This book has been written for the use of students, teachers, tutors, instructors and lecturers of Colleges of Technology, Monotechnics, Polytechnics, Universities, Research Institutes and all forms of tertiary educational institutions offering construction-related courses. The book will enable students of tertiary institutions to understand the fundamentals of estimating, price analysis and build-up of rates for construction works. In addition, the book will prepare students for career progression, upon graduation, as required by the Nigerian Institute of Quantity Surveyors (NIQS), Nigerian Institute of Building (NIOB), Nigerian Institution of Estate Surveyors and Valuers (NIESV), Royal Institution of Chartered Surveyors (RICS) and other allied professional associations.

Abdullateef Shittu
John Idiake

Estimating & Price Analysis for Construction Works

A Guide for Students and Teachers in Higher Institutions

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(A Guide for Students and Teachers in Higher Institutions)

BY

Abdullateef Adewale Shittu

&

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2023

ESTIMATING & PRICE ANALYSIS FOR CONSTRUCTION WORKS
(A Guide for Students and Teachers in Higher Institutions)

BY

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2023

FOREWORD

This book was written to address the areas where students usually have problems in understanding the basic principles of estimating and price analysis in construction works. And arising from this deficiency, ultimately, is the employability problem amongst graduates who wish to practice. Consequently, in this book, the basic principles of estimating and price analysis of construction works are simplified for better understanding. This, hopefully, will bring about cordial and mutual working relationship amongst contractors, clients and employees in the construction industry. The authors of the book are professionals and seasoned academics with a wealth of experience in the construction industry. The book is therefore recommended to construction stakeholders across the globe to tap from the wealth of experience of the authors in addressing related problems that may be encountered.

Prof. J. E. Idiake ***(PhD; RQS)***

PREFACE

This book has been written for the use of students, teachers, tutors, instructors and lecturers of Colleges of Technology, Monotechnics, Polytechnics, Universities and Research Institutes and all forms of tertiary educational institutions offering construction-related courses. The book will enable students of tertiary institutions to understand the fundamentals of estimating, price analysis and build-up of rates for construction works. In addition, the book will prepare students for career progression, upon graduation, as required by the Nigerian Institute of Quantity Surveyors (NIQS), Nigerian Institute of Building (NIOB), Nigerian Institution of Estate Surveyors and Valuers (NIESV), Royal Institution of Chartered Surveyors (RICS) and other allied professional associations.

This book will also serve as a course manual for teachers, tutors, instructors and lecturers of tertiary institutions offering construction-related courses all over the world and especially in West Africa and Nigeria. Therefore, this book has been broken down into nineteen (19) chapters. These chapters cover the most common work items executed day-to-day in construction projects. Furthermore, the book was written to address identified areas where students usually have problem in understanding the basic principles of estimating and price analysis in construction works. A list of references has been provided at the end of the book for further readings. This book is therefore recommended to all students and teachers of the tertiary institutions offering construction-related courses for effective teaching-learning process.

DEDICATION

This book is dedicated to the glory of God and all academic and non-academic staff members of the Department of Quantity Surveying, Federal University of Technology, Minna, Niger State, Nigeria.

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We wish to express our sincere gratitude to God almighty who has spared our lives and made it possible for the successful completion of this work. Our sincere appreciation goes to all academic staff members of the Department of Quantity Surveying, Federal University of Technology, Minna, Niger State, Nigeria, for their great contributions and constructive criticism towards the quality and successful completion of this work. The immediate past Head of Quantity Surveying Department, Dr. Y. D. Mohammed, and the current Head of Quantity Surveying Department, Dr. A. D. Adamu, have been very helpful in making the atmosphere very conducive for learning and research. Thanks a lot Sir and Ma. We will not forget to thank Lambert Academic Publishing Group, especially Dr. Wolfgang Philipp Müller, Christine Cateaux and Anna Haritonova, for providing a user-friendly forum and platform for academics and scholars to disseminate their brilliant ideas to the general public. Finally, we thank all readers for going through this book.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

Material estimating is the systematic breakdown of a measured item into its components from a bill of quantities. For example, concrete can be broken down to cement, sand and aggregate by volume. While preparing the estimate, the quantities of various materials of work are determined by using simple mathematical formula. For example, from the quantities so determined, the abstract of material cost is prepared.

For correct estimation, the correct dimensions are to be taken from the drawings. Therefore, good knowledge of technical drawing is the pre-requisite for accuracy in estimating. In material estimating, allowances must be made to cover wastage which may arise as follows:

(i) **Handling Breakages:** Brittle materials such as bricks, pre-cast concrete paving slab, etc. are prone to breakage even with the advance in mechanised handling of material which is wrapped and delivered on pallets.

(ii) **Site Losses:** Loose materials such as sand and aggregate delivered and tipped on site will, to some extent, be trapped into the ground, washed away by rain, etc. and an allowance has to be made for this loss.

(iii) **Cutting Losses:** Materials delivered in sheet form such as plaster board, plywood, glass, carpet, etc. are cut to fit. Where the material is patterned or has to be cut to a difficult/irregular shape, losses can be considerable. Therefore, it is essential to make allowance for these cutting losses during material estimation.

CHAPTER TWO

EXCAVATION AND FILLING

2.1 Construction Equipment used for Excavation and Filling

The equipment used in the construction industry for construction activities are mainly **Earth Moving Equipment**. These are equipment used in heavy construction, especially civil engineering projects, which often require the moving of millions of cubic metres of earth. The removal of earth or materials from bottom of bodies of water is performed by dredges. These include:

2.1.1 Bulldozers

The primary earth-moving machine is the heavy-duty tractor, which, when fitted with endless tracks to grip the ground and with a large, movable blade attached in front, is called a bulldozer (See Figure 2.1). Bulldozers are used to clear bush or debris, remove boulders, and level ground.

Fig. 2.1: A Bulldozer (Source: Ikupolati & Olaleye, 2016 cited in Shittu, 2022)

2.1.2 Scraper

A scraper is a machine that may be pulled by a tractor or may be self-powered. It consists of a blade and a box or container. Dirt is scraped by the blade into the container. The dirt may then be released so as to form an even layer of a predetermined thickness, or be carried off for disposal elsewhere. Scrapers are used to level contour land, as in road construction. Figure 2.2 shows the picture of a typical scraper.

Fig. 2.2: A Scraper (Source: Ikupolati & Olaleye, 2016 cited in Shittu, 2022)

2.1.3 Grader

Somewhat similar to scrapers are graders, self-propelled, wheeled machines with a long, inclined, vertically adjustable steel blade. Graders are primarily finishing equipment; they level earth already moved into position by bulldozers and scrapers. A grader has a laser levelling unit mounted on its blade.; the levelling device constantly adjusts the height of the blade to ensure that the ground is made precisely flat. See Figure 2.3 for the picture of a typical grader.

Fig. 2.3: A Grader (Source: Ikupolati & Olaleye, 2016 cited in Shittu, 2022)

2.1.4 Tractor

Lightweight tractors fitted with wheels in place of tracks are used for comparatively light construction jobs. Equipped with a backhoe, which is an open scoop attached rigidly to a hinged boom, such a vehicle can dig shallow trenches; equipped with a front-end loader, a scoop shovel affixed to the front of the tractor, it can lift and carry gravel, stone, sand, and other construction materials (see Figure 2.4).

Fig. 2.4: A Tractor (Source: Ikupolati & Olaleye, 2016 cited in Shittu, 2022)

2.1.5 Dragline

Draglines and power shovels are primary forms of excavation equipment. A dragline is fitted with an open scoop supported from the end of a long boom by a wire cable. The scoop is dragged along the ground by the cable until it is filled with earth, which is then dumped elsewhere. Draglines are used primarily to excavate deep holes. Power shovels are fitted with buckets called clamshells, which dig into the earth and shovel it up. The bottom of the clamshell opens to dump the dirt into a truck for removal. See Figure 2.5 for the picture of a typical dragline.

Fig. 2.5: A Dragline (Source: Ikupolati & Olaleye, 2016 cited in Shittu, 2022)

2.1.6 Mobile Derrick Crane

The derrick crane moves heavy objects through the use of a motor, which winds cable around a winch, and a system of pulleys. See Figure 2.6 for the picture of a typical mobile derrick crane.

Fig. 2.6: A Mobile Derrick Crane (Source: Ikupolati & Olaleye, 2016 cited in Shittu, 2022)

2.1.7 Dump Truck

Dump trucks have large open beds for hauling loose materials such as gravel or soil. To empty the bed's contents, a hydraulic lift inside the truck tilts the bed, dumping the contents behind the truck. Dump trucks are common at busy construction sites, where large amounts of building materials are frequently moved (see Figure 2.7).

Fig. 2.7: A Dump Truck (Source: Ikupolati & Olaleye, 2016 cited in Shittu, 2022)

2.2 Site Preparation

This section is concerned with the removal of trees, tree stumps, bushes, shrubs, undergrowth and hedges. A tree or tree stump is defined in the Standard Method of Measurement (SMM) as having a trunk of at least 600mm girth at 1.00m above ground level or at the top of the stump. The assumption can only be made that anything smaller is a bush.

2.3 Excavation & Earthwork

Excavation & earthwork is given a provisional sum depending on the nature and volume of the work. Items that come under this section are as follows:

1. Over Excavation
2. Backfilling of surplus excavated material from site
3. Level and compact bottom of excavation
4. Earthwork support (not common in simple buildings)

2.4 Bulking

When earth and the like are excavated, they increase in volume. Therefore, an allowance has to be made for this in computing volume of material required. Table 2.1 shows the rates of bulking while Table 2.2 shows the capacity of excavated material hauled per load.

Table 2.1: Range of Increase in Bulk for Various Soil Types

TYPES OF SOIL	RATE OF INCREASE (%)
Gravel	10.00
Sand	12.50
Normal	25.00
Clay	33.33
Chalk	33.33
Rock	50.00

Table 2.2: Volume (in m^3) of Excavated Material Hauled per Load

Nature of Material Hauled	Haulage by Lorries					
	The m^3 of solid material hauled per load					
	1 Tonne Lorry	2 Tonne Lorry	3 Tonne Lorry	4 Tonne Lorry	5 Tonne Lorry	6 Tonne Lorry
Loamy soil and soft clay	0.58	1.16	1.74	2.32	2.90	3.48
Chalk	0.44	0.88	1.32	1.76	2.20	2.64
Stiff clay	0.52	1.04	1.56	2.08	2.60	3.12
Gravel	0.57	1.14	1.71	2.28	2.85	3.42
Sand	0.66	1.32	1.96	2.64	3.20	3.96
Soil	0.62	1.24	1.86	2.48	3.10	3.72
Broken rock	0.37	0.74	1.01	1.48	1.85	2.22

2.5 Hardcore or Laterite Filling

Usually, the given area (m^2) of each of these items is multiplied by the required thickness of each to convert to m^3 and the m^3 is divided by the carrying capacity of the lorry to arrive at the tipper load.

Example 2.1:

Suppose it is required to estimate the laterite filling for $120m^2$ of floor area assuming normal ground.

