LABOUR PRODUCTIVITY NORMS FOR ALUMINIUM SYSTEM FORMWORK IN LOW-COST HOUSING CONSTRUCTION PROJECTS IN SRI LANKA

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ABSTRACT

In enhancing the living standards of the society advanced technologies can be used in gaining the labour productivity and competitive advantage. There the low-cost housing projects are facilitating a proper labour productivity adhering the effect of labour productivity factors. Thereby, Aluminium system formwork is a use of advanced methodology which enhance the labour productivity in low-cost housing projects while highlighting the significance and domain created within the industry.

Meanwhile, tendency of poor performance in Aluminium System Formwork is observed due to improper planning in high rise building construction. Consequently when maintaining productive advantage, productivity norms are number of labour hours required to complete a particular task while facilitating the efficient evaluation of labour performance in enhancing the merits of the Aluminium System Formwork. Hence, deficiency of researches have been done to establish particular standards or norms, this research aims at investigating the realistic measure of the labour performance for Aluminium System Formwork in low cost housing projects.

Accordingly, a case study was conducted using direct observations to prepare the labour productivity norms and collected data were analysed based on labour productivity factors. Finally conclusions were drawn and recommendations were put forward.

Findings proved the combination and varying effect of weather factors, crew factors, management and projects factors, site conditions represent different labour productivity norms in each four different occasions. Meanwhile within each occasion the effect of structural elements towards the norms is highlighted and facilities the realistic measurement of the labour performance in Aluminium system formwork while embossing low cast housing concept.

Keywords: *Aluminium system formwork; labour productivity; labour productivity factors; labour productivity norms; low cost housing projects.*

1. INTRODUCTION

The construction industry plays a significant role in any developing country, promoting main human needs required in socio-economic development (Karim *et al.*, 2012). Meanwhile, in order to fulfil that Tam*et al*. (2004) suggested that, advance technological improvements plays a vital role in achieving the speedy construction. Further, Durdyev and Mbachu (2011) pointed out that, in the industry level, the productivity enables the sector to maintain satisfied clients, attract investment, remain viable and contribute to the economic growth and well-being of the nation. Meanwhile,Cheetham and Lewis (2001) emphasized that, productivity can be increased by ensuring proper and efficient use resources such as, material, labour management expertise and capital. Among them labour productivity stands as a foremost measuring tool, since almost all the aspects of the construction industry are labour oriented (Mar, 1985). Furthermore, Moselhi and Khan, (2009) emphasized that, when focusing on formwork technology it has a direct impact on labour productivity. Additionally**,** Tam et al. (2004) declares that, formwork represents a significant part of the cost of concrete structure and following that concept, Urban Development Authority of Sri Lanka hasstarted urban regeneration projects in Colombo to eliminate shanties, slums

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and other dilapidated. Accordingly, Aluminium System Formwork has become the ideal cost effective tool for the mega housing projects with intension of obtaining the higher reputation and higher productivity (Mivan Aluminium formwork, 2012). Ultimately, by considering different factors, it is essential to have realistic estimates of expected labour productivity to plan and carry out labour-based work effectively (Stiedl, 1998).Therefore AbouRizk and Dozzi (1993) stressed, labour norms are essential and act as a guideline for cost estimating and provide a logical and reliable consistent values which facilitate the planning and scheduling, resource planning, and risk assessment in the construction Therefore, the author further stressed that when determining a realistic norm productivity is very much critical .

