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FORECASTING LABOUR COST OF CONSTRUCTION TRADES FOR TWO-STOREY HOUSES: A SINGLE RATE-BASED APPROACH

RAMACHANDRA. T[1], MADUSHIKA. U, G, D.[2*] & NIRASHA. K, C[3]
[1, 2,3]Department of Building Economics, University of Moratuwa, Sri Lanka,
[1]thanujar@uom.lk, [2]dilakshimadushika96@gmail.com, [3]cheshkn@gmail.com

Abstract: With the labour cost contribution of 30%- 50% to the total construction cost of a typical building, construction is recognized as a labour-intensive industry. The extant literature evidenced that there exists labour scarcity in many construction trades, which has caused several negative effects. Hence, the assessment of labour requirements prior to the commencement of the building construction would help to mitigate the effects due to labour shortages at the organization and project level. This research aimed to assess the labour requirements for the cost significant trades of two-storey houses in Sri Lanka. The study involved a survey of thirty-eight (38) two-storey houses to collect the required data. The required data were extracted from the Bill of Quantities (BoQs) of those 38 buildings and assessed based on the norms available in the building schedule of rates (BSRs) practised by the key construction companies. The analysis identified that the finishes, in situ concrete works, doors and windows, services, masonry works, and roof works are the significant trades, respectively in the descending order of their contribution to the total cost. However, in the descending order of their labour requirements, finishing works, masonry works, concrete works, reinforcement, formwork and roofing work are more labour-based activities, require 0.274 skilled labour days and 0.228 unskilled labour days, on average for the construction of per unit (sq.ft) of gross floor area (GFA) of a two-storey house in Sri Lanka. Further, in the case of two-storey houses, cost significant trades contribute to around 19% of its total cost. This would enable estimating the labour cost for a proposed project and thereby implement appropriate strategies to manage the labour shortages in projects and the construction industry as a whole.

***Keywords**: Forecasting; Significant cost elements; Skilled labours; Two Storey; Unskilled labours*

1. Introduction

The construction industry is an essential component of the socio-economy (Nazarkoa & Chodakowskaa, 2015). Horta, Camanho, Johnes, and Geraint (2012) illustrated that approximately 9% of the world's Gross Domestic Product (GDP) had been represented by the global construction industry. Similarly, the construction industry plays a significant role in the Sri Lankan economy by occupying 6.8% of the GDP (Central Bank of Sri Lanka, 2018).

Construction performance and productivity improvement are the main focused areas of the construction industry in any country (Prachi & Pravin, 2016). According to Sara and Alexander (2017) and Attar, Gupta, and Desai (2013), the term "productivity" is referred to the relationship between output and input. It can be applied to mitigate the negative impacts of construction, such as project delays, liquidation losses, and contractor profit margins (Argaw & Ajibade, 2018). Labour productivity is one of the main factors which is impacted construction productivity (Sara & Alexander, 2017). Kazaz and Acikara (2015) indicated that the success of a construction project mainly depends on the labour force due to the labour-intensive nature of the construction industry. Labour cost in the construction industry is estimated to be about 33%- 50% of its entire project cost (Gundecha, 2012). However, Abdul-Rahman et al., (2006) stated that the labour shortage negatively impacted the project schedule and safety while increasing the project duration and construction cost. To this end, Zaki, Mohamed, and Yusof (2012) stated that the construction labour shortage has become the greatest challenge which is faced by the global construction industry. Similarly, in the Sri Lankan context, the labour shortage is one of the most important factors that affect labour productivity (Abeynayake, Perera, & Hadiwattege, 2018).

According to Annigeri, Kelka, and Kulgude (2018), labour management is one of the best solutions for labour shortages in the construction industry. Oseghale, Falemu, and Oseghale (2015) indicated that the assessment of the current state of the construction industry's skilled workforce can be used for the labour management process. Though

*Corresponding author: Tel: +94 771446934 Email Address: dilakshimadushika96@gmail.com
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many researchers have identified the factors that affected construction productivity, labour productivity and labour shortages in the construction industry (Prasath, 2014; Jayasinghe, 2014; Nadekumar, 2018), there seems to be a limited focus on the assessment of labour requirements per unit area. Hence, this study aims to assess the labour requirements per sq.ft of Gross Floor Area (GFA) as a measure of forecasting the labour days requirements and cost of labour to be incurred for a proposed project.