Solution:

Area of Hardcore = $120m^2$
Required Thickness = 0.15m
Tipper load required assuming a 3 Tonner;
Therefore; Laterite Filling = 120 x 0.15 + [25% for bulking]
= $(18m^3 + 4.5) \times 1.86$
= $22.5m^3 \times 1.86$
= 41.85
Approximately 42 Tipper Loads

2.6 Earthwork Support

The SMM specifies, among other things, that the vertical faces of excavations shall be supported by materials other than sheet piling for any face over 250mm high and the angle of slope is 45^0 and above. The type of soil to be retained governs planking and strutting. The estimator is left to decide how to achieve this support and he/she will take into account the following:

a) Thickness of the boarding and whether it is to be closed boarded if it is a loose soil or whether mere polling board only will be required as moderately firm ground and the size of such polling board.
b) The size of walling (if required).
c) The size of timber strut.

The estimator, having decided on the above, will have to calculate the timber required. Figure 2.8 shows an example of the method for earthwork support in moderately firm ground.

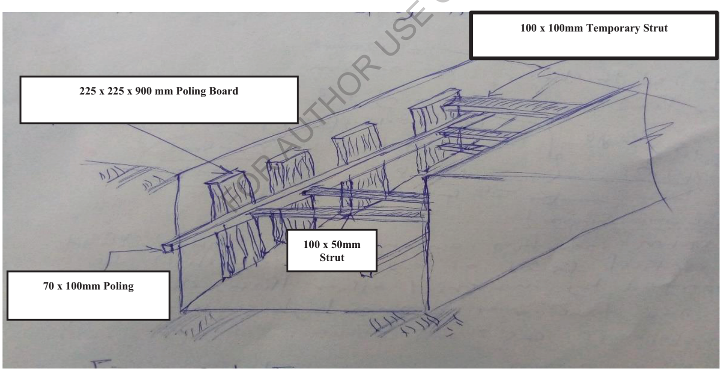


Fig. 2.8: Earthwork Support to Moderately Firm Ground

<u>Example 2.2</u>:

Suppose planking and strutting to vertical face of foundation trench is needed. Starting from foundation level not exceeding 2.00m between opposing faces. Assume moderately firm soil and take 10 x 1.00m depth.

Solution:

- ❖ 25mm Boarding: (Size: 225 x 25mm)

$$= \quad 2 \text{ faces} \left(\frac{1.00m}{0.25m}\right) \text{ x } 10.00\text{m}$$

$$= \quad 2 \text{ x } 4 \text{ x } 10 \quad = \quad 80\text{m}$$

- ❖ Polling Board: (Size: 225 x 25 x 900mm) @ 2.0 c/c

$$= \quad 2 \text{ faces} \left(\frac{10m}{2.0m}\right)$$

$$= \quad 10 \text{ No.}$$

- ❖ Strut: (Size: 100 x 100mm) @ 2.0 c/c

$$= \quad 2 \left(\frac{10m}{2.0m}\right)$$

$$= \quad 10 \text{ No.}$$

2.7 Excavation

Table 2.3 presents hourly rates of workers/machines for excavation work.

Table 2.3: Hourly Rates of Workers/Machines

S/N	WORKER/MACHINE	RATE COMPUTATION
1	Skilled Labour	=N=3,500/7 = =N=500.00
2	Unskilled Labour	=N=2,000/7 = =N=285.714
3	Concrete Mixer	=N=10,000/7 = =N=1,428.571
4	Vibrator (Poker)	=N=6,000/7 = =N=857.14
5	Hoist	=N=14,000/7 = =N=2,000.00
6	Mechanical Driver	=N=5,000/7 = =N=714.286
7	Banksman	=N=2,500/7 = =N=357.148

The rates in Table 2.3 were given based on the effective hours of 7 hours per day.

Example 2.3 (Topsoil Excavation):

Excavate oversite average 150mm deep, remove to a distance n.e. 100mm & deposit in spoil heaps (m^2). Hand/manual excavation.

N.B: Consider 1m^3 of excavation

Solution:

Labour:

- Excavation = 2 ½ hours
- Wheel = 1 ½ hours

4.0 hours

Labour Cost = 4hours @ =N=285.714 = =N=1,142.856

Add 25% Profit & Overhead = =N= 285.714

=N=1,428.570

Cost/m^2 = $\frac{1,428.57 \times 150}{1,000}$ = =N=214.29

Example 2.4 (Trench Excavation):

Excavate trench to receive foundation n.e. 1.50m deep starting from 150mm below ground level (m^3). Hand/manual excavation.

N.B: Consider 1m^3 of excavation

Solution:

Labour:

Excavate & Get Out:

3 hours @ =N=285.714 = =N=857.142

Add 25% Profit & Overhead = =N=214.285

Cost/m^3 = =N=1,091.427

Example 2.5 (Pit Excavation):

Excavate pit to receive concrete base n.e. 1.50m deep commencing @ 150mm below ground level.

N.B: Consider 1m^3 of excavation

Solution:

Labour:

Excavate & Get Out:

4 hours @ =N=285.714 = =N=1,142.586

Add 25% Profit & Overhead	=	=N= 285.714
Cost/m^3	=	=N=1,428.570

Example 2.6 (Level & Compaction):
Level & compact bottom of excavation (m^2). Hand labour.

N.B: Consider $1m^3$ of trench

Solution:
Labour:

Level & compact 1/6 hours @ =N=285.714	=	=N=47.619
Add 25% Profit & Overhead	=	=N=11.905
Cost/m^2	=	=N=59.524

Example 2.7 (Back Filling):
Backfill selected materials around foundation (m^3). Hand labour.

N.B: Consider $1m^3$ of trench

Solution:
Labour:

Backfill 1 ½ hours @ =N=285.714	=	=N=428.571
Add 25% Profit & Overhead	=	=N=107.143
		=N=535.714

Example 2.8 (Spreading Surplus excavated Material):
Spread on-site surplus excavated material (m^3). Hand labour.

Solution:
Labour:

Spread on-site 1 ½ hours @ =N=285.714	=	=N=428.571
Add 25% Profit & Overhead	=	=N=107.143
		=N=535.714

Example 2.9 (Hardcore Filling/Blinding):

225mm bed of hardcore filling, compacted and blinded with fine sand (m^2). Hand labour.

N.B: Consider 1m^3 of Hardcore, 10m^2 of fine sand and 100mm thick for blinding.

Solution:

❖ Hardcore: 1m^3 of hardcore @ =N=3,000 = =N=3,000.000
Add 20% for consolidation = =N= 600.000
=N=3,600.000

❖ Labour for laying & consolidation:
1 ½ hours @ =N=285.714 = =N= 428.571
Cost/m^3 = =N=4,028.571

Therefore; Cost/m^2= =N=4,028.571 / 1,000

= =N=906.428 --------------------- =N=906.428

Blinding:

❖ 10m^2 of fine sand 100mm thick:
1m^3 of fine sand @ =N=2,000 = =N=2,000
Hence; Cost/m^3 = =N=2,000
Therefore; Cost/m^2 = =N=2,000 x 100 / 1,000 = =N=200
Thus; Cost/10m^2 = =N=200 x 10 = =N=2,000.000
Add 20% for consolidation = =N= 400.000

Labour for laying and consolidation:

❖ ½ hour @ =N=285.714 = =N= 142.857
Cost/10m^2 = =N=2,542.857
Therefore; Cost/m2 = =N=2,542.857 / 10
= =N=254.288 ---------------------------- =N= 254.288
=N=1,160.716
Add 25% Profit & Overhead = =N= 290.179
=N=1,450.895

CHAPTER THREE

MECHANICAL EXCAVATION

All types of excavation, whether to remove vegetable topsoil, reduce level to distance, foundation level or column base, can be carried out by machine at the discretion of the contractor. Such decision will, however, be guided by the following:

a) The volume of work to be excavated in order to be economical.
b) Non-availability of required number of manual labour and the price of such labour.
c) Accessibility of such plant into the site.
d) Asset of space availability for safe measure of such plant on the site. However, contractor can explore or adopt two methods.

Tables 3.1 and 3.2 give the output of tractors and excavators respectively.

Table 3.1: Tractor Crowler or Scraper Output per Hour

Size of Excavator	Wheeling Distance		
	200mm	400mm	600mm
$4m^3$	$22m^3$	$18m^3$	$14m^3$
$8m^3$	$40m^3$	$31m^3$	$23m^3$
$12m^3$	$54m^3$	$43m^3$	$32m^3$

N.B:
Wheeling distance is from the excavation to spoil heaps.

Table 3.2: Excavators' Output – Including Excavation and Loading in Lorry in Soft Clay

Bucket Size	Dragline	Skimmer	Backactor	Shovel
$0.29m^3$	$8m^3$	$8m^3$	$10m^3$	$11m^3$
$0.38m^3$	$10m^3$	$10m^3$	$11m^3$	$12m^3$
$0.50m^3$	$12m^3$	$12m^3$	$15m^3$	$16m^3$
$0.76m^3$	$19m^3$	$19m^3$	$23m^3$	$24m^3$
$1.00m^3$	$29m^3$	$29m^3$	$32m^3$	$34m^3$
NOTE	For stiff clay, decrease output of both Tables.			

N.B:
For mechanical excavation, note the following:

- Driver/Operator = =N=5,000/day = =N=5,000/7 = =N=714.286/hour
- Bankman = =N=2,500/day = =N=2,500/7 = =N=357.143/hour

Example 3.1:
Excavate to reduce level (m^3) using skimmer.

Solution:
Labour:

0.50m3 bucket size skimmer @ =N=18,000/hour	=	=N=18,000.000
Driver/Operator @ =N=714.286/hour	=	=N= 714.286
		=N=19,071.429

Output:

0.50m3 bucket size skimmer output =12m^3/hour

Therefore; Cost/m^3= =N=19,071.429 / 12	=	=N=1,589.286
Add 25% Profit & Overhead	=	=N= 397.321
Cost/m^3	=	=N=1,986.607

Example 3.2:
Excavate foundation trench from formation level n.e. 1.00m maximum depth. Assume common soil 0.29m^3 backactor @ =N=20,000/hour.

Solution:
Labour:

0.29m^3 bucket size backactor @ =N=20,000/hour	=	=N=20,000.000
Driver/Operator @ =N=714.286/hour	=	=N= 714.286
Banksman @ =N=357.143/hour	=	=N= 357.143
		=N=21,071.429

Output:
0.29m^3 output @ 10m^3/hour

Therefore; Cost/m3 = =N=21,071.429 / 10	=	=N=2,107.143
Add 25% Profit & Overhead	=	=N= 526.786
Cost/m^3	=	=N=2,633.929

CHAPTER FOUR

CONCRETE WORK

4.1 In-Situ Concrete

Concrete is a mixture of cement, fine aggregate, coarse aggregate and water. The strength and durability of concrete are dependent on the proportion of materials in a particular mix. Therefore, for every given volume of concrete, the estimator has to work out the quantities required for each of these constituents. Table 4.1 shows the estimated quantity of materials required per cubic metre of compacted concrete.