When Aluminium System Formwork is concerned, it is one of the most economical, new technological approach to maintain the site labour productivity, norms can be considered as an ideal yardstick to prove the effectiveness of the new system. Even though deficiency of researches have been done to establish particular standards or the norms to measure the labour productivity of the Aluminium System Formwork. Therefore a gap is found that, there was no standard to generate a clear idea about the actual and realistic measure of the site labour and their efficiency of using this system in the industry. Hence, the research problem has been identified as the necessity of appropriate norms for new formwork system related to Sri Lankan context, in providing the maximum out of this new technology and archiving a value for money

2. LITERATURE SYNTHESIS

In Sri Lanka, according to Samarathunge(2012), over $700 million worth of building construction is expected in next 5 years, driven by urban development and among them 40,000 low-income housing units project. Further, Ministry of Defence and Urban Development (2013) andSamaratunga, (2012) reported, government is targeting nearly 66000 housing units remarking the biggest relocation program for ever. CICRA Lanka (2011) and Wijesundara (n.d.) reported that, number of relocation of underserved settlement programs have been conducted by Urban Development Authority (UDA), to provide comfortable housing with relevant common amenities. Therefore, a great necessity has been arrived under the urban development plans in Sri Lanka to consider about the rehabilitation of low income populace in Colombo city and there, low cost housing projects plays a significant role within the economical scope of poor majority

2.1. CONSTRUCTION LABOUR PRODUCTIVITY

Wilcox et al, (2000, as cited in Enshassi, Mohamed *et al.*(2007) has successfully elaborated that, for any profit oriented organization improving productivity is a major apprehension with respect to effective and efficient conversion of resources into marketable products. Therefore the endeavour for defining, measuring and comparing the productivity has become a critical task.According to Chia et al. (2012), construction industry is an industry which depicts a core strategic importance due to its significant effect of level of productivity on national economic growth. Furthermore, CICRA Lanka (2011) supported as, in 2010 Sri Lanka`s Gross Domestic Product (GDP) growth was 8% when compared to 3.5% in 2009 and among that figure higher construction activity resulted in 12% growth in domestic production of buildingmaterials. Therefore, above statistical data emphasized that the economic boom in Sri Lanka has been significantly powered by the construction industry while gaining similar advances in accelerating the productivity growth. In achieving the economic growth, Karunatilake (2009) and Kazaz and Ulubeyli (2007) have emphasized, human resource can be identified as a key strategic resource in ensuring improved productivity. With the intention of that significance, Nasira*et al.*(2013) has figure out, the labour productivity as;**Labour productivity = Actual work hours/Installed quantity.**Therefore the labour productivity in the construction industry can be generalized as the physical progress achieved per unit of time period and the investigation about the factors in order to enjoy comparative advantages in international markets, which is domineering in a rapid changing nature in global environment.

2.2. LABOUR PRODUCTIVITY NORMS

Meanwhile Vliet (2011), has introduced a mathematical equations for labour productivity norm (LPN) as, ***"Number of labour hours (workeffort) required to complete a defined construction activity, given the specific qualifications associated with each individual labour"***.Moreover according to Nes (n.d.) and Bastraw (2015) the LPN can be considered under the category of the Key Performance Indicator (KPI) which is typically used to measure individual and group performance and it is the amount of output per the number of hours worked per day, week or month while creating a time frame on which to base the inputs of the measurement.Therefore, estimating the correct productivity of the labour is critical and International Labour Organisation, Advisory Support, Information Services, and Training (ASIST) (1998), it is beneficial in re-measurement, for easy rectification of the employees, leads to maintain the required labour force, undergone the best work practice, using correct tool having minimum disturbances and mainly as a benchmark to facilitate standardization and efficient evaluation. Association for the Advanced Cost Engineering (AACE) International Recommended Practice (2004) has recommended, some methods of estimating the labour productivity by work study or the work sampling method where the number of direct observations are possible. Therefore, by using an appropriate measurement technique, and building up the suitable norms would become the dynamic measure of labour productivity and it drives towards the economic growth and living standards.

2.3. FACTORS AFFECTING LABOUR PRODUCTIVITY

Meanwhile Doloi (2008), also was able to build up a strong relationship between labour productivity and its changes, as changes or the variations are essential in the construction industry to improve the labour productivity and to build up accurate norms. Further to author, a single factor cannot affect the status of productivity to be high or low, but set variables or factorssuch as management, design, economic, social-psychological,labour, material, technological, environmental, administrative and organisational related factors and etc.which are interacting each other generate the final result. Hence, the necessity has been occurred to conduct a critical evaluation of the factors affecting the productivity in analysing and developing critical evaluation standards.