2. Literature Review

The construction industry in Sri Lanka is expected to grow steadily and systematically in the long-term while being an important and integral part of the economy (Ramachandra, Rotimi, & Rameezdeen, 2013). According to the Central Bank of Sri Lanka (2018), the Sri Lankan construction industry contributes 6.8% to the country's GDP. There are different types of construction activities such as building construction projects, heavy and light civil engineering construction projects, and specialised industrial constructions (Muhwezi, Faisal, Kyakula, & Batambuze, 2012).

Labour productivity plays a key role in modernising the concept of a low-cost residential building, as it improves accessibility, quality and time savings (Jayasinghe & Fernando, 2017). Since labour is more complex and uncertain than other components of project costs, the effects of various factors on labour productivity need to be understood (Gundecha, 2012). The construction industry is a labour-intensive industry that heavily relies on the skills of its workforce and labour cost in the construction industry is estimated to be about 33%- 50% of the entire project cost (Agapiou, Price, & Mccaffer, 2006; Gundecha, 2012).

According to Enshassi, Mohamed, and Mayer (2010), Ghoddousi and Poorafshar (2015), and Karunarathna and Siriwardana (2018), labour shortage is one of the major factors which affect labour productivity. The labour shortage refers to the scarcity of human resources with formal accreditation of higher education or vocational education and training, including professional qualifications such as engineering, architecting, quantity surveying, surveying or trade qualifications such as those associated with electricians, mechanics, plumbers, and masons (Montague, 2013). Similarly, Praveen, Niththiyananthan, Kanarajan, and Dissanayake (2013) depicted that skills drain and scarcity as the main problem in the Sri Lankan construction sector. According to Basnayake and Premathilaka (2015), delays in the projects, inability to figure out drawings, inability to manage unforeseen site conditions, lower quality of work, material wastage, and errors during construction, safety issues, and additional cost of removing bad work are some drawbacks of labour shortage.

Labour management referred to the process of channelling the vitality and abilities of mankind in achieving business objectives which can be considered the best solution to reduce labour shortages (Annigeri, Kelka, & Kulgude, 2018). Labour management in construction activities includes improving labour productivity and reducing project time and cost overruns (Annigeri, Kelka, & Kulgude, 2018). Moreover, better labour management practices are required in order to improve labour performance and human resource planning to achieve the ultimate project goals (Soe & Cho, 2014). To this end, an assessment of labour requirements can be used to manage labour in the construction industry. Moreover, if the supply of labour is adequate for all construction work to be carried out, the work can be completed on time without any delay.

Due to the rapid population growth and economic growth, many countries are experiencing intense infrastructure expansion, especially with regard to residential buildings in the construction sector (Taleb & Sharples, 2020). According to the Department of Census and Statistics (2016), residential building construction in Sri Lanka contributes 24% to the overall building construction value. Furthermore, in recent years, the housing construction sector in Sri Lanka shows rapid growth due to the rising housing demands as well as the government incentives for new housing projects (Galagoda, 2017). In this aspect, it is pertinent to assess the labour requirements for the construction of residential buildings in line with the increased demand for the same.

3. Research Methodology

This study was conducted to assess the labour requirements for the construction of residential buildings through a survey of low-rise housing projects completed during the last five years, by referring to bills of quantities (BOQs) of those projects. Initially, eighty-seven (87) BOQs of low-rise houses were collected. The sample consisted of sixteen (16) single storeys, forty-nine (49) two storeys, eighteen (18) three storeys, three (3) four storeys and one (1) five-storey building. Since the majority of house buildings belonged to the two-storey category, it was decided to assess the labour requirements for the construction of two-storey houses. Of the forty-nine (49) BOQs of two-storey houses, thirty-eight (38) buildings were considered for analysis due to the unavailability of detailed specifications in the remaining BOQs. The profile of the selected projects is shown in Table 1.

Table 1: Profile of the Selected Projects

Year of Construction	No.	GFA (sq.ft)	No.	Location	No.
2016	11	less than 2500	7	Western Province	26
2017	5	2500 - 3500	18	Southern Province	5

2018	5	3500 - 4500	5	Others	7
2019	10	more than 4500	8		
2020	7				

As per Table 1, the GFAs of the selected 38 projects range from less than 2500sq.ft to more than 4500sq.ft. Of them, most of the projects belong to the category of 2500 – 3000 sq.ft. GFA. This offers an average floor of a two-storey house as 3000sq.ft.