Table 4.1: Estimated Quantity of Materials Required per Cubic Metre

Normal Mix			Quantity of Cement		Quantity of Sand (m^3)	Quantity of Aggregate (m^3)
Cement	**Fine Aggregate**	**Coarse Aggregate**	**By Weight (Kg)**	**By No. of Bags**		
1	1.00	2.00	550	11.00	0.382	0.764
1	2.00	2.00	425	8.50	0.590	0.590
1	1.50	3.00	395	7.90	0.411	0.820
1	1.67	3.33	360	7.20	0.417	0.834
1	2.00	3.00	355	7.10	0.493	0.740
1	2.00	3.50	330	6.00	0.458	0.802
1	2.00	4.00	305	6.10	0.424	0.848
1	2.50	3.50	305	6.10	0.529	0.741
1	2.50	4.00	285	5.70	0.495	0.792
1	3.00	4.00	265	5.30	0.552	0.736
1	2.50	5.00	255	5.10	0.443	0.886
1	3.00	5.00	240	4.80	0.500	0.833
1	3.00	6.00	215	4.30	0.448	0.896
1	4.00	8.00	165	3.30	0.458	0.916

4.2 Shrinkage in Concrete Mix

During the process of mixing materials to form concrete, a reduction in bulk takes place. This is due to the finer particles of sand and cement filling the voids or interstices of the coarse aggregate. In order to attain the required volume in a particular mix, one has to increase the quantities of materials to compensate for the reduction in bulk.

In the calculations in this chapter, we can anticipate shrinkage of between 20 and 33 per cent. Allowances for additional materials are determined as follows:

(i) Shrinkage of 20%:
A volume of 1m^3 less 20% gives 0.80m^3. Therefore, to obtain 1m^3, we shall have to add 0.200m^3. This represents an increase of:

$$\frac{0.20}{0.80} \times 100 = 25\%$$

(ii) Shrinkage of 28.6%:
A volume of 1m^3 less 28.6% gives 0.714m^3. Therefore, to obtain 1m^3, we shall have to add 0.286m^3. This represents an increase of:

$$\frac{0.286}{0.714} \times 100 = 40\%$$

(iii) Shrinkage of 20%:
A volume of 1m^3 less 33.33% gives 0.667m^3. Therefore, to obtain 1m^3, we shall have to add 0.333m^3. This represents an increase of:

$$\frac{0.333}{0.667} \times 100 = 50\%$$

The example below shows how the estimator goes about arriving at quantities using Table 4.1.

Example 4.1:
Suppose it is required to estimate the materials needed to provide 7m^3 of plain in-situ concrete (1:3:6 – 38mm aggregate) mix in foundation. Assume 20% shrinkage.

Solution:
Cement:
A volume of 1m^3 of concrete contains 4.3 bags of cement. Therefore, 7m^3 of concrete contains:

7 x 4.3 bags = 30.10 bags

Allow shrinkage (20%) = $\frac{0.20}{0.80} \times 100$ = 25%

Therefore; required bags of cement = 30 bags + 25% for shrinkage

= 37.5 bags or 38 bags approximately

Sand:

A volume of $1m^3$ of concrete contains $0.448m^3$ of sand. Therefore, $7m^3$ of concrete contains:

$7 \times 0.448m^3$ = $3.14m^3$ of sand

Allow shrinkage (20%) = $\frac{0.20}{0.80} \times 100$ = 25%

Therefore; required volume of sand = $3.14m^3$ + 25% for shrinkage

= $3.93m^3$

Assuming using a 3-tonner truck with a carrying capacity of $1.98m^3$ to deliver to site.

Then, number of tipper load = $\frac{3.93}{1.98}$ = 1.98 or 2 tipper load

Aggregate:

A volume of $1m^3$ of concrete contains $0.896m^3$ of coarse aggregate. Therefore, $7m^3$ of concrete contains:

7×0.896 = $6.27m^3$ of aggregate

Allow shrinkage (20%) = $\frac{0.20}{0.80} \times 100$ = 25%

Therefore; required volume of aggregate = $6.27m^3$ + 25% for shrinkage

= $7.84m^3$

Assuming using a 3-tonner truck with a carrying capacity of $4.20m^3$ to deliver to site.

Then, number of tipper load = $\frac{7.84}{4.20}$ = 1.86 or 2 tipper load

Example 4.2:
Suppose it is required to estimate the materials needed to produce $5m^3$ of reinforced concrete (1:2:4 – 20mm aggregate) mix in column. Assume 28.6% shrinkage.

Solution:
Cement:
A volume of $1m^3$ of concrete contains 6.1 bags of cement. Therefore, $5m^3$ of concrete contains:

7 x 6.1 bags = 30.50 bags

Allow shrinkage (28.6%) = $\frac{0.286}{0.714} \times 100$ = 40%

Therefore; required bags of cement = 31 bags + 40% for shrinkage
= 43.4 bags

Sand:
A volume of $1m^3$ of concrete contains $0.424m^3$ of sand. Therefore, $5m^3$ of concrete contains:

5 x $0.424m^3$ = $2.12m^3$ of sand

Allow shrinkage (28.6%) = $\frac{0.286}{0.714} \times 100$ = 40%

Therefore; required volume of sand = $2.12m^3$ + 40% for shrinkage

= $2.97m^3$

Aggregate:
A volume of $1m^3$ of concrete contains $0.848m^3$ of coarse aggregate. Therefore, $5m^3$ of concrete contains:

5 x 0.848 = $4.24m^3$ of aggregate

Allow shrinkage (28.6%) = $\frac{0.286}{0.714} \times 100$ = 40%

Therefore; required volume of aggregate = $4.24m^3$ + 40% for shrinkage

= $5.94m^3$

4.3 Reinforcement

Reinforcement is required in columns, beams, floor slab, column base, lintel, etc., which are load-bearing components in buildings. As such, reinforcement in these areas is such that they are capable of providing the required strength to support loads. The amount of reinforcement in any of these areas largely depends on its position, capacity as required by the specification. Spacing of reinforcement such as rod will depend on the required strength and according to specification. But where the spacing is not specified, the estimator does that from previous experience. Reinforcement bars are of two types: the high tensile (H/T) and the mild steel (m/s).

Reinforcement bars are of different sizes and thus having different multiplying factors in converting to Kilograms. Table 4.2 shows the relationship between bar weight and space per tonne.

Table 4.2: Relationship between Bar Weight and Price per Tonne

Diameter (mm)	**6**	**8**	**10**	**12**	**14**	**16**	**18**	**20**	**25**	**32**	**40**
Weight/Metre (Kg/m)	0.222	0.395	0.617	0.888	1.210	1.580	2.000	2.470	3.850	6.310	9.860
Price/Tonne Plain Bars 9m Length	477	281	180	125	90	70	49	44	28	17	11
Price/Tonne Ribbed Bars 12m Length	375	210	134	93	68	52	42	33	21	13	8

Bars are fixed and secured in position using spacers and tie wire. Average quantities for tie wire per 1,000 Kg of reinforcement bar are given in Table 4.3.

Table 4.3: Average Quantities of Tie Wire for Reinforcement Bar

Reinforcement Bar Diameter (mm)	**Tie Wire per 1,000Kg of Bar including Waste (Kg)**
6 - 12	12
16 - 25	7
32 - 50	5

Where cutting, bending and fixing bars are carried out on site, 5% wastage should be added. On the other hand, where reinforcement is delivered to site cut and bent, 1% should be added to allow for damage and loss.

Example 4.3:
Suppose you are to calculate from a Bill of Quantities (BOQ), extract the piece of plain bars in 3,000Kg of 10mm diameter bars.

Solution:
Plain Bars:
If 1,000Kg contains 180 pieces of plain bar;

Then, 3,000Kg will contain:	180 x 3	=	540
Add:			
Waste @ 5%		=	27
			567 pieces

Tie Wire:
If 1,000Kg requires 12Kg tying wire;

Then, 3,000Kg will require	3 x 12Kg	=	36Kg
Add:			
Waste @ 5%		=	1.8Kg
			37.8Kg

4.4 Formwork

The materials employed to construct formwork for in-situ concrete are generally softwood boards, plywood and steel sheet for working faces, supported on a softwood or steel, framework often in conjunction with proprietary props. Timber is still widely used in the making of formwork because of the variety of forms that it will allow. Plywood has generally superseded timber board for forming the faces of members. Sheet or boards must be of sufficient thickness ranging from 25 – 50mm depending on the structures to be formed and the span involved. The spacing of the props determines the number of 1 x 12 x 12mm hardwood. Nails are given provisional sum depending on the volume of work. Formwork (plank) is measured in linear metre and in length of 3.60m. Timber forms for in-situ work are usually unfit for further use after three-four (3-4) uses. Figure 4.1 shows the structure of a formwork to a concrete beam.

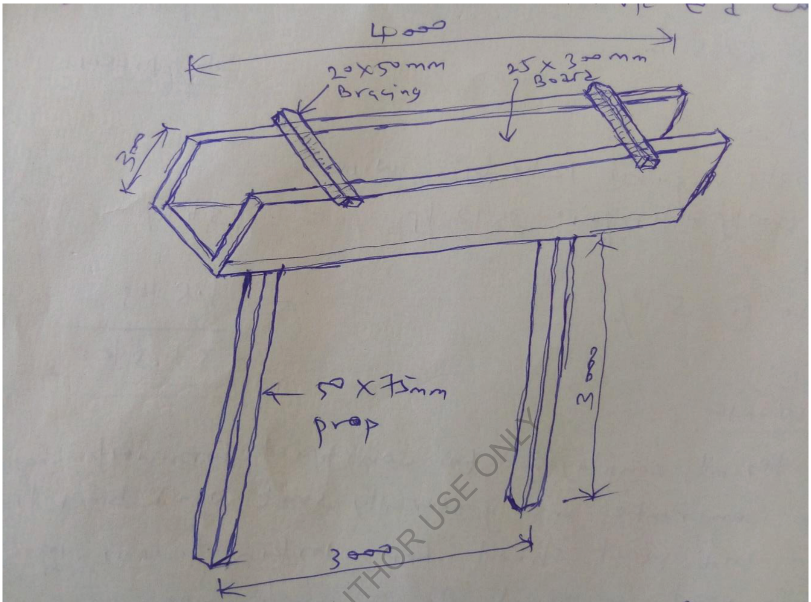


Fig. 4.1: Formwork to Concrete Beam

Example 4.4:
In Figure 4.1, the formwork to a concrete beam was shown. Using the same figure, consider this example.

Assume the beam is 4.00m long; 250mm wide; and 300mm deep. The bracings are spaced 1.00m c/c and the props (50 x 75mm) are spaced at 1.50m c/c. Determine the timber requirement to make this formwork.

Solution:
First, it should be noted that timbers are in lengths of 3.60m in the Nigerian market. Therefore, to compute for the 25 x 50mm bracing; we have:

25 x 50mm Bracing Timber

$\left(\frac{Length\ of\ Beam}{Spacing\ of\ Bracing} + 1 \right)$ x Length of Bracing

= $\left(\frac{4,0000}{1,500} + 1 \right)$ x 0.30m

= 1.50m of 25 x 50mm Timber

Props

The approach for bracing is applicable here also.

$\left(\frac{Length\ of\ Beam}{Spacing\ of\ Props} + 1 \right)$ x Length of Props

= $\left(\frac{4,0000}{1,500} + 1 \right)$ x 0.30m

= 3.66 x 3 = 10.99m of 50 x 75mm Timber

Or 3 lengths of 50 x 75mm Timber

The Form

In this case, the length of the side to be measured for side covers for beam falls within the width of the board. Linear measurement is given. In situation where the depth of beam of surface to be formed is more than the width of board, the area in square metre is to be taken. For this example;

Total Length = 3(4.0m)

= 12m

As earlier mentioned, length of timber in the Nigerian market are at 3.60m. Therefore;

Length Required = $\frac{12.00}{3.60}$ = 3.33

Or 3 ½ Lengths

Figure 4.2 shows the formwork to a concrete column.

