitions are widely varied in several studies. Prefabrication is a construction or production process with the end-product (preassembly) components which are normally prepared at a specialized site with the combination of different construction materials. The end-product (preassembly) components can be wall panels, windows shades, column and slab pairs as well as a complete building component sometimes. Preassembly is a single unit which is prefabricated at the separate facility with the combination of different construction materials before installation. The process of prefabrication could be carried out anywhere but on the actual construction site or in close proximitywould be preferable.

II. Research Objectives

It is, no doubt, not negotiable to reduce the negative impact of building production on the environment. The techniques in prefabrication construction are developing the platform to improve the building construction, waste reduction as well as cost performance as prefabrication is well known key element in construction.The major focus of this research is to improve the construction techniques to enhance the sustainability of the construction environment by reducing waste and saving construction cost. It would not be false, if it is stated that prefabrication techniques have most competentresulton time and cost reduction in construction projects. Prefabrication methods are liable to use more in building construction and it would be more possible to depict that the future of prefabrication and a closer joining between the building construction would further be improved if the disadvantages of prefabrication are minimized. Following are the major objectives of the present research:

- The project includes a dynamic design approach to evaluate the cost performance towards sustainability raised by applying prefabrication construction technique on reduction in construction waste.
- The project would identify the fierce needs of up-skilling of the trades and training required to improve construction techniques, methods and technologies in construction industry.
- The data analysis will be carried out through the regression and correlation analysis.
- The prefabrication technique will emphasis over the reduction in energy consumption.

III. Literature Review

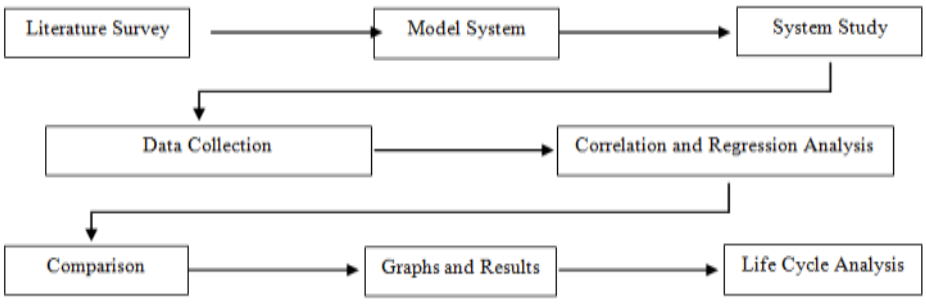
The present condition of the environment has led the future researchers to study and find the sustainable and protective construction techniques to cover the dangerous aspects of GHG emissions, carbon dioxide as well as energy consumption. The construction activities are still considered as unfriendly to environment even being more beneficial and productive.The research has done on 30, light to medium commercial buildings constructed through prefab content in Auckland, New Zealand during one particular year to investigate the significant cost and time performance of the final contract sums. Prefab content value as a percentage of total contract sum, gross floor area, initial and final completion costs, estimated and actual duration were the tier investigation parameters. Results showed that the prefab content, cost and time performance improved significantly within the certain limits[1]. The various construction industry departments as well as Government in Hong Kong, over the past decades, have actively introduced a significant initiatives of construction waste management (CWM) policies, codes and regulations based on the latest CWM philosophies like reuse, reduce and recycle principle and polluter pays principle [2].The agenda is highly aggressive in finding the useful ways not only to reduce the energy demand but also to use the energy in more competent way

to use renewable energy in production process. Competitive advantages of minimizing energy consumption have proved to be cost reduction and carbon dioxide emission reduction which can be accomplished by both augmenting the existing production and looking into new knowledges [3].The construction industry is producing a significant amount of construction waste in a result of environmental pollution all over the world. In only 2005, it is calculated that about 21.5 million tonnes of construction waste were produced, of which 11% ironically disposed of in landfills and 89% in public substantial areas. Densely-populated area like Hong Kong would soon run out of the public filling area as well as landfill space within the next few decades if the construction waste continues increasing with the same sequence [4]. Latest research trends of the researchers from developed and developing countries has examined and results showed that researchers have made significant contributions to the effective development of prefabrication construction technique in reducing construction waste and environmental impacts while enhancing the cost performance as the construction is the main economic activity in some the developing countries [5].