Further,

The collected data was analysed to achieve the three main objectives of this study: 1) to identify the significant cost elements, 2) to assess the labour requirement per sq.ft. of GFA of the cost significant elements, and 3) to assess the labour cost contribution. The outcome of this analysis is presented in the following section.

4. Data Analysis

4.1. SIGNIFICANT TRADES OF TWO-STOREY HOUSES IN SRI LANKA

Initially, a Pareto analysis was carried out to identify the cost elements, which contribute significantly to the total cost of the two-storey houses. Pareto's 80/20 rule defines 20% of significant causes that contribute to 80% of the average of the target value (Horner & Zakieh, 1996). Accordingly, the cost of individual elements was normalised by dividing the elemental cost by the respective GFA of each project. Then, the percentage contribution of each element to the mean value of total costs of measured work items of 38 buildings was computed and elements were arranged in descending order of their percentage contribution. Finally, the cumulative percentage was obtained and the results are presented in Table 2.

Table 2: significant cost elements of two-storey houses

Elements	Avg. cost per GFA	%	Cumulative %
Finishes (including floor, wall, and ceiling)	1,452.00	22%	22%
In situ Concrete works (including concrete, formwork and reinforcement)	1,136.69	17%	39%
Doors and windows	889.24	14%	53%
Services (Electrical, plumbing, and mechanical)	701.18	11%	64%
Masonry works	655.23	10%	74%
Roof works (including roof plumbing)	555.80	8%	82%
External works & landscaping	275.47	4%	86%
Preliminaries	209.03	3%	89%
Excavation and earthwork	182.30	3%	92%
Metalwork	137.21	2%	94%
Waterproofing	126.22	2%	96%
Woodwork	115.72	2%	98%
Composite items	84.78	1%	99%
Glazing	44.09	1%	100%
Total cost of measured works	**6,565,00**	**100%**	

As illustrated in Table 2, 6 out of 14 (only 40% of the cost elements) cost elements have contributed to 80% of the total costs of the two-storey houses. Amongst, finishes (including floor, wall, and ceiling) are the dominant cost element with a contribution of approximately 22% to the total costs of the two-storey houses. The second most significant cost element is the in situ concrete works including concrete, reinforcement, and formwork trades (17%). Next, the costs incurred for doors and windows, services (including electrical, plumbing, and mechanical), masonry works, and roofing works are significantly influencing the construction costs with the contribution of approximately 14%, 11%, 10%, and 8%, respectively.

However, doors and windows, and services trades were excluded in the next step, for the assessment of labour requirements per GFA as the cost of those elements vary significantly in accordance with design and specifications for a given context.

4.2. ASSESSMENT OF LABOUR REQUIREMENTS FOR SIGNIFICANT TRADES

As the first step of assessing the labour requirements, quantities per GFA were calculated for each of the above-identified significant cost element. Then, Building Schedules of Rates (BSR) practised by the leading construction companies, which provide standard norms for work items, were used to derive the labour requirements (Refer to Annexure 1).

4.2.1 Analysis of labour requirements for finishing work

Under the finishing works, all the floor, wall, ceiling finishes and paintings were considered. Wall finishes include the external and internal wall plastering, and tiling while floor finishes include the cement rendering and tiling. Under the ceiling finishes, soffit plastering and timber ceiling were considered. Paintings cover all external and internal walls and soffit paintings. Table 3 illustrates the labour required for the finishing work of selected projects per GFA.

Table 3: Labour Requirement per GFA for Finishing Work

GFA Category (sq.ft)	Unit	Finishing work – Labour requirement per GFA	
		Un Skilled	Skilled
less than 2500	Days	0.112	0.151
2500 - 3500	Days	0.115	0.155
3500 - 4500	Days	0.118	0.184
more than 4500	Days	0.128	0.193
Average	**Days**	**0.118**	**0.171**

Labour requirement per sq.ft. of GFA for finishing works of a two-storey house is higher than all other significant cost elements. In the finishing works, skilled labour required per sq.ft. is higher compared to the unskilled labour requirement. Labour requirement for finishing works shows a direct relationship with the GFA. According to Table 3 average unskilled and skilled labour requirement per GFA (sq.ft.) for finishing work of two-storey house is 0.118 days and 0.171 days, respectively.