2.4. NECESSITY OF LABOUR PRODUCTIVITY FOR LOW COST HOUSING PROJECTS

Mainly the variations of the labour productivity has ability to generate a greater impact on national economy (Jayaweera, 1997). Moreover, Olotuath (2002) emphasised labour productivity has become the underlying goal of low cost housing projects. Better productivity can increase affordability by improving the quality of building work, and by reducing residential construction costs. When referring to residential construction costs especially for low income, materials, labour, subcontracted work, and other costs such as overheads and profit margins are concerned and the usage of prefabrication or modular components has been suggested as an effective mechanism to uplift building productivity and then facilities the reduction of cost for the housing projects (Olotuath, 2002). According to, Ministry of Federal Affairs (n.d.) and Richard (2014), cost efficiency is achieved through prefabricated standardized materials and tools, as reusable metal formwork. Consequently, through number of urban renewal programs Sri Lanka is attempting to empower the labour productivity, moving from the conventional building materials especially with respect to formwork systems in order to make the concept of "low-cost housing" a reality.

2.5. DIFFERENT TYPES OF FORMWORK SYSTEMS USED IN LOW COST HOUSING PROJECTS

Innovation in the building system and the techniques are required, towards better productivity in low cost housing projects (Richard, 2014). According to Huanga and Chenb(2004), since Concrete formwork is a labour-intensive and time-consuming operation, to facilities productivity and cost effectiveness, many modular formwork systems have been developed. According to Tam, Tong, Lau, and Chan (2005), and Construction Industry South Australia (2012), selection of appropriate formwork system facilitates speedy construction, maintain the smooth flow, and on the other hand Suryakant (n.d) emphasized, delivering good quality, cost effective, durable structure and good speed is highly demanded in housing sector. Therefore Elbeltagi*et al.*(2011), Common formwork system (n.d.), and Lyngcoln (1991) highlight

that, suitable formwork system would dominate the success of the housing projects in terms of time, cost and quality. Meanwhile Rubaratuka (2013), Johnston (n.d.) and Smith and Hanna (1993) stressed that, the selection of formwork based on quality, safety, economy compatibility with architectural, structural and mechanical and maximum reusability is essentials.According to Formwork (n.d.), general classification based on materials such as timber, hardboard, steel aluminium, plywood used in low-cost housing projects in Sri Lanka depending on the required quality, cost and time.

2.6. THE EFFECT OF LABOUR PRODUCTIVITY FACTORS ON FORMWORK SYSTEMS

Baxi (2011) and Nemati (2007) describe that, cost of formwork is higher than the total cost of reinforcement and concrete material and labour and among formwork, greater portion of cost more towards labour. Further Smith and Hanna (1993), also proved that labour productivity has a higher influence on the formwork productivity and factors affecting the labour productivity have been used to examine their impact on formwork in Sri Lankan construction industry and it can be elaborated though table 1 that the co-relationship with the labour productivity factors and the formwork types, while highlighting the requirements to be fulfilled to enhance the labour productivity through a proper formwork system.

Table 1: The effect of labour productivity factors on formwork in Sri Lankan Construction Industry