The research analysis disclosed that the environmental alarms and social consciousness were considered the top tier progressively important parameters in the selection of construction methods [6]. An eight-storeymulti-residential building was investigated for steel-structured prefabrication method and was resulted in a significant increase (~50%) in embodied energy as compared to the concrete building and reduced material consumption up to 78% by mass as compared to the conventional concrete construction [7].It has been revealed that the recent research in achieving green building criteria accelerating prominently due to the importance attached to GB by the construction industry. Major investigation particularssuch as energy performance, advanced technologies, GB project delivery and developments, and GB certifications were taken into account [8].Authors described their research approach when they have applied Life Cycle Analysis (LCA) to the general waste management. According to this article, the best way to minimize the construction waste and its environmental effects is the diversion of the waste from a landfill to incineration which can solely be accomplished through the energetic participation of stakeholders [9].The construction waste ironically provides the severe impacts not only the environment but also on the individual life. Construction waste is the negative enormous quantity in the form of building materials which is considered as the wastage of valuable natural resources. Construction waste also decreases the land resources by consuming a massive landfill space. Furthermore, it contains the harmful substances jeopardizing the environment and human wellbeing. Half of the municipal waste came from the construction of new buildings [10]. Due to increasing occupation of landfills and public fills by construction waste in Hong Kong, the government have been implemented the Construction Waste Disposal Charging Scheme (CWDCS) to offer the financial incentives to the C&D waste generators for the reduction of waste and to encourage material reuse and recycling. The research results showed that after the implementation of CWDCS the reduction in waste was noticed to be less than 5% [11].

IV. Data Collection

Using a building design approach, data is collected from the cost of each building component by using traditional construction and then by using prefabrication technique. The comparison between the final costs of traditional and prefabrication construction hasbeen taken out.



Building Design

Following is the building plan to be constructed by both traditional and prefabricated construction techniques.

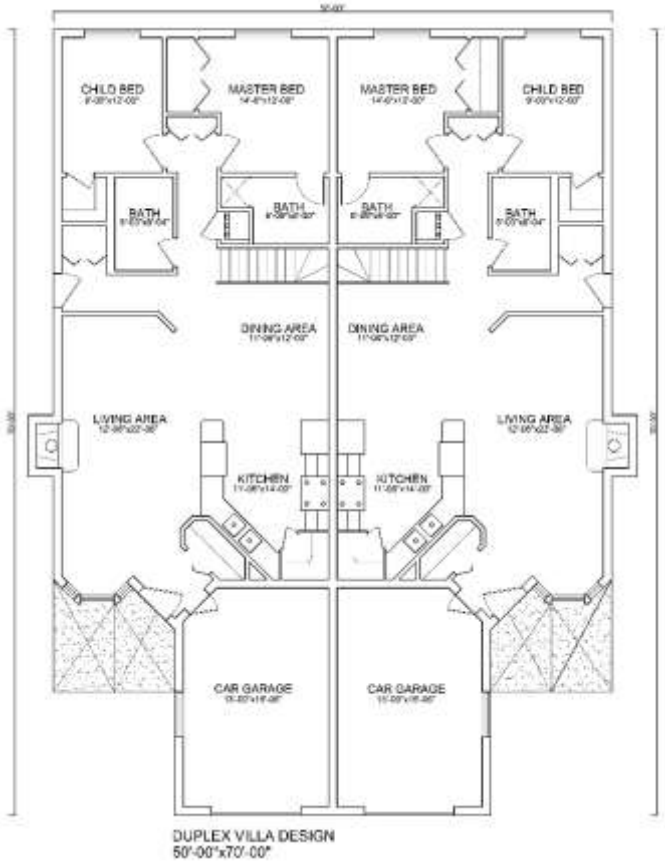


Figure 1: Duplex villa plan

Cost Calculations

Final cost, as a result of both traditional and prefabrication construction methods has been calculated. The cost of every major component of construction material has been noticed in traditional construction while the cost of specific preassembly has been taken into account. The material costs in the traditional construction have been taken from the original construction expenses for the given building case study. Building design meeting the modern luxury outfits was constructed by the local anonymous contractor company in Lahore city of Pakistan. The prefabricated assembly prices for the given building design have been taken from the present market rates.