4.2.2. Analysis of labour requirements for in-situ concrete work

According to New Rules of Measurement (NRM1), the in-situ concrete trade involves three main sub-trades: concrete, formwork, and reinforcement. In situ concrete trade includes foundation, columns, beams, slabs, stairs, and walls. Using the respective work norms for both skilled and unskilled labours, the labour requirements for these trades were calculated separately for each category of GFA for the site mix concrete and shown in Table 4.

Table 4: Labour Requirement per GFA for Concrete Trade

GFA Category (sq.ft)	Unit	Labour requirement per GFA					
		Concrete Work		Formwork		Reinforcement	
		Un Skilled	Skilled	Un Skilled	Skilled	Un Skilled	Skilled
less than 2500	Days	0.033	0.011	0.0010	0.0216	0.030	0.030
2500 - 3500	Days	0.036	0.012	0.0012	0.0226	0.031	0.031
3500 - 4500	Days	0.038	0.013	0.0010	0.0228	0.032	0.032
more than 4500	Days	0.040	0.013	0.0011	0.0233	0.032	0.032
Average	**Days**	**0.037**	**0.012**	**0.001**	**0.023**	**0.031**	**0.031**

In concrete work, skilled and unskilled labours are mainly required for concrete mixing, placing, and curing of all grades of concrete of grade 10 to grade 30. Analysis revealed that the skilled labour required per sq.ft of concrete work was less compared to the unskilled labour requirement. Further, as seen in Table 4, there is only a marginal increase in the skilled and unskilled labour requirements with the increase in GFA. This indicates that on average the unskilled and skilled labour requirement per GFA (sq.ft.) for concrete trade of a two-storey house is 0.037 days and 0.012 days, respectively.

Similarly, the skilled and unskilled labourers required for the fixing of the formwork were calculated. As per Table 4, on average, the fixing of formwork requires 0.001 unskilled labour days and 0.023 skilled days to complete the formwork involved in the construction of a two-storey house. Unlike concrete trade, fixing formwork requires more skilled labours than unskilled labours. The Labour requirement for formwork does not show variation with GFA.

Reinforcement is the other main element in the concrete work where an equal number of both skilled and unskilled labours are employed, as per the norm. Table 4 depicted that the labour requirement is increased with the increment of GFA. On average unskilled and skilled labour requirement per GFA (sq.ft.) for reinforcement of a two-storey house is 0.031 days.

4.2.3. Analysis of labour requirements for masonry work

Masonry works include random rubble masonry for the sub-structure and walls for the superstructure. Both bricks and block works of half and full bonds were considered to calculate the skilled and unskilled labour requirements and the results are shown in Table 5.

Table 5: Labour Requirement per GFA for Masonry Work

GFA Category (sq.ft)	Unit	Masonry work – Labour requirement per GFA	
		Un Skilled	Skilled
less than 2500	Days	0.034	0.030
2500 - 3500	Days	0.034	0.030
3500 - 4500	Days	0.035	0.033
more than 4500	Days	0.039	0.035
Average	**Days**	**0.036**	**0.032**

As per Table 5, the skilled labour required per sq.ft. is lesser compared to the unskilled labour requirement in the masonry work of two-storey houses. As per the analysis, the average unskilled and skilled labour requirement per GFA (sq.ft.) for masonry work of a two-storey house is 0.036 days and 0.032 days, respectively.

4.2.4. Analysis of labour requirements for roofing work

When considering the roofing work of these selected projects, slabs, asbestos roofing and Calicut tile roofing were mainly available. Slabs were not considered in this section since it is already included under the concrete works. Therefore, the GFA range of 3500 – 4500 sq.ft. was ignored when calculating the labour requirement for roofing works due to out of five projects in this range, two projects contain slabs as roofs and the other three show significant deviation from each other.

Roofing works include roof covering, structure and roof plumbing. Skilled and unskilled labour requirements for roofing works of other categories are shown in Table 6.

Table 6: Labour Requirement per GFA for Roofing Work

GFA Category (sq.ft)	Unit	Roofing work – Labour requirement per GFA	
		Un Skilled	Skilled
less than 2500	Days	0.003	0.005
2500 - 3500	Days	0.004	0.004
more than 4500	Days	0.007	0.006
Average	**Days**	**0.0046**	**0.005**

According to Table 6, the average unskilled and skilled labour requirement per GFA (sq.ft.) for roofing work of a two-storey houses is 0.0046 days and 0.005 days, respectively.