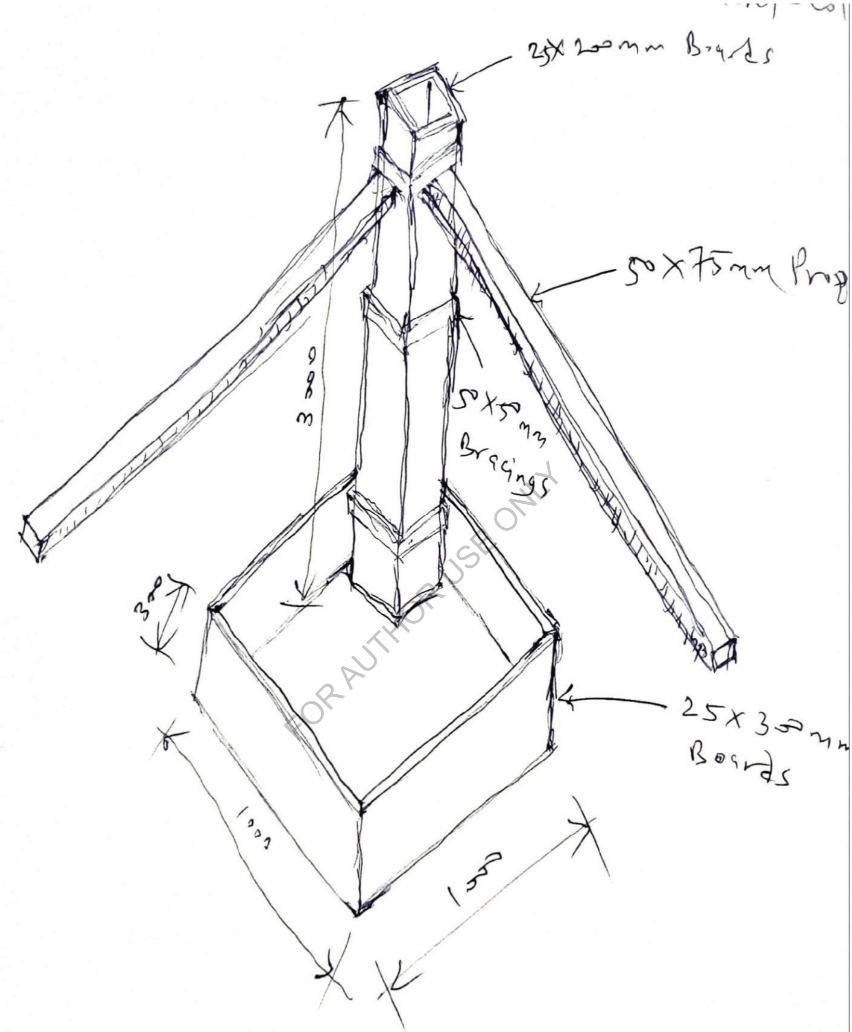


Fig. 4.2: Formwork to Concrete Column

Example 4.5:

Figure 4.2 shows the formwork for a typical column. Assume the column is 300 x 300mm to be 3.00m high with bracing 50 x 50mm spaced at 1.00m c/c. The form is supported to plumb on 4 No. props. Determine the timber requirement.

Solution:

- The Form:
  - i. To compute the base form, we shall compute the perimeter of the base. Since the depth falls within the width of a board; therefore, 3 x 1.00m = 4 x 1.00m of 25 x 300mm board is required.
  - ii. To compute the column form, we shall multiply the length of column by the sides. That is: 4 x 3.00m = 12.00m of 25 x 300mm board. Therefore, length required = $\frac{12.00}{3.60}$ = 3.33

    Or 3 ½ lengths.
- Bracings:

  The computation of bracings is similar to that of the form. That is Length of Bracing x Number of Sides x Number of Spacing.

  = 0.30m x 4 x 3

  = 3.6m or 1 length of 50 x 50mm bracings
- The Props:

  The computation is simple except where joints are involved. In this example, there are no joints. Therefore, 50 x 75mm timber requirement:

  = Length of Prop x Number of Sides

  = 3.00m x 4 = 12m length of 50 x 75mm timber.

4.5 Concrete Work (Hand and Machine Mixing/Reinforcement)

The following examples are on concrete work where the mixing of cement, sand, aggregate and water was done using manual and mechanical means.

Example 4.6 (Hand Mixing):

Plain in-situ concrete (1:3:6 – 19mm aggregate) in foundation over 150mm but n.e. 300mm thick.

N.B: Consider 1m^3 of concrete and cement @ =N=50,000.00/Tonne

<u>Solution</u>:

<u>Material</u>:

<u>Cement</u>		**=N= : K**
1m^3 of cement = 1.44 Tonne @ =N=50,000.00/Tonne	=	72,000.000
Unload & stack cement @ 1hour/Tonne/Labourer:		
= 1 x 1.44 x =N=285.714	=	<u>411.428</u>
		72,411.428
Allow 5% waste on cement	=	3,620.571
<u>Sand</u>		
3m^3 of sand @ =N=2,000/m^3	=	6,000.000
Allow 25% bulking of sand	=	1,500.000
Allow 10% stock pile waste on sand	=	600.000
<u>Aggregate</u>		
6m^3 of aggregate @ =N=9,000/m^3	=	54,000.000
Allow 10% stock pile waste on aggregate	=	<u>5,400.000</u>
	=	143,531.999
<u>Add</u>: 50% for shrinkage & waste	=	<u>71,766.000</u>
Cost/10m^3	=	<u>215,297.999</u>
Cost/m^3 = $\frac{\text{=N=215,297.999}}{10}$	=	21,529.799
<u>Add</u>: 5% waste for concrete	=	<u>1,076.489</u>
		22,606.288
<u>Labour</u>		
Mixing:		
1m^3 @ 5hours/Labourer @ =N=285.714 = 1,428.570		
Allow 5% waste = <u>71.429</u>		
=N=1,499.990 ----	=	1,499.990
Placing & Compacting:		
1 Mason @ 3 ½ hours @ =N=500/hour		
1 Labourer @ 2 ½ hours @ =N=285.714/hour		
→ 6 hours/m^3/gang @ =N=785.714/hour	=	<u>4,714.284</u>
		28,820.563
<u>Add</u>: 25% profit & overhead	=	7,205.141
Cost/m^3 =	=N=	<u>36,024.704</u>

<u>Example 4.7 (Machine Mixing)</u>:

Plain in-situ concrete (1:3:6 – 19mm aggregate) in foundation over 150mm but n.e. 300mm thick.

<u>N.B</u>: Consider 1m^3 of concrete and cement @ =N=50,000.00/Tonne

<u>Solution</u>:

<u>Material</u>:

<u>Cement</u>		**=N= : K**
1m^3 of cement = 1.44 Tonne @ =N=50,000.00/Tonne	=	72,000.000
Unload & stack cement @ 1hour/Tonne/Labourer:		
= 1 x 1.44 x =N=285.714	=	411.428
		72,411.428
Allow 5% waste on cement	=	3,620.571
<u>Sand</u>		
3m^3 of sand @ =N=2,000/m^3	=	6,000.000
Allow 25% bulking of sand	=	1,500.000
Allow 10% stock pile waste on sand	=	600.000
<u>Aggregate</u>		
6m^3 of aggregate @ =N=9,000/m^3	=	54,000.000
Allow 10% stock pile waste on aggregate	=	5,400.000
	=	143,531.999
<u>Add</u>: 50% for shrinkage & waste	=	71,766.000
Cost/10m^3	=	215,297.999
Cost/m^3 = $\frac{\text{=N=215,297.999}}{10}$	=	21,529.799
<u>Add</u>: 5% waste for concrete	=	1,076.489
		22,606.288

<u>Labour</u>

Mechanical Mixing:

<u>N.B</u>:

i. Mixer 10/7 with 4 mins mixing (3m^3/hour output)

ii. Concrete distance has to be transported/70m round trip

Hire rate of 10/7 mixer/hour @=N=15,000/day:

→ =N=15,000/7 hour = =N=2,142.857

Add fuel (1.8 Ltr of diesel):

→ @ =N=180/Ltr = 1.8 x 180 = =N= 324.000

Mixer Driver @=N=500/hour = =N= 500.000

Attendance Labourer:

→ 2 No. @=N=285.714 = =N= 571.428

Cost/3m^3 = =N=3,538.285

Cost/m^3 = $\frac{\text{=N=3,538.285}}{3}$ = 1,179.428

Add: 5% for waste	=		58.971
			23,844.688

Vibrating:

N.B: Output of Poker Vibrator = 2.97m^3/hour

Hiring rate (=N=6,000/day)	=	=N= 857.14/hour		
Add fuel (0.125 Ltr of Diesel):				
→ @=N=180/Ltr	=	=N= 22.50		
One Operator @ =N=500/hour	=	=N= 500.00		
Cost/2.97m^3	=	=N=1,379.64		
Cost/m^3 = $\frac{=N=1,379.64}{2.97}$			=	464.525
Add: 5% for waste			=	23.226

Placing:

1 Mason @ =N=500.000

1 Labourer @ =N=285.714

Gang Cost = =N=785.714

Therefore; 6hours/m^3/gang @ =N=785.714	=	4,714.284
	=	29,046.723
Add: 25% profit & overhead	=	7,261.681
Cost/m^3 =		=N=26,308.404

Example 4.8 (Wire Mesh):

BRC Square Mesh reinforcement in bed (m^2).

N.B: Consider 10m^2 of mesh.

Material:		**=N= : K**
BRC Mesh reinforcement (10 m^2) @ =N=1,200/m^2	=	12,000.000
Unload and stack mesh: 1/6 hour @ =N=285.714/hour	=	47.619
Add 15% for lap & waste from cost of mesh	=	1,800.000
Allow for distance & tying of biding wire (say =N=1,000)	=	1,000.000
Labour:		
Cutting & Laying: 1 ½ hours/Fitter @ =N=500	=	750.000
		15,597.619
Add: 25% profit & overhead	=	3,899.405
Cost/10m^2	=	=N=19,497.024

Therefore; Cost/m^2= $\frac{=N=19,497.024}{10}$ = =N=1,949.702

Example 4.9 (Mild Steel Reinforcement):

12mm diameter mild steel reinforcement in beam, slab, column and stair case (Kg).
N.B: Consider 1 Tonne of reinforcement.

Solution:

Material:		**=N= : K**
Mild Steel Reinforcement (1 Tonne) @ =N=260,000	=	260,000.000
Unload & stack reinforcement:		
→ 2 Labourers @ =N=285.714/hour	=	571.428
Add 5% for waste and rolling	=	13,028.571
Add concrete spacer: 2No. @ =N=5 each	=	1,000.000
		274,599.999

Labour:
Cutting & bending: 47 hours
Fixing: 93 hours
140 hours

Therefore; 140 hours @ =N=500/hour	=	70,000.000
		344,599.999
Add: 25% profit & overhead	=	86,149.980
Cost/Tonne	=	=N=430,749.980

Therefore; Cost/Kg $= \frac{=N=430,749.980}{1,000} =$ =N=430.750

CHAPTER FIVE

BRICKWORK AND BLOCKWORK

5.1 Brickwork

Bricks can be obtained in a number of sizes and various compositions, strengths and shapes, to mention only the more obvious factors. The appropriate British Standards give details of clay, concrete, sand-lime and other bricks. To give examples using all the different types of bricks would be impossible due to time-frame. For example, in this chapter, concentration would be on a metric brick with the dimension of 215mm long, 102.5mm wide and 65mm thick. Whether the brick is solid, hollow or perforated will make no difference in computing the number of bricks per unit area in this context.