Labour Productivity Factor	Effect on Formwork	Requirement for a good formwork system to enhance labour productivity
Design factors	It increase or decrease the time required for fabrication, erection and dismantling the forms. Further dimensions of walls jointing pattern, length of wall, surface finish, floor height and	Time Saving and good quality output
Management factors and Project factors	Site planning, construction process and site supervision and the interpretation ability of site supervisor for an effective communication with the labourers to reduce rework	Well documented instructions thereby time and cost saving
Buildability factors	Average slabpanelareawithinthefloor, variabilityofbeamsizes, repetitionoffloorlayouts, floorarea, beamtofloorratio, intersectionofbeams, percentageofcurvedbeams; and percentageof nonrectangularslabpanelsinfloors affects the buildability. Which resulting simplicity, uniformity,standardization,andrepetitionof elements on formwork labourproductivity system and this can also be depend upon the material selected	Reusability, standardization and minimize repetition effect Faster and lower cost delivery of the product with the corporation of new technology
Site conditions	Storage facilities, accessibility of site, underground pipe line and adjacent buildings need to be considered since it highly affect the security and maintenance of the formwork.	Lesser damage at site conditions, save space and time consuming for supporting, handling and maintenance
Crew Factors	Gang size labour percentage are more critical. Since depending on the number of skilled unskilled labourers and their age levels the time required for the construction may differ.	Properly trained labours
Weather conditions	Temperature of the environment, humidity factor, wind speed and precipitation highly effects since depending on the material, those factors may affect the potential properties of the each formwork type	Material which is highly steady in the change of different weather conditions

Source: (Tam (2004); Smithand Hanna (1993); Nemati (2007); Jarka (2010); Jarkas (2012); Moselhi, and Khan (2010))

2.7. SIGNIFICANCE OF THE ALUMINIUM SYSTEM FORMWORK IN THE SRI LANKAN LOW COST HOUSING PROJECTS COMPARED TO CONVENTIONAL FORMWORK SYSTEM

Wijesekara and Gunathilaka (n.d.), thoroughly mentioned that, in terms of speed, quality and safety of the formwork system used, nearly 40% of the cost of structure, 60 % of time, success of the construction project can be determined. Huanga and Chenb (2004) also highlighted that, modular formwork systems have become the optimum solution to improve the productivity and the cost effectiveness. Further Sattigari*et al*. (2007), also pointed out that amongst various alternatives used at mass housing construction, Aluminium system formwork is in the highest position. Basically, according to Suryakant (n.d.), under the parameters of cost, time quality as well as quantity conventional and the Aluminium formwork system is compared firstly according to the table 2.

Table 2: Compare and contrast the Aluminium System Formwork with the other conventional formwork system

Requirement	Conventional (Timber and Plywood)	Aluminium System Formwork
Quality	Normal- Sometimes good quality cannot be achieved when dismantling	Superior- In – Situ casting of whole structure using controlled concrete mixers, places and compacted in leak proof mouldsusinghighfrequency vibrators
Speed of construction. (Time)	Due to step by step completion of different stages Erection of formwork is done in the site as well as concreting and de-shuttering take a long cycle nearly two weeks and then only plasteringandother finishingactivities can commence	In a one continuousoperation thewalls and floors arecast together and enableremoval andre-useof forms ondailycycle basis due to special inbuilt accelerated curingovernight
External finishes.	Finishing- Painted with cement based needs every in three years, since plastering needed to be done.	Finishing- No need of frequent repainting. Textured concrete fascia can be provided
Maintenance	The major expenditure is involved due to; plaster of walls / ceiling etc., require repairs and maintenance. Outer and inner walls painting Leakages occurred in plumbing and sanitation installation.	Concrete repairs for plastering and leakage's are not at all required due to the walls and ceiling being smooth and high quality
Requirement of labour	Extensive labour requirement	Less skill labour requirement, due to standardized and simple installation procedure.
Installation Procedure and reusability	Maximum 5 or 6 times, since the shuttering can get damaged when de-shuttering.	Facilitating less material wastage can be reused over and over within or between projects with more effectiveness and standardized and simple installation procedure
Safety	Need remove props when dismantling slab panels	Not necessary to remove props when dismantling slab panel

Source: (Common formwork system (n.d.); Hanna (1999); Huanga andChenb (2004); Kumkang Kind Co.Ltd. (2011); Wijesekara andGunathilaka (n.d.); Rahim andHaron (2013))

Significance of system formwork is identified by Wijesekara and Gunathilaka (n.d.) as very much economical type of formwork used in high-rise buildings and in Sri Lankan context it is feasible to be used in low cost housing projects. Further Man (n.d.), clearly pointed out that the major highlighted difference in between Steel and Aluminium is, Aluminium is lightweight but the steel panels are heavy weight and when considering the cost, aluminium would be more economical and suitable to support the low cost housing concept, and specifically Aluminium system formwork has its own authority for high-rise and typical apartment, housing construction.