4.2.5. Summary of the average labour requirement for cost-significant elements

As per the above analysis, it is clear that there are no such significant differences in labour requirement of the above-discussed cost elements on GFA. Hence, a summary of the average labour requirement of each identified significant cost element can be illustrated as in Table 7.

Further, as stated in the research methodology section, the average floor of a two-storey building can be considered as 3000 sq.ft. Hence, in Table 7, the labour required for the significant cost elements of a typical two-storey house is derived considering the average floor area of 3000 sq.ft.

Table 7: Summary of Labour Requirements per GFA

Cost Element	Unit	Average Labour requirement					
		per sq.ft of GFA			For a typical Two-storey house (3000 sq.ft)		
		Un Skilled	Skilled	Total	Un Skilled	Skilled	Total
Finishing work	Days	0.118	0.171	0.289	354	513	867
Masonry work	Days	0.036	0.032	0.068	108	96	204
Reinforcement	Days	0.031	0.031	0.062	93	93	186

Concrete work	Days	0.037	0.012	0.049	111	36	147
Formwork	Days	0.001	0.023	0.024	3	69	72
Roofing work	Days	0.005	0.005	0.01	15	15	30
Total	Days	0.228	0.274	0.502	684	822	1,506

Out of the considered cost-significant elements, finishing works is the highest labour required trade item. Following, masonry works, reinforcement, concrete works, formwork and roofing works used the labour. When considering the above cost significant items, the skilled labour requirement is higher than the unskilled labour requirement.

4.3. ASSESSMENT OF LABOUR COST CONTRIBUTION OF COST SIGNIFICANT ELEMENTS

As the next step of the analysis, labour costs for the above-considered cost significant elements were calculated. To obtain the labour cost, average labour rates for the last five years were considered. Accordingly, Rs. 3,000.00 and Rs. 2,000.00 per day for skilled and unskilled labour, respectively was considered for the calculation. Average labour costs for the above-considered cost significant items for a typical two-storey house are listed in Table 8.

Table 8: Labour Cost contribution for a typical two-storey house

Item	**Skilled Labour Cost**	**Unskilled Labour Cost**	**Total labour Cost**	**%***
	Amount (Rs.)	**Amount (Rs.)**	**Amount (Rs.)**	
Finishing work	1,539,000.00	708,000.00	2,247,000.00	11%
Masonry work	288,000.00	216,000.00	504,000.00	3%
Reinforcement	279,000.00	186,000.00	465,000.00	2%
Concrete work	108,000.00	222,000.00	330,000.00	2%
Formwork	207,000.00	6,000.00	213,000.00	1%
Roofing work	45,000.00	30,000.00	75,000.00	0.4%
Total	**2,466,000.00**	**1,368,000.00**	**3,834,000.00**	**19%**
	64%	**36%**	**100%**	

***% contribution of labour cost to the total cost of construction**

As observed in Table 8, the contribution of skilled labour cost to the total cost of significant trades is 64% while unskilled labour cost contribution is 36%. Amongst the significant trades, finishing works are the highest labour cost contributor, representing 11% of total construction cost followed by a 3% contribution from masonry works. The reinforcement and concrete work contribute equally 2% to the total labour cost of significant trades. Roofing works contribute the least to the total cost of construction.

Based on the selected 38 buildings, the average construction cost per GFA of a two-storey house can be derived as Rs. 6,565.00. Accordingly, the total cost of construction is calculated as 19,694,970.00 and the labour cost contribution of significant trades (Finishing work, masonry work, concrete work, reinforcement, formwork, and roofing work) is derived as 19%.

5. Conclusion

This study has aimed to assess the labour requirements for significant cost elements of two-storey housing construction projects in Sri Lanka. The scope of this study was narrowed down into two-storey housing constructions with time constraints and data availability.