Example 5.1:

Suppose you are required to determine the number of bricks per square metre using metric brick with dimension of 215mm x 102.5mm x 65mm and mortar joints of 10mm, this can be given as thus:

Solution:

$$\frac{1{,}000 \times 1{,}000}{215 \times 102.5} = 45.38 = \text{Approx. } 46$$

$$\text{Add 5\% waste} = 2.25 = \text{Approx. } \underline{\ \ 2}$$

$$\underline{48} \text{ pieces}$$

5.2 Bedding/Mortar Mix

Mortar is a mixture of cement and sand, and it is used for bonding bricks/blocks. It could be of ratio 1:6, 1:4, 1:3, etc. These ratios depend on the required strength of mortar. Smaller ratios are known to be stronger and more effective. Table 5.1 shows the estimated quantity of materials required per cubic metre of compacted mortar.

Table 5.1: Estimated Quantity of Materials Required per Cubic Metre of Compacted Mortar

Normal Mix		Quantity of Cement		Quantity of Sand
Cement	Fine Aggregate	By Weight (Kg)	By Number of Bags	Quantity of Sand (m^3)
1	1	1005	20.1	0.687
1	1.5	810	16.2	0.844
1	2	680	13.6	0.944
1	2.5	580	11.6	1.007
1	3	505	10.1	1.052
1	4	395	7.9	1.097
1	6	280	5.6	1.167
1	8	220	4.4	1.222

Example 5.2:

Suppose it is required to determine the mortar requirement for 1,000 bricks with no perforation and are absolutely rectilinear, laid on a bed of mortar 10mm thick and have each end jointed 10mm in cement mortar (1:4).

Solution:

1,000 bricks require the following volume of mortar:

i.e., $0.287m^3$ of mortar.

To determine the cement and sand constituents, we use Table 5.1.

Cement

From Table 5.1, $1m^3$ of mortar mix (1:4) contains 7.9 bags of cement.

Therefore; $0.287m^3$ will contain 0.287 x 7.9 = 2.26 bags

Sand

From Table 5.1, $1m^3$ of mortar mix (1:4) contains $1.097m^3$ of sand.

Therefore; $0.287m^3$ will contain 0.287 x 1.097 = $0.31m^3$ sand

N.B:

The amount of mortar taken by estimate varies from 0.50 – $0.8m^3$. This makes allowance for the mortar which disappears into the frogs, hollows or perforations in the brick and also for large amount of waste generated. These wastes occur throughout the process: cement and sand are dumped on the ground and trodden in mortar is squeezed out of the bed and joints of every brick. The allowance is large but there is a lot of waste.

5.3 Blockwork

Blocks are manufactured in a variety of materials. These are clay and concrete being the most usual among others. Blocks can be hollow and joggle jointed, and may be finished on one or both faces with a variety of decorative finishes or left plain to receive plaster. Blockwork is treated in the same way as for brickwork. Examples here will concentrate on a metric block with dimensions of 450mm long, 230mm wide and 230mm thick as shown in Figures 5.1 and 5.2. The blocks are usually 10 pieces in one square metre.

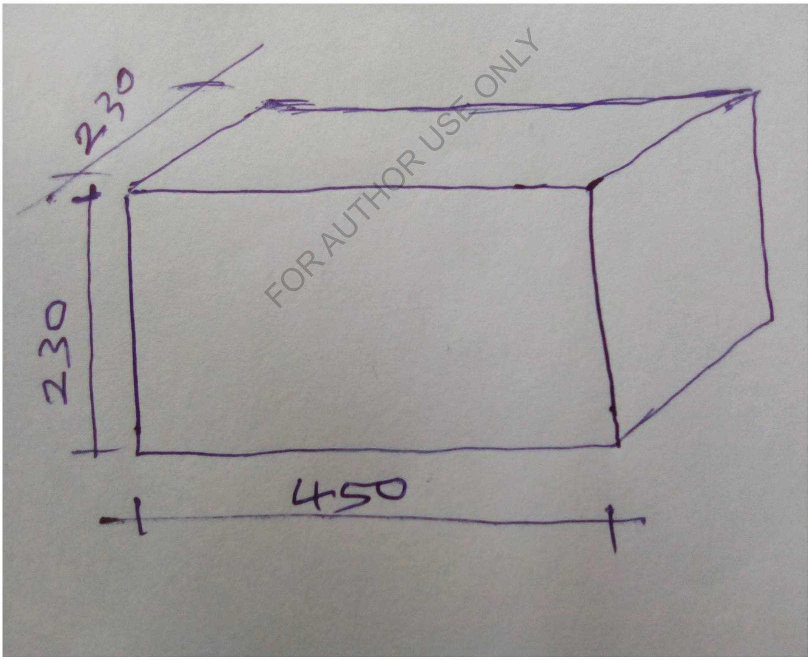


Fig. 5.1: Solid Block

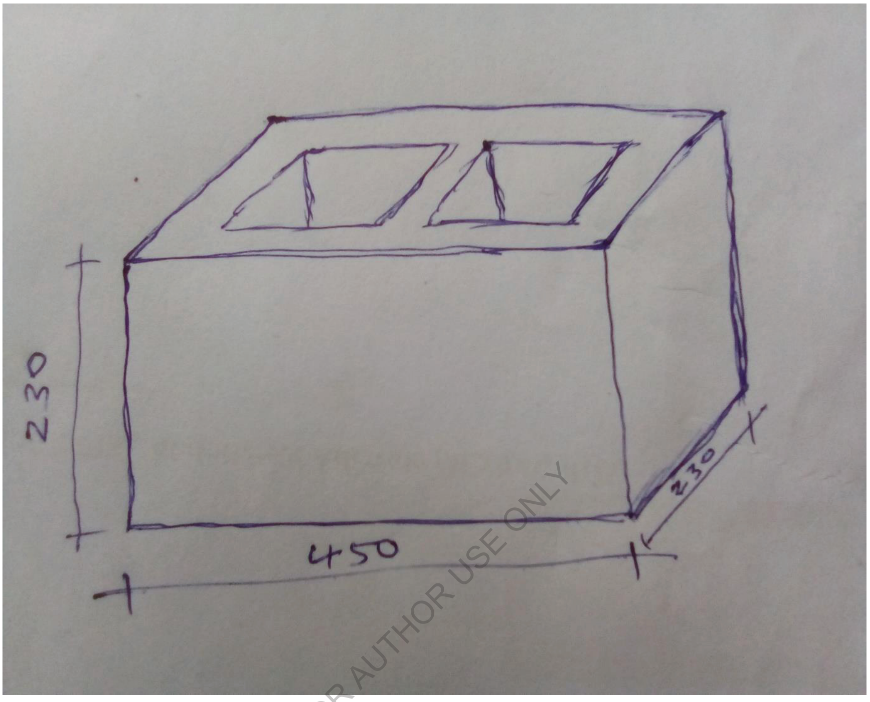


Fig. 5.2: Hollow Block

Example 5.3:
Suppose it is required to determine the mortar requirement for 1,000 blocks with no perforation and are absolutely rectilinear, laid on a bed of mortar 10mm thick and have each end jointed 10mm in cement mortar (1:6).

Solution:
N.B: 1,000 blocks require 1,5m^3 of mortar.
To determine the cement and sand constituents, we use Table 5.1.

Cement:
From Table 5.1, 1m^3 of mortar mix (1:6) contains 5.6 bags of cement.
Therefore; 1.5m^3 will contain 1.5 x 5.6 = 8.4 bags

Sand:
From Table 5.1, $1m^3$ of mortar mix (1:6) contains $1.167m^3$ of sand.
Therefore; $1.5m^3$ will contain 1.5 x 1.167 = $1.75m^3$

5.4 Sun-breaker

Sun-breakers are commonly called screen walls and are used to break sunrays, allow for lighting and ventilation, etc. Area of screen wall is given in square metre. They are of different types and sizes for specific purposes. Therefore, it is important to know the type and area of screen walls to be estimated for. One could easily proceed in calculation for screen wall with such basic information.

Example 5.4:
Suppose it is required to determine the number of decorative screen bricks in an area of $10m^2$ using 225 x 85 x 250mm classic feldor (Tolaram Ceramic).

Solution (Alternative 1):
From the catalogue, we have 18 pieces in 1 m^2.
Therefore; in $10m^2$, we have 10 x 18 = 180 pieces
Allow for waste 5% = 9 pieces
Total requirement = 189 pieces

Solution (Alternative 2):
This approach is very useful where the number of screen brick is not known but the brick size is known. Thus, for example:
To determine the number of bricks in 1 m^2, we have:

$$\frac{1}{0.225 \times 0.25} = 17.85 \text{ ….. Approx. 18 pieces}$$

Therefore; in $10m^2$ = 10 x 18 = 180 pieces
Allow for waste 5% = 9 pieces
Total requirement = 198 pieces

Example 5.5:
Recall:
$1m^3$ of cement = 1.44 Tonnes = 28.8 bags
1 Tonne = 1,000 Kg, while 1 bag of cement = 50Kg
Thus; number of bags of cement in 1 Tonne can be computed as:

$$\frac{1,000}{50} = 20 \text{ bags}$$

Therefore, 1.44 x 1,000 = $\frac{1,440Kg}{50Kg}$ = 28.8 bags in 1.44 Tonnes

Question:

225mm hollow sandcrete blockwork bedded in cement mortar (1:4) in wall.

N.B: i. Consider 10m^2 of wall, i.e., 1,000 blocks.

ii. Hand mixed method will be used due to the nature of the job.

Solution:

Material:

		=N= : K
Block		
Sandcrete block: 100 No. @ =N=160/No.	=	16,000.000
Unloading & stacking (included in the cost of block)		
Add 10% on block for waste	=	1,600.000
		17,600.000

Mortar (1:4)

1m^3 of cement = 1.44 Tonnes @ =N=50,000 = =N=72,000.000

Unloading & stacking cement: 1hour/Tonne/Labourer;

= 1.44 x =N=286.714 = =N= 411.428

Sand

4m^3 @ =N=2,000/m^3 = =N= 8,000.000

=N=80,411.428

Add 33.33% for shrinkage & waste = =N=26,803.809

Cost/5m^3 = =N=107,215.237

Cost/m^3 = $\frac{\text{=N=107,215.237}}{5}$ = =N=21,443.047

Quantity of mortar in 10m2 wall = 0.14m3		
Therefore; 0.14m^3 of mortar @ =N=21,443.047	=	3,002.030
Add 10% waste on mortar	=	300.203
Sub-total C/F		20,902.233

Labour for Mixing Mortar:

0.14m^3 @ 5hours/m^3 per labour @ =N=285.714/hour = =N=199.998…Approx	200.000
	21,102.233

Labour for Laying Blocks:

Considering 2 Masons & 1 Labourer:

2 Masons @ =N=500	= =N=1,000.000		
1 Labourer @ =N=285.714	= =N= 285.714		
	=N=1,285.714		
Therefore; 9 gang hours @ =N=1,285.714		=	11,571.426
			32,673.659
Add: 25% profit & overhead		=	8,168.415
Cost/10m^2		=	40,842.074

Therefore; Cost/m^2 = $\frac{=N=40,842.074}{10}$ = =N=4,084.207

CHAPTER SIX

ROOFING

6.1 Introduction

It is the covering of roof structure which prevents rain and sunlight from entering the building. This covering could be of asbestos, galvanized corrugated zinc, or corrugated aluminium roofing sheets just to mention a few.