2.8. SIGNIFICANCE OF ALUMINIUM SYSTEM FORMWORK WITH RESPECT TO THE LABOUR PRODUCTIVITY

In obtaining labour productivity in low-cost housing projects, the uniqueness of the Aluminium system formwork is highlighted by Prasanth (n.d.) and has stressed that, urbanization, increasing housing demand cannot be fulfilled using conventional materials since, limited quality, slow process Ultimately Suryakant (n.d.) exaggerated that, Aluminium system formwork is advanced, fast, simple and adoptable for mass housing construction and provides a total quality work with planned complete methodology to enhance the labour productivity. Therefore, it is very much crucial to select the best choice of formwork which is compatible with the building structure with a more collaboration between all the stakeholders. Therefore, AACE International Recommended Practice (2004) suggested, measuring and tracking work hours for a particular working elements and building up norms allows to determine the root cause poor labour productivity. In the meantime, Gatti *et al.* (2013) found that Aluminium system formwork found somewhat unsuccessful in achieving the potential productivity advantage, due to lack planning in high rise construction. Even though, the literature vastly describes the above topic still remains two questions as "what is the actual importance of a norm with respect to the labour productivity analysis?" and "how to build up the labour productivity norms for the Aluminium System Formwork to analyse its productivity?". The data collection and analysis should be done in order to find the answers to these problems.

3. RESEARCH METHODOLOGY

Tellis (1997) emphasised that, when a holistic and in-depth investigation is in needed, the case study is an ideal research approach under quantitative methodology. Therefore, in order to accomplish the aim of this research as to investigate the realistic measure for the labour productivity for Aluminium System Formwork used in low cost housing projects, sensitive observations of the human behaviour has been used under the case study approach.In casestudy design two main aspects were considered as identificationof unit ofanalysis and selection ofcases. The unit ofanalysis in this research is the labour productivity norms for the Aluminium system formwork and it was within the boundary of low-cost housing projects in Sri Lanka. Under the selection of cases, only the 4 available low cost housing projects having Aluminium System Formwork in Colombo were selected and the study was limited to the preparation of productivity norms only for the selected structural elements such as slabs, beams and columns, by conducting time studies. There the collected data under the direct observations by observing the time duration for labour work done in a selected area were analysedstatistically using the mean value of the numerical figures and eventually detailed cross case analysis is done in establishing the labour productivity norms.

4. ANALYSIS AND RESEARCH FINDINGS

Four low cost housing projects were selected in Colombo using Aluminium system formwork. Out of four, three projects have already finished the structural work and only one project is running at the later part of the structural work. Table 3 indicates the general information about the projects. Therefor due to the time restrictions and resource availability

Table 3: Summary of the cases

Description	Case 1	Case 2	Case 3	Case 4
Type	Low cost housing projects/Urban Regeneration Projects in City of Colombo for underserved settlements			
Employer	Government-Urban Development Authority			
Condition	Work is on progress	Nearly Completed	Nearly Completed	Nearly Completed
ICTAD grading	C1	C1	C1	C1
	For building works			
Duration	24 Months	24 Months	30 Months	24 Months
Contract Price	Rs. 2.18 Billion	Rs. 1.36 Billion	Rs. 2.89 Billion	Rs. 915 Million
Floors	12	12	12	12
Work Status	ASF on progress	Aluminium system formwork have already been used		
Data collection	Direct Observation-Time Study	Document Review		

4.1. CONDUCTING DOCUMENT REVIEW AND DIRECT OBSERVATION

At the time of the data collection, only one case was remaining with the ongoing superstructure to observe the procedure going on with Aluminium System Formwork. Therefor due to the time restrictions and resource availability it was decided to carry out the document review for three cases and direct observation for the remaining case which was the only case available in line with the requirement. There the document review was conducted using the site labour attendance documents and the measurement sheets available at site regarding the Aluminium System Formwork labour work done for a particular month.The observed date were entered to the observation sheet and then finalised in the checklist while keeping time allowances for performance rating and (Performance, Fatigue, Delay) PFD allowance. Thereafter, number of labours (Skilled and unskilled) in each task were multiplied by the total time allowed for the each task. After calculating the related areas to particular item, labour productivity norm was calculated.