Table 1: Cost Estimation of Duplex Villa through Traditional Construction Method

Sr. No.	Item Description	Quantity	Rate (PKR)	Per (Unit)	Amount (PKR)
1	Excavation (Earth work)	163860.00	05.50	ft^3	901230.00
2	PCC 1:5:10 for foundation work	1633.50	135.00	ft^3	269527.50
3	Sand filling	60220.00	05.00	ft^3	220522.50
4	PCC 1:5:10 flooring	3735.00	145.00	ft^3	541575.00
5	RCC for column	9702.00	385.00	ft^3	3735270.00
6	Brick work in C:M=1:5	13805.00	90.00	ft^3	1242450.00
7	RCC 1:2:4 for lintel beam	19.50	380.00	ft^3	7410.00
8	RCC 1:2:4 for sunshade	1078.45	275.00	ft^3	296573.75
9	RCC 1:2:4 for beam	2653.15	380.00	ft^3	1008197.00
10	RCC for slab	10078.85	350.00	ft^3	3527597.50
11	Plastering in C:M=1:5	64585.00	13.00	ft^2	839605.00
12	Weather course 75mm thick	542.25	50.00	ft^2	27112.50
13	White wash	64585.00	05.00	ft^2	322925.00
14	Flooring in C:M30mm thick	620.25	135.00	ft^3	83733.75
15	Iron fasteners	170.50	75.00	Kg	12787.50
16	Grill iron work	45.00	9750.00	Nos	438750.00
17	Wood work	38.55	35.00	ft^2	1349.25
18	Miscellaneous	20% Approx.		-	2695323.25
Total amount (PKR)					**16171939.50**

Table 2: Cost Estimation of Duplex Villa through Prefabricated Construction Method

Sr. No.	Item Description	Quantity	Rate (PKR)	Per (Unit)	Amount (PKR)
1	Excavation (Earth work)	163860.00	05.50	ft^3	901230.00
2	PCC 1:5:10 for foundation work	1633.50	135.00	ft^3	269527.50
3	Sand filling	60220.00	05.00	ft^3	220522.50
Details of prefabricated assemblies					
4	Prefabricated wall panels for; I) Living room II) Bedroom III) Toilet IV) Kitchen V) Verandah	14125.00	355.00	ft^3	5014375.00
5	Doors; I) 8 Nos of size 3'-00"x8'-00" II) 12 Nos of size 2.5'-00"x7'-00" III) 06" thicknesswith GI powder coated frame IV) 04" thick with GI flush and honey comb finishing	1059.00	315.00	ft^3	333585.00
6	Finishing/crafting; I) Reinforcement enriched craft paper, PUF infill, mineral wool etc. at hinges II) Desired coloring and finishing at door locks, case fittings and closers etc.	3575.00	305.00	ft^3	1090375.00
7	Windows; I) 8Nos of size 5'-00"x4'-00" II) 06" thickness with GI powder coated frame and double sliding shutter III) Enriched with 25mm thick glazing IV) Desired fittings and colors	973.00	370.00	ft^3	360010.00
8	Ventilators; I) 6 Nos of size 2'-00"x2'-00" thickness with GI powder coated frame and double sliding shutter II) Enriched with 25mm thick glazing	437.00	360.00	ft^3	157320.00
9	Miscellaneous	25% Approx.		-	2086736.25
Total amount (PKR)					**10433681.25**

Project Duration

The project estimated duration was decided before starting the traditional construction between owner and contractor. Following is the details of estimated and actual duration of both traditional and prefabricated construction techniques.

Table 3: Project Duration of both Traditional and Prefabricated Construction Techniques

Sr. No.	Description	Estimated Duration (Days)	Actual Duration (Days)	Lag (Days)
1	Traditional construction technique	90	135	45
2	Prefabricated construction technique	60	75	15

Project Cost

The project estimated cost was decided before starting the traditional construction between owner and contractor. Following is the details of estimated and actual cost of both traditional and prefabricated construction techniques.

Table 4: Project Cost of both Traditional and Prefabricated Construction Techniques

Sr. No.	Description	Estimated Cost (PKR)	Actual Cost (PKR)	Lag (PKR)
1	Traditional construction technique	12050000.00	16171939.50	4121939.50
2	Prefabricated construction technique	9250000.00	10433681.25	1183681.25

Comparison of Cost and Time Savings

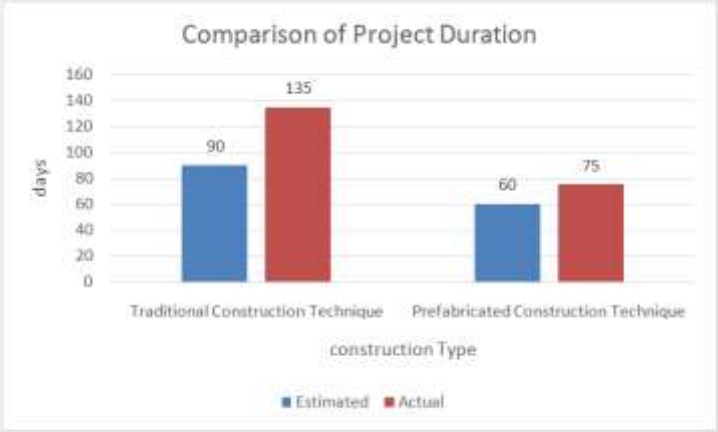


Figure 2: Project duration for both traditional and prefabricated construction technique