6.2 Zinc

When estimating for zinc roofing sheets, the estimator considers the following:

(a) Effective coverage area.
(b) How many sheets in a bundle.
(c) Packet of nails required.
(d) Waste: Usually 5% for nails and washers and 2 ½ % for sheets.

The material is usually specified by zinc gauge. This material is available in plain sheet form or corrugated sheet. The latter is common in Nigeria both for home and industrial buildings. Though different sizes can be made to order. The common marketed sizes are: (a) 2134 x 914mm and (b) 2438 x 914mm. The estimator allows for 0.20m end laps and 0.10m side laps which gives an effective coverage area of 1.57m^2 and 1.83m^2 respectively (see Figure 6.1).

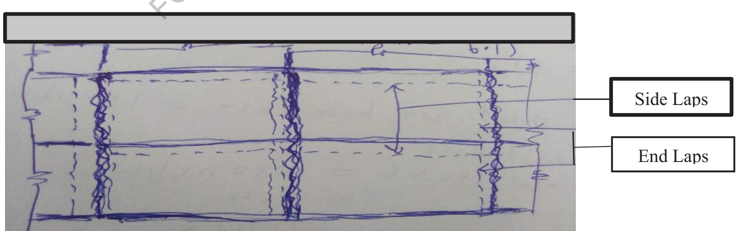


Fig. 6.1: End Laps and Side Laps

Twenty (20) sheets are in one bundle. Therefore, with the known area of roofing usually given in m^2, the estimator calculates the bundles or number of roofing sheets that will go into that area. Averagely, about 6 number of galvanized roofing nails and washers are used per sheet.

Example 6.1:
Suppose you are to determine the total number of roofing sheets required for a roof coverage 265m^2.

Solution:
Total Area = 265m^2

No. of bundles to cover 265m^2 = $\frac{265}{1.57} \times \frac{1}{20}$ = 8.439

Add 2 ½ % for waste = 0.210

8.640 Approx. 9 bundles

Having known the number of sheets or bundles of roofing sheets, it is important to know how many packets of nails that will go into these sheets. Galvanized roofing nail contains approximately 500 pieces of nails.

Example 6.2:
Suppose you are to determine the total number of roofing nails to be used in roofing 265m^2 (refer to Example 6.1).

Solution:
In 9 bundles of roofing sheets, we have 9 x 20 = 180 sheets

If 6 nails are used to nail one (1) sheet:

Then; 180 sheets will need 180 x 6 = 1,080

Add 5% waste = 54

1,134 pieces

Therefore; No. of packets = $\frac{1,134}{500}$ = 2.26 or 2 packets

6.3 Asbestos
Asbestos is available in tiles and sheets. The corrugated sheets are namely: Light Super 7; Super 7; Super Light Weight; Life Span and Self-supporting Long Span Amiantus. The corrugated asbestos sheets are in lengths of 1.00m – 3.60m except Amiantus which can be obtained in up to 9.15m length. Each type of the sheet is made in standard widths, which differs in types, and they are laid to specified end and side laps. Therefore, the covering capacities differ. The sheets are usually fixed

aluminium hook bolts and galvanized nails. Each sheet is fixed with 6-Number such bolts shared by the overlapping sheet. Thus, an average of 3 bolts per square metre, 5% waste allowance should be made on the hook bolt and asbestos sheet. The tiles are manufactured in 600mm x 300mm and 300mm x 300mm sizes. For example, in this section, the dimension of the superior asbestos-cement roofing sheets will be as manufactured by the Bauchi Asbestos Company. The sheets are manufactured into two sizes of 1.05m x 2.40m and 1.05m x 1.80m. The estimator allows for 150mm end laps and 75mm side laps, which gives an effective coverage area of $2.20m^2$ and $1.61m^2$ respectively.

Example 6.3:
Suppose you are to determine the number of asbestos-cement roofing sheets needed for a roof coverage of $100m^2$ using asbestos-cement roofing sheet size 1.05m x 2.40m.

Solution:
The effective coverage of 1 asbestos roofing sheet is $220m^2$.

Therefore; 100m2 will need $\frac{100m^2}{200m^2}$ sheets

= 45.45

Add 5% waste = 2.27

47.72 …….. Approx. 48 sheets

Having known the number of asbestos-cement roofing sheets, it is important to know how many nails that will go into nailing these sheets. Usually, aluminium hooks and galvanized roofing nails and accompanying rubber washers are packaged in 100 pieces per packet.

Example 6.4:
Suppose you are required to determine the number of aluminium hooks or galvanized nails needed in roofing as in Example 6.3.

Solution:
Since one (1) sheet of asbestos require 6-Number nail/hook:
Therefore; 48 sheets will need 48 x 6 = 288 nails Approx. 3 packets
OR:

Since, averagely, 1m^2 requires 3-Number nails:
Therefore; 100m^2 will need 100 x 3 = 300 nails or 3 packets

6.4 Asbestos Ridge

This item is measured in Linear Metre (m) and is of standard length. When estimating for this item, the estimator calculates the total quantity and divides the quantity by the standard length to arrive at the exact numbers of each required. Waste is usually added and depends on the total number of each. Figure 6.2 shows a two-piece Asbestos flat wing ridge.

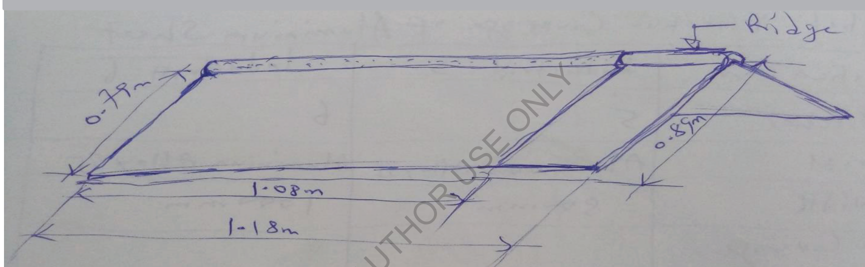


Fig. 6.2: Two-Piece Asbestos Flat Wing Ridge

<u>Example 6.5</u>:
Suppose you are to determine the number of ridge capping to cover hip of 30m long. Assume using a 1,050mm long ridge with 150mm side lap.

<u>Solution</u>:

Total length to cover = 30m
Effective length of ridge = 1,050 – 2/150 (lap)
= 750mm

Therefore; Number required = $\dfrac{30m}{0.75m}$ +1 = 41 No.

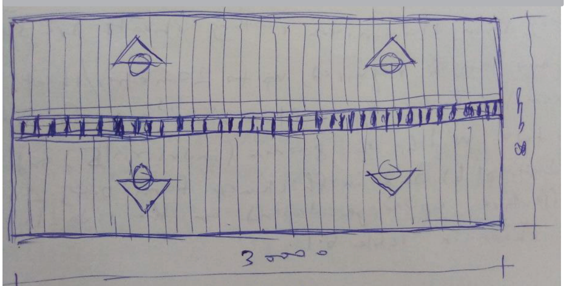
6.5 Aluminium Roofing Sheet

Long span aluminium roofing sheets are supplied in any length required; up to 20m/sheet. For example, Tower Span Aluminium is manufactured mainly into two widths of 800mm (Industrial 5) and 1,000mm (Industrial 6) and in thickness from 0.45 – 0.90mm. Effective coverage depends on the side laps given as shown in Table 6.1.

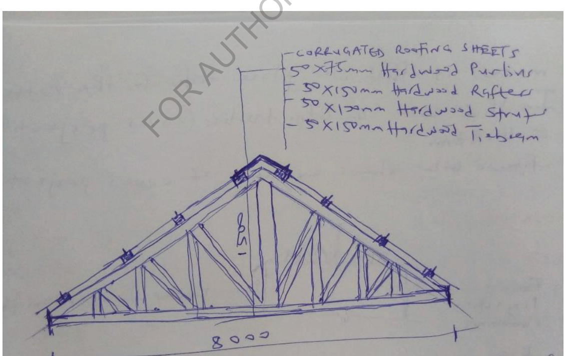
Table 6.1: Effective Coverage of Aluminium Sheet

Specification	**Industrial 5**	**Industrial 6**
Number of Pitches	5	6
Material	Aluminium Alloy 35	Aluminium Alloy 35
Full Width	800mm	1,000mm
Effective Coverage Single Lap Double Lap	 750mm 600mm	 900mm 750mm
Pitch of Profile	150mm	150mm
Depth of Profile	32mm	32mm

Aluminium has certain special qualities that make it superior to other roofing materials like asbestos and galvanized steel sheets. It does not corrode like steel or break like asbestos and therefore has a long life-span. When estimating for aluminium roofing sheets, the estimator takes linear dimensions along the ridge of the roof. An average of 3 bolts per metre square is used. Figure 6.3 shows the plan and section for a typical aluminium roof.



ROOF PLAN



ROOF SECTION

Fig. 6.3: Plan and Section for Aluminium Roof

Example 6.6:

Suppose it is required to determine the number of aluminium roofing sheets needed to cover the roof plan shown in Figure 6.3 using Industrial 5 profile with double side lap.

Solution:

Using trigonometry, we can establish the rafter length (L) to be:

$$L = \sqrt{(half\ span\ of\ roof)^2 + (height\ of\ rise)^2}$$

$$= \sqrt{4^2 + 1.5^2} \qquad = \qquad \sqrt{16 + 2.25^2}$$

$$= 4.27\text{m}$$

Next, we calculate the number of aluminium roofing sheets needed along the length of the roof.

Therefore; No. of sheets $= \dfrac{30}{0.6\text{m}} + 1 = 51$ No.

Having determined the number of aluminium roofing sheets needed along the length of the roof and we also know the rafter length, we can now specify the number of aluminium sheets needed. Since aluminium sheets can be manufactured to desired length, what this means is that we place order for the rafter length. In this case;

4.27m + 0.6m (eaves projection) = 4.87m

Figure 6.4 shows example of eaves projection.

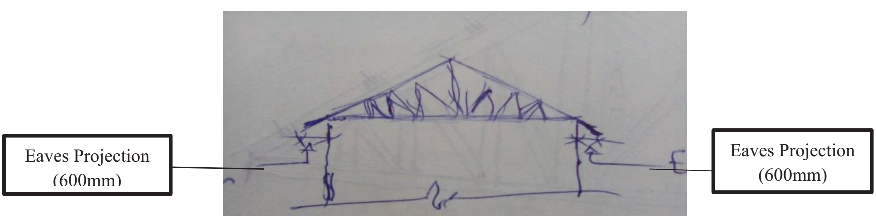


Fig. 6.4: Eaves Projection

For this example, we need:

51 No. x 2 aluminium roofing sheets
= 102 No. aluminium roofing sheets of 4.87m length each to cover the roof.

6.6 Ridge Capping, Flashing Apron, etc.

These are aluminium roofing accessories. They are measured in Linear Metres with a standard length of 3.0m long. Effective length coverage depends on the end laps given, usually 150mm is allowed. Thus, having known the length to be covered, the total number of ridge capping needed for Figure 6.3 can be determined. Therefore;

$$\text{Ridge capping} = \frac{30}{2.85} + 1$$

$$= 11.5 \text{ …... Approx. } 12 \text{ pieces}$$

6.7 Slate/Tile Roofing

Roof tiles are manufactured from clay and concrete to a wide range of colours and profiles suitable for pitches from 17 to 45 degrees. Greater pitches up to vertical cladding are achievable but require additional or special fixing. Roof tiles are generally sold by the thousand in crates or strap banded to be stored on site pallets. They vary from 225 x 150mm to 610 x 355mm in 27 different sizes.