4.2. COMPARISON OF THE FINDINGS IN DOCUMENT REVIEW AND DIRECT OBSERVATIONS

Under the time restrictions, document review had been done for the Case 2, Case 3 and Case 4 and for Case 1 the time studies have been done. Therefore, arrived labour productivity norms in both methods were compared and a remarkable deviation was highlighted since the results generated through the process of document review was considerably lesser than the labour productivity norms which were achieved through the direct observations.Therefore, the analysis of labour productivity norms in an advanced manner were emphasised as essential in the detailed analysis.

4.3. DETAILED ANALYSIS OF THE TIME STUDY RESULTS BASED ON THE EFFECT OF LABOUR PRODUCTIVITY FACTOR

In depth analysis was done for the varying effect labour productivity factor time studies.

Weather condition

In a fair weather condition, increment in the labour productivity can be observed. Whereas the mix of all weather conditions results vast deviations of labour efficiency. The impact of the weather conditions in transporting, erecting, dismantling, fasting jacks and aligning the elements, implied that heavy rains had not affect the tasks in a considerable manner. Whereas the average labour productivity norm had been increased gradually especially upper floors due to the impact of the wind speed.

Crew factor

Gang head`s involvement especially for the levelling, alignment and setting out activities and the proper labour mix, geared the labour efficiency in to a higher level. Experience and skills are critically important, for this systematic process and teamwork, cooperativeness is essential to follow the order properly whilesaving time and enhancing labour efficiency.

Management and Project factors

Supervision is needed in planning the site schedule and it is highlighted, that the less supervision for the activities is one of the major issues. Apart from that in planning some concurrent activities was impacted such as concreting activities. Further, the delays in proceeding activities such as reinforcement fixing, cleaning concreting and scaffolding work create a large effect.

Site conditions

In time study 3 and 4, labours were not used safety belts when transporting the panels due to the improper mechanism in ensuring the safety at site and lack of site supervision and delaying in scaffolding work. Moreover, the labour facilities and site security was in an averaged manner. Consequently, the analysis concluded that not only a single parameter or factor, but also a combine effect of the several parameters in different factors had contributed the considerable deviations in labour productivity norms.

4.4. DETAILED ANALYSIS OF THE TIME STUDY RESULTS IN STRUCTURAL ELEMENT BASIS

The in-depth study was done considering the structural elements such as columns, beams and slabs. Therefore, the results obtained through each time study based on structural elements illustrated in figure 1.