According to the sample considered in this study, the average floor of a two-storey house is 3000 sq.ft. From the study findings, it was apparent that finishes, in situ concrete works, doors and windows, services, masonry works, roof works, and external works and landscaping are the significant cost elements of a two-storey house in Sri Lanka. The analysis results of the current study revealed that there is no significant deviation of labour requirement per sq.ft. of GFA with the size of the project (GFA) for significant cost elements in the two-storey house. Among the analysed cost elements, finishing works account for the highest labour requirement per sq.ft. of 0.118 and 0.171 days for unskilled and skilled labours, respectively. When considering the average labour requirement per sq.ft. of GFA, concrete works require 0.037 unskilled labours days and 0.012 skilled labour days while formwork consumes 0.031 unskilled labour days and 0.031 skilled labour days. Reinforcement and roofing works account for a similar number of skilled and unskilled labours separately for each element as 0.031 and 0.005 days, respectively. Further, unskilled labour requirement is higher in concrete work and masonry works while skilled labour requirement is higher in formwork and finishing works. Analysis results further revealed that the considered cost-significant items contribute to 19% of the average total cost of a two-storey house. Hence, it is expected that these findings of the study would enable the contractors, site engineers, labour subcontractors/suppliers, and other professionals engaged in construction trades businesses for appropriate planning and estimation of labours and thereby mitigate the labour shortages in the organisations as well as in the industry as a whole.

The study findings are limited to two-storey houses in Sri Lanka. Further, out of the identified cost-significant elements, labour requirements for services, and doors and windows which represent 25% of total construction cost were excluded in this study as there are significant variations in design and specifications of those amongst the selected buildings. However, an appropriate allowance for the labour cost of these work items can be established by referring to standard two storey house estimates. The labour cost so derived is added to the labour cost of significant items excluding services, and doors and windows and to derive the total labour cost of a proposed two storey house. Hence, it is recommended to extend the study to other elements and other types of residential buildings by considering a larger sample.

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Annexure 1: Labour norms for the significant cost items used in this study

Elements	Unit	Norms	
		Un Skilled	**Skilled**
01. Finishes			
1.1 Wall finishes			
1.1.1 Internal wall plastering/rendering	Days	1.250	1.000
1.1.2 Internal wall painting (Emulsion 2 coats)	Days	-	1.250
1.1.3 External wall plastering	Days	1.500	1.000
1.1.4 External wall painting (Weather shield 2 coats)	Days	-	0.670
1.1.3 Tiles	Days	4.000	4.000
1.2 Floor finishes			
1.2.1 Cement rendering	Days	2.000	1.000
1.2.2 Tiles	Days	3.500	4.000
1.3 Ceiling finishes			
1.3.1 Soffit plastering	Days	2.500	2.500
1.3.2 Soffit painting (Emulsion 2 coats)	Days	-	1.750
1.3.3 Timber ceiling	Days	1.000	1.000
02. In situ Concrete works			
2.1 Concrete			
2.1.1 Grade 10	Days	2.500	0.180
2.1.2 Grade 15	Days	4.000	1.330
2.1.3 Grade 20	Days	7.000	2.330
2.1.4 Grade 25	Days	7.000	2.330
2.1.5 Grade 30	Days	7.000	2.330
2.2 Formwork			
2.2.1 Sides of foundations	Days	6.670	6.670
2.2.2 Sides of column base	Days	6.670	6.670
2.2.3 Sides of ground beam	Days	10.910	5.450
2.2.4 For slabs	Days	0.045	0.023
2.2.5 For beams	Days	0.109	5.455
2.2.6 For Columns	Days	0.067	0.067
2.2.7 For Portal frames	Days	0.014	0.345
2.3 Reinforcement			
2.3.1 For slabs	Days	1.000	1.000
2.3.2 For beams	Days	1.000	1.000
2.3.3 For Columns	Days	1.000	1.000
2.3.4 For staircases	Days	1.000	1.000
2.3.5 For walls	Days	1.000	1.000
03. Masonry works			
3.1 Random rubble masonry	Days	6.000	4.000
3.2 Brickwork			
3.2.1 225 mm brickwork	Days	3.750	2.250
3.2.2 112.5 mm brickwork	Days	2.000	1.500
3.3 Blockwork			
3.3.1 100 mm blocks (16"x 8"x 4")	Days	2.250	1.250
3.3.2 150 mm blocks (16"x 8"x 6")	Days	2.250	1.250
04. Roof works			
4.1 Asbestos roof covering and structure	Days	1.389	0.972
4.2 Tile roof covering and structure	Days	1.833	1.667
4.3 Barge/Valance board (3/4" x 9")	Days	0.030	0.030
4.4 Ridge/ hip tiles (Calicut)	Days	0.021	0.021
4.5 Eave Gutters -PVC 6"half round	Days	0.500	0.500
4.6 Downpipes - PVC -3.5"	Days	0.330	0.330