The estimator when computing material requirement foe slate tiling must consider the following:

a) Whether head-nailed or centre-nailed is specified. This is because head-nailed is more expensive since there are more slates required for the same m_2 than centre-nailed.
b) The size of batten specified.
c) The type of nail required. Two nails will be required for fixing each slate whether centre-nailed or head-nailed. Therefore, number of nails depends on number of slates per m^2.

A typical eaves detail is shown in Figure 6.5 from which it will be apparent that the lap is the amount by which the tails of slate in one course overlap the heads of slates in the next course but one below.

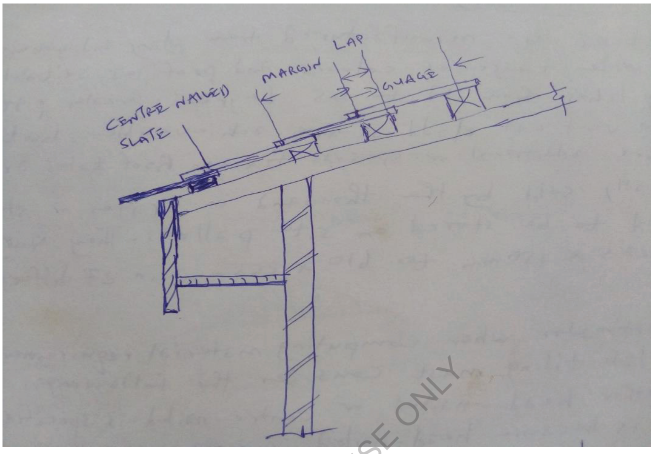


Fig. 6.5: Typical Eave Detail for Slate/Tile Roofing

It is customary to centre-nail all but the smallest slates, as there is a tendency for the larger head-nailed slates to lift in high winds. The main advantage claimed for head-nailed slates is that there are two thickness of slate covering the nails, but this involves the use of a larger number of slates and they are not so easily repaired. Nailed slates should not be less than 30mm from the edges and 25mm from the heads of slates. The gauge is the distance between the nail holes in one slate from those in the adjoining slate and for centre-nailed slates = (Length - Lap)/2 whereas for head-nailed slates, it is [Length - (Lap + 25mm)]/2.

Example 6.7:

Suppose it is required to estimate the number of slates in 1m^2 of head-nailed slating using 500 x 250mm Welsh slate laid to 75mm lap.

Solution:

$$\text{Slate No.} = 1{,}000{,}000 \div \frac{\{500 - (75 + 25)\}}{2} \times 250$$

$$= 1{,}000{,}000 \div (200 \times 250) = 20 \text{ No.}$$

Since each slate is secured by 2 nails, then total number of nails required is:

20 x 2 = 40 No.

Example 6.8:

Suppose it is required to estimate the number of slates in $1m^2$ of head-nailed slating using 500 x 250mm Welsh slate laid to 100mm lap.

Solution:

$$\text{Slate No.} = 1{,}000{,}000 \div \frac{\{500 - (100 + 25)\}}{2} \times 250$$

$$= 1{,}000{,}000 \div (187.5 \times 250) = 21.33 \text{ Approx. 21 No.}$$

Since each slate is secured by 2 nails, then total number of nails required is:

21 x 2 = 42 No.

N.B:

$1{,}000{,}000mm^2$ = $1m^2$

500mm = Length of Slate

100mm = Lap

250mm = Width of Slate

Others are constants

Example 6.9:

Suppose it is required to estimate the number of slates in $1m^2$ of centre-nailed slating using 500 x 250mm Welsh slate laid to 75mm lap.

Solution:

$$\text{Slate No.} = 1{,}000{,}000 \div \frac{\{(500 - 75)\}}{2} \times 250$$

$$= 18.82 \text{ …... Approx. 19 No.}$$

Since each slate is secured by 2 nails, then total number of nails required is:

19 x 2 = 38 No.

Example 6.10:

Suppose it is required to estimate the number of slates in $1m^2$ of centre-nailed slating using 500 x 250mm Welsh slate laid to 100mm lap.

Solution:

$$\text{Slate No.} = 1{,}000{,}000 \div \frac{\{(500 - 100)\}}{2} \times 250 = 20 \text{ No.}$$

Since each slate is secured by 2 nails, then total number of nails required is:

20 x 2 = 40 No.

6.8 Timber Batten

The length of batten can be determined by applying the gauge to the area as laid. If area as laid is 1,000mm x 1,000mm, then the horizontal length will be 1m. the vertical length which is 1,000mm should be divided by the gauge. Thus, the number of batten lines will be established. This, multiplied by horizontal length, will produce the length of the batten required per m^2 as shown in Example 6.11 and 6.12.

Example 6.11:

Suppose it is required to estimate the batten length required in $1m^2$ of centre-nailed slating using 500 x 250mm Welsh slate laid to 100mm lap.

Solution:

$$\text{Gauge} = \frac{500 - 100}{2} = 200\text{mm}$$

$$\text{Batten No.} = \frac{1{,}000\text{mm}}{200\text{mm}} = 5$$

Therefore; Batten Length = 1m x 5 = 5m Batten Length

Example 6.12:

Suppose it is required to estimate the batten length required in $1m^2$ of head-nailed slating using 500 x 250mm Welsh slate laid to 100mm lap.

Solution:

$$\text{Gauge} = \frac{(500 - 25) - 100}{2} = 187.5\text{mm}$$

$$\text{Batten No.} = \frac{1{,}000\text{mm}}{187.5\text{mm}} = 5.33$$

Therefore; Batten Length = 1m x 5.33 = 5.33m Batten Length

CHAPTER SEVEN

FINISHINGS

7.1 Introduction

Finishings in construction of buildings comprise the required final finish related to wall, floor and ceiling.

7.2 Wall and Ceiling Finishings

In selecting wall and ceiling finishings, probably the two most important considerations are appearance and maintenance cost. In particular situations, other factors may also be important, such as resistance to condensation, acoustic properties and provision of a smooth even surface.

7.2.1 Wall Finishings

The types of work here include the following:

(i) Rendering:
This is the application of mortar mix of cement and sand on block wall to give a smooth finishing look. Area of rendering is usually given in m^2 and may be of the same thickness of mortar for laying blocks when estimating. Table 7.1 gives the estimated quantity of materials required per m^3 of compacted mortar while Table 7.2 shows the quantity of materials required per square metre for various thickness of plaster.

Table 7.1: Estimated Quantity of Materials Required per m^3 of Compacted Mortar

Normal Mix		Quantity of Cement		Quantity of Sand (m^3)
Cement	Fine Aggregate	By Weight (Kg)	By Number of Bags	
1	1	1,005	20.1	0.687
1	1.5	810	16.2	0.844
1	2	680	13.6	0.944
1	2.5	580	11.6	0.007
1	3	505	10.1	1.052
1	4	395	7.9	1.097
1	6	280	5.6	1.167
1	8	220	4.4	1.222

Table 7.2: Quantity of Materials Required per Square Metre for Various Thickness of Plaster

Normal Mix		Materials	Thickness of Plaster in mm					
Cement	**Fine Aggregate**		**5**	**10**	**20**	**30**	**40**	**50**
1	1	Cement	5.1	10.1	20.3	30.5	40.6	50.8
		Sand	3.5	7.1	14.2	21.3	28.6	35.5
1	1.5	Cement	4.1	8.2	16.3	24.5	32.6	40.8
		Sand	4.3	8.6	17.1	25.6	34.2	42.7
1	2	Cement	3.4	6.9	13.7	20.6	27.5	34.4
		Sand	4.8	9.6	19.3	28.9	38.4	48.1
1	2.5	Cement	2.9	5.9	11.7	17.5	23.4	29.2
		Sand	5.1	10.2	20.5	30.7	41.0	51.2
1	3	Cement	2.5	5.1	10.1	15.2	20.7	25.2
		Sand	5.3	10.6	21.2	31.8	42.4	53.0
1	4	Cement	2.0	4.0	7.9	11.9	15.8	19.7
		Sand	5.5	11.1	22.1	33.2	44.2	55.2
1	6	Cement	1.4	2.9	5.7	8.6	11.4	14.3
		Sand	6.0	12.0	23.9	35.9	47.9	59.9
1	8	Cement	1.1	2.2	4.4	6.6	8.8	11.0
		Sand	6.2	12.3	24.6	37.0	49.3	61.6

N.B:
Cement = Weight of cement in Kg
Sand = Volume of sand in Litres
No allowance has been made for bulking and wastage.

Example 7.1:
Suppose it is required to determine the cement and sand mortar mix (1:4) required to render $200m^2$ blockwork area.

Solution:
Cement:
Firstly, the m^2 is multiplied by the thickness (10mm) to convert area of plaster to m^3. That is;

$$\frac{10}{1,000} \times 200 = 0.010 \times 200 = 2m^3 \text{ of mortar}$$

This area is then multiplied by the number of bags/m^3 of cement for the specified mix (see Table 7.1).

Therefore; $2m^3$ x 7.9 bags/m^3 = 15.8 ……. Approx. 16 bags

Sand:

In calculating the sand requirement, the $2m^3$ is multiplied by the factor for sand shown in Table 7.1. That is;

1.097 x $2m^3$ = $2.19m^3$

This can be converted to lorry load by dividing by the haulage capacity of the lorries as shown in Table 2.2.

(ii) Tiling:

Tiles are of different types and sizes for specific purposes. Therefore, it is important to know the type and area of the tiles to be estimated for, whether the quantity in a packet, crate or carton.

Example 7.2:

Suppose it is required to determine the requirement for coverage of $20m^2$ using 150mm x 150mm Royal White glazed ceramic wall tiles with 88 pieces ($2m^2$) in a carton.

Solution:

Total area of tiling = $20m^2$

Total area of 1 tile = 0.15 x 0.15 = 0.0225

Therefore; number of tiles in $1m^2$ = 1 ÷ 0.0225 = 44.40 pieces

Add waste @ 5% = 2.22 pieces

46.62 pieces

Total number of tiles in $20m^2$ = $20 \times \frac{46.62}{88}$

= $\frac{932.40}{88}$ = 10.59 …… Approx. 11 cartons

(iii) Brick-facing:

Another way of giving a smooth finishing look to walls is by fixing brick-facing tiles. Brick-facing tiles are usually of two sizes; these are: 250 x 13 x 600mm and

250 x 18 x 85mm. therefore, it is important to know the type and area of the tiles to be estimated for the quantity in $1m^2$.

Example 7.3:
Suppose it is required to determine the facing-brick requirement for coverage of $10m^2$ with 25 x 18 x 85mm Tolaram brick-facing tiles with 52 pieces in $1m^2$.