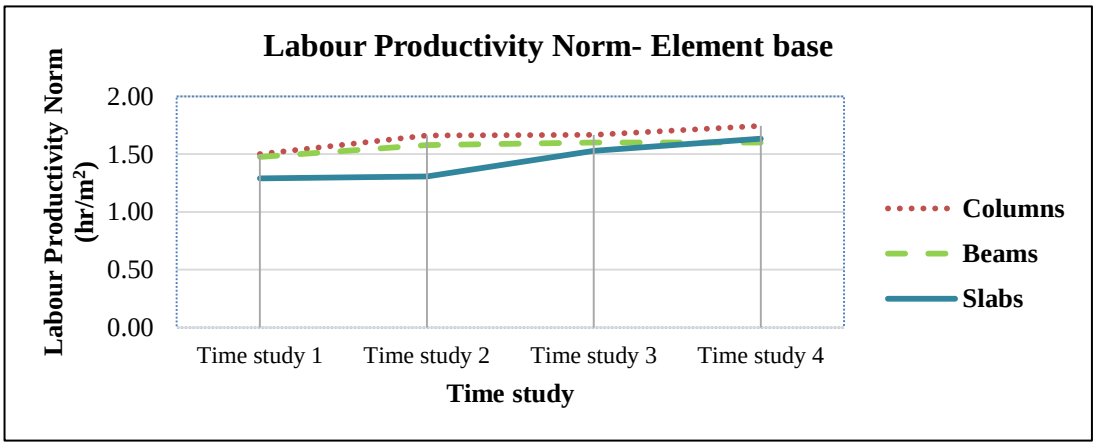

Figure 1: Element base LPN

According to figure 3 a slight deviations among columns, beams and slabs was identified and it is clear that some hidden factors creating a deviation for norms arrived in each structural elements. Therefore, following factors identified as critical such as; initial setting out, effect of fixing points, need of supports or props, necessity for alignment, gang head`s involvement in alignment, effect from handling panels, effect of re-fixing, and arrangement of the element and it is notified that, depending on the columns alignment all the other structural elements stand. Therefore it is clear that a considerable effect can be identified through a an element base comparison which provides a strong evidence for the necessity of in depth analysis since some element base factors are unique compared to conventional formwork. Moreover the labour efficiency also based on the labour mix, time spent for each task, the ratio between areas observed for each element. Further, when productive work, non-productive work and supportive work inherited were measured, in each element the productive labour hours had been increased whereas in non-productive and supportive labour hours were divided in nearly same amounts while proving the need of supportive labour hours relating to the main tasks. Therefore, proper balance in the productive and non-productive labour hours critically resulted in labour efficiency. Ultimately, in different conditions the effect of labour productivity factors and differentiating effect of structural element on labour productivity norm had been identified as more critical. Whereas slight deviations need to be considered on the basis of the factors which make unique, the element among other elements and to have a realistic outcome for the labour performance both.

4.5. PREPARATION OF LABOUR PRODUCTIVITY NORMS (LPN)

Based on the analysis in each time study, labour productivity norms had been prepared for four different occasions, to provide a realistic outcome for the labour performance for the Aluminium system formwork

- **Step 1 -** Each element generatethe different labour performances even within the situation where the same conditions were applied.

- **Step 2-** Having considering the factors related to the each element labour mix and the ratio between the areas of each elements are considered maintaining the labour mix by 50 % in-between skilled and unskilled with in each element create an average labour performance while correlating with the other factors identified in each element.

- **Step 3-** Thereby, having considering the each element and there differencing characteristics, the varying effect of the labour productivity factors need to be considered in different occasions.

- **Step 4-** All these four occasions demonstrated, the changing sequence of the labour productivity factors and its impact to the labour productivity norm shown in table 4 and it must be notified that this significant change had been clearly identified in each occasion and thereby with a thorough analysis a realistic figures had been obtained.

Table 4: Four different occasions identified

STEP 4	***Occasion 1***	***Occasion 2***	***Occasion 3***	***Occasion 4***
Characteristic	• fair weather condition • good combination • supervision and corporation of the labours • average planning sequence better site supervision • average site conditions prevails such as site safety and securit	•an average weather condition specially sunny day with cloudy sky, •average combination, •lesser corporation of the labours as a team, average planning sequence •site supervision exist , average site conditions including site safety and security	• Poor weather conditions (sunny weather to heavy rains as a mix. • average crew factors poor gang head`s involvement. • Poor planning sequence • Poor site conditions specially the safety factors.	• poor weather condition (mix of all the effects) • having lesser experience and lack of team spirit, • poor site management and lack of site safety poor site condition

STEP 4	***Occasion 1***			***Occasion 2***			***Occasion 3***			***Occasion 4***		
Element	**Column**	**Beam**	**Slab**	**Column**	**Beam**	**Slab**	**Column**	**Beam**	**Slab**	**Column**	**Beam**	**Slab**
Avg. LPN (hr/m^2) for occasion	1.42	1.42	1.42	1,53	1,53	1,53	1.60	1.60	1.60	1.67	1.67	1.67
Avg. LPN (hr/m^2)element	1.50	1.49	1.29	1.66	1.56	1.38	1.67	1.67	1.53	1.74	1.65	1.63
% of deviation	5%	4%	10%	8%	2%	10%	4%	0%	4%	4%	2%	2%