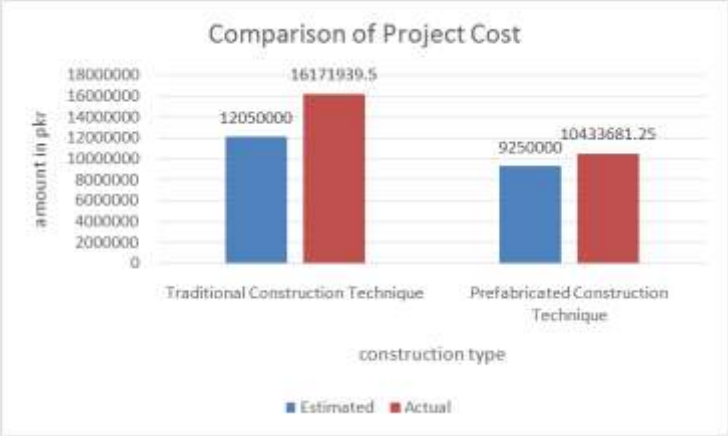


Figure 3: Project Cost for both traditional and prefabricated construction techniques

It has been clearly noticed that there was a significant benefit of using prefabricated construction technique both regarding time and cost performance. Using prefabricated construction, there was a significant cost saving of **5738258.25 PKR (05.74 million PKR)**. Furthermore, prefabricated construction technique is preferable over traditional construction technique dur to its environmental friendly outcome by reducing construction waste and reduction in energy consumption.

V. Conclusion

Several previous studies have showed that prefabricated concrete construction technique reduces environmental emissions as well as explores other benefits including building sustainable performance, time and cost performance, material and energy conservation, material reuse and recycling, waste reduction, quality and durability enhancement, and health and safety improvements. The present research has concluded with the estimation and performance of cost and time for both traditional/conventional and prefabricated construction techniques. In order to express the main conclusion, there was a sound cost performance of about **05.74 million PKR** when prefabricated construction was supposed to use for the given case study building project construction. Prefabrication technique is the best way towards sustainability to reduce waste and energy consumption which are the prime factors in the present environmental need. Although prefabrication represents prominent benefits but still requires further improvements in trainings and skillful workspace to meet present environmental purification.

References

[1] Shahzad W.M., Mbachu J., and Domingo N., Prefab content versus cost and time savings in construction projects: A regression analysis, *Proc. 4th New Zealand Built Environment Research Symposium*, Auckland, NZ, 2014.

[2] Lu W., and Tam V., Construction waste management policies and their effectiveness in Hong Kong: A longitudinal review, *Renewable and Sustainable Energy Reviews, V.23*, 2013, 214-223.

[3] UNFPA Green procurement strategy, *Procurement Services Branch*, New York, USA, 2013.
[4] Jaillon L., Poon C.S., and Chiang Y.H., Quantifying the waste reduction potential of using prefabrication in building construction in Hong Kong, *Waste Management*, *V.29*, 2009, 309-320.
[5] Li Z., Shen G.Q., and Xue X., Critical review of the research on the management of prefabricated construction, *Habitat International*, *V.43*, 2014, 240-249.
[6] Chen Y., Okudan G.E., and Riley D.R., Sustainable performance criteria for construction method selection in concrete buildings, *Automation in Construction*, *V.19*, 2010, 235-244.
[7] Aye L., Ngo T., Crawford R.H., Gammampila R., and Mendis P., Life cycle greenhouse gas emissions and energy analysis of prefabricated reusable building modules, *Energy and Buildings*, *V.47*, 2012, 159-168.
[8] Darko A., and Chan A.P.C., Critical analysis of green building research trend in construction journals, *Habitat International*, *V.57*, 2016, 53-63.
[9] Kularatne R.K., Case study on municipal solid waste management in Vavuniya township: practices, issues and viable management options, *J Mater Cycles Waste Manag*, *V.17*, 2015, 51-62.
[10] Huang X., and Xu X., Legal regulation perspective of eco-efficiency construction waste reduction and utilization, *Urban Dev Stud*, *V.9*, 2011, 90-94.
[11] Poon C.S., Yu A.T.W., Wong A., and Yip R., Quantifying the impact of construction waste charging scheme on construction waste management in Hong Kong, *Journal of Construction Engineering and Management*, *V.139(5)*, 2013, 466-479.