The table 4 clearly depicts that when the severity of the occasion is high the LPN arrived are high compared to the calm situations like in occasion 1 and 2.1.42 is the average LPN for the occasion 1 since it inheriting a better advantage where in any kind of a project can adopt with higher level of labour efficiency. Meanwhilethe LPN has been changed accordingly with the element indicating 1.50 for the columns and 1.29 for slabs depicting the different productivity levels which can be achieved in each element within the same occasion. Other than that when occasion 2 is considered it too contains the same characteristics but clearly shown the deviations which can be addressed due to the effect of Crew factors. Since the average figure has been taken as 1.53 compared tooccasion 1.Occasion 3 has been created addressing the shortcomings of the weather, management factors and accordingly 1.60 average figure can be obtained and as the finally occasion 4 is defined as a situation where lesser amount of labour efficiency leading the worse impact of the labour productivity factors and having a 1.67 average labour productivity. There it had been shown how the element wise figures changed accordingly based on the productivity levels of the element and the finds clearly adopt the percentage deviations between the figures of average labour productivity norm and the labour productivity norms for each element. Thereby the LPN can be taken in to practise where theelement wise deviation can be maintained with in the given percentage level from the average LPNs in different occasions.

5. CONCLUSIONS

In order to sustenance the concept of the low-cost housing projects, better labour productivity can be thoroughly taken in to consideration. Since the better productivity automatically enhanced the affordability, improve quality and save the time as well. Therefore, an appropriate formwork system was one of the ideal creature in facilitating the concept of low-cost housing and the impact of labour productivity factors such as weather conditions, design, buildability, site, management and project factors and crew factors were need to be considered. Specifically the direct relationship between labour

productivity factors and the productivity of the formwork enhance the importance of using formwork as a material to achieve the expectable productivity.

Eventually, Aluminium system formwork is heavily used in Sri Lankan low-cost housing construction projects, due to its systematic and advanced procedurecompared to conventional formwork. Further, a positive effect towards labour productivity factors in Aluminium System Formwork and a considerable incensement in labour productivity were highly beneficial in achieving the objectives of parties in the contract. Therefore, Aluminium system formwork had been accepted by the Sri Lankan construction industry as the easiest and most suitable advanced method in obtaining the best of labour productivityThereby, the introduction of a proper labour productivity norm under the elemental basis in a position of addressing the incensement of the labour productivity, facilitating the project planning and management, standardization and efficient evaluation generated a clear picture for the construction practitioners regarding the labour productivity while investigating the in-depth analysis of the characteristics of each element.

When building up labour productivity norms, it indicate the differences in each elements while considering the fluctuating effect of the labour proactivity factors. Further the labour productivity norms for Aluminium system formwork was targeting at the planning stage of the construction activates and also in estimating procedures for all the parties interested. Here, in element wise consideration and critical analysis of the labour productivity factorsin different occasions elaborated that varying effect of the LPN in each occasion and each element is mainly due to the factors differentiating each structural element such as initial setting out, effect of fixing points need of supports or props, necessity of alignment, arrangement of the element and etc. Furthermore when building up mores to measure the labour productivity labour mix and the ratio between the areas covered under each element need to the thoroughlyconsidered. Thereafter occasional deviation can be highlighted due to the varying effect of the labour productivity factors, such as weather conditions, crew factors, management and project factors and site conditions due to unforeseeable circumstances since the slight can of those can provide the ultimate outcome totally deviated from each otherThereby a realistic measure, can be obtained for the construction labour performance for Aluminium system formwork to facilities the concept of time cost and quality product while embossing the low cost housing concept as another beneficial pathway for its stakeholders, when adopting the advanced nature of the technological outcomes.

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