Solution:
Total area of facing = $10m^2$
$1m^2$ = 52 pieces
Therefore; $10m^2$ requires 10 x 52 = 520 pieces
Add waste @ 5% = 26 pieces
= 546 pieces

Therefore; to determine number of bricks, we have:

$$\rightarrow \frac{546}{11} = 49.6 \ldots\ldots \text{ Approx. 50 facing-bricks}$$

(iv) Backing:
Backing is the application of mortar mix as described for walls for bonding tiles to the wall. In essence, it is made for holding in position the tiles and thus has the same area in tiling. The computation for the cement and sand materials content is the same as that of plaster.

7.2.2 Ceiling Finishings

This is the covering which seals off the roof structure from the space. We have external and internal ceiling. The external ceiling is known as the eaves. The internal ceiling (i.e., within the internal walls of the building) is called the ceiling. The ceiling area is measured in m^2. When estimating, the estimator has to consider the area of the ceiling board and type required in the specification before proceeding. The total area of the external ceiling is usually added to the internal area for a straight-forward calculation.

Example 7.4:
Suppose it is required to determine the asbestos-ceiling requirement for ceiling of $250m^2$ using asbestos-ceiling board size 1.22mm x 1.22mm.

Solution:

Total area of 1 No. asbestos sheet	=	1.22 x 1.22		
	=	$1.4884m^2$		
Therefore; number of sheets required in $250m^2$	=	$\frac{250}{1.488}$	=	168.01
Add 5% waste			=	8.40
				176.41
	→	Approx. 176 pieces		

Example 7.5:

Suppose it is required to determine the hardboard ceiling requirement for ceiling of $250m^2$ using hardboard ceiling size 1.20mm x 2.40mm.

Solution:

Total area of 1 No. asbestos sheet	=	1.20 x 2.40		
	=	$2.88m^2$		
Therefore; number of sheets required in $250m^2$	=	$\frac{250}{2.88}$	=	86.81
Add 5% waste			=	4.34
				91.15
	→	Approx. 91 sheets		

7.2.3 Floor Finishings

Floor finishings in this book will be treated under the following:

(i) Floor Screeds:

Screeding is the application of mortar mix on the floor to give it a smooth finished look. Floor screeds may serve a number of functions as described below:

a) To provide smooth surface to receive the floor finish.
b) To bring a number of floor finishes each of different thickness up to the same finished level.
c) To provide falls for drainage purposes.
d) To accommodate service pipes and cables, although the thin screed over pipes is liable to crack and access to defective services is costly and difficult.

The computation for the cement and sand content in floor screed is similar to that of plaster work using Table 7.2.

<u>Example 7.6</u>:
Suppose it is required to determine the cement and sand requirement for screeding 200m^2 floor area using mortar mix (1:6) and 50mm thick.

<u>Solution</u>:
<u>Cement</u>:
Firstly, using Table 7.2, the weight of cement per Kg is calculated thus:
200 x 14.3 = 2,860Kg
This is then divided by the weight of cement per 50Kg bag to get the number of bags as thus:

$$\frac{2,860}{50} = 57.2 \text{ ………… Approx. 57 bags}$$

<u>Sand</u>:
Similarly, using Table 7.2, the volume of sand per Litre is calculated thus:
200 x 59.9 = 11,980 Ltrs
This is then divided by 1,000 to convert to m^3
Therefore; $\frac{11,980}{1,000} = 11.98\text{m}^3$

This can be converted to lorry load by dividing by the haulage capacity of the lorries as shown in Table 2.2.

(ii) <u>Terrazzo Paving</u>:
Another way of giving a smooth finishing look to floors is by casting terrazzo paving after the concrete. Terrazzo is made up of cement, sand, white chipping, black chipping mixed together, spread trowelled smooth. The data below are for every m^2 of terrazzo:

WHITE CHIPPINGS	=	0.20 bag/m^2
BLACK CHIPPINGS	=	0.75 bag/m^2
CEMENT	=	0.50 bag/m^2
SAND	=	0.03m^3/m^2

<u>N.B</u>: 1 bag is equivalent to 50Kg

Example 7.7:
Suppose it is required to determine the cement, sand and chippings requirements for cast in-situ terrazzo floor finish for a total area of $84m^2$ and 25mm thick.

Solution:
White Chipping:
Since 0.20 bag of white chipping is required per m^2, then:
$84m^2$ require 84 x 0.20 = 16.8 or 17 bags

Black Chippings:
Since 0.75 bag of black chipping is required per m^2, then:
$84m^2$ require 84 x 0.75 = 63 bags

Cement:
Since 0.50 bag of cement is required per m^2, then:
$84m^2$ require 84 x 0.50 = 42 bags

Sand:
Since $0.03m^3$ of sand is required per m^2, then:
$84m^2$ require 84 x 0.03 = $2.52m^3$ of sand

(iii) Ebonite Strip:
In between terrazzo paving are dividing strip known as black ebonite dividing strip usually of length 1.50m. The strip separates the paving giving a plusher finish.

Example 7.8:
Suppose it is required to determine the ebonite strip requirement in dividing a floor area of 42m x 42m wide paved 1.20m apart.

Solution:
Length = 42m
Width = 42m
Spacing Area = 1.20m
Therefore; ebonite requirement along length = $\frac{42}{1.2} + 1$ = 36

Ditto along width = $\frac{42}{1.2} + 1$ = 36

Total = 36 + 36 = 72 Number

Therefore; total length	=	72No. x 42m	=	3,024.00m
Add waste @ 5%			=	151.20m
				3,175.20m

If 1 strip is 1.50m long, then:

Number of ebonite strip = $\frac{3,175.20}{1.50}$ = 2,116.8 Number

If 50 pieces make one bundle, then:

Number of bundles = $\frac{2,116.8}{50}$ = 42.34 or 43 bundles

As could be seen mathematically above, the total length is divided by the width of paving (1.20m) and add one (1) as waste (ends). Same was done to the width of the area and added to give the total strip which is 72 number. Knowing that 1 strip of ebonite is 1.50m long, this is used to divide the total length to give the actual total number of strips required.

(iv) PVC Tiling (SEMTEX):

PVC Vinyl Co-polymerized floor tiles are a blend of PVC resins suitably supported by pigment, stabilizers and filler which are processed to produce a tough homogeneous and resilient flooring material. We have up to fourteen (14) colours with tile size 250mm x 250mm and 300mm x 300mm. Thickness 1.60mm, 2.00mm and 3.00mm. Normally, tiles are fixed to a level cement screed prepared by builders. Specialist laying contractors have, however, several alternative forms of underlay treatment necessary for other foundation.

Example 7.9:

Consider a total floor area of 160m^2 to be covered with Dunlop (SEMTEX) PVC titling of 250 x 250mm with a carton covering 8m^2 using 128 pieces fixed with Vinyl adhesive.

Solution:

Since 1 carton of SEMTEX covers 8m^2, then:

160m^2 will require $\frac{160m^2}{8m^2}$	=	20 cartons
Add 5% waste	=	1 carton
Total	=	21 cartons

Vinyl Adhesive:
From literature, a tin of National Vinyl Adhesive (Standard) contains 5Ltrs of adhesive with $0.25Ltr/m^2$ coverage.

Since 1 tin of adhesive will cover: $\dfrac{5Ltr}{0.25Ltr/m^2} = 20m^2$

Therefore; $160m^2$ will need: $\dfrac{160m^2}{20m^2} = 8$ tins

(v) Unglazed Ceramic Tiling:

Example 7.10:
Consider a total floor area of $160m^2$ of unglazed ceramic titling with 250mm x 123mm x 25mm tiles with 32 pieces in $1m^2$.

Solution:
Since $1m^2$ of tile needs 32 pieces, then:

$160m^2$ will need $160m^2$ x 32	=	5,120 pieces
Add 5% waste	=	526 pieces
Total	=	5,376 pieces

(vi) Ceramic Floor Tiling:

Example 7.11:
Consider a total floor area of $160m^2$ of titling with 300mm x 300mm glazed ceramic floor tiles.

Solution:
Firstly, you need to know the number of tiles needed in $1m^2$. Since $1m^2$ will need 10 tiles, then:
$160m^2$ will need 160 x 10 = 1,600 or 160 cartons

(vii) Paving Slab (Interlocking Tiles):

Example 7.12:
Consider a total paving area of $160m^2$ using Bone paving stone (Lider Type) with 39 pieces/m^2.

Solution:
Since $1m^2$ needs 39 pieces, then:

$160m^2$ will need 160 x 39	=	6,240 pieces	
Add 5% waste	=	312 pieces	
		6,552 pieces	

(viii) Carpet Tiles:

Example 7.13:
Suppose it is required to determine the Admera Carpet Tiles requirement in carpeting a floor area of $160m^2$ using carpet tile size 500mm x 500mm x 8.5mm.

Solution:
Since 1 carton of Admera Carpet Tile contains $4m^2$, then:
$160m^2$ will require: $\frac{160}{4}$ = 40 cartons

(ix) Granolithic Paving:
Granolithic paving is laid where a hard-wearing surface is required and is composed of angular granite chips and cement; a proportion of clean granite dust often being added. It may be mixed manually or mechanically in concrete mixing plant. The material is usually superimposed on a concrete foundation laid ready to receive it or on prepared existing concrete such as floors, etc. The finished surface may be trowelled or wood floated. The latter finish being suitable for receiving paving of the asphalt or wood block type. Table 7.3 gives the quantity of materials required per m^3 of granolithic paving.

Table 7.3: Quantity of Materials Required per m^3 of Granolithic Paving

Mix			Material Required per m^3 of Granolithic Paving		
Granite Chips	Granite Dust	Cement Cement	Granite Chips (m^3)	Granite Dust (m^3)	Cement/Tonne
2	-	1	0.77	-	1.11
2 ½	-	1	1.02	-	0.72
3	-	1	1.10	-	0.53
1 ½	1	1	0.70	0.46	0.67
2	1	1	0.77	0.40	0.56

N.B: The data shown in Table 7.3 are based on the following:
(i) Cement weighing $1,442Kg/m^3$

(ii) Granite chips weighing 1.47 Tonnes/m^3

<u>Example 7.14</u>:

Suppose it is required to determine the cement and granite chips requirements for cast in-situ Granolithic Paving (2:1) finish for a total area of 160m^2 and 25mm thick.

<u>Solution</u>:

<u>Cement</u>:

Since material required are given in m^3, the granolithic paving needs to be converted to m^3. Therefore, paving area (160m^2) = $\frac{160 \times 25}{1{,}000}$ = 4m^3

Since 1m^3 of granolithic paving in mix (2:1) requires 1.11 Tonnes of cement (see Table 7.3), then:

4m^3 will need: 4 x 1.11 = 4.44 Tonnes of cement

Or 4.44 x 20 = 88.8 or 89 bags of 50Kg cement

<u>Granite Chips</u>:

From Table 7.3, since 1 m^3 of granolithic paving in mix (2:1) requires 0.77m^3 of granite chips, then:

4m^3 will need: 4 x 0.77 = 3.08m^3 of granite chips

CHAPTER EIGHT

GLAZING

8.1 Introduction

The use of glass in the building industry has increased greatly over the past few decades. The versatility of flat glass – the generic term used to describe unbowed glass used in the glazing of windows and doors – has enabled it to be used in many ways which ultimately enhance the quality of life. Glass has been adopted to reduce both heat loss and noise with double and triple glazed units. Laminated and toughened glass offer greater safety than ordinary sheet and float glass. Laminated glass gives the added advantage of increased security protection. Wired glass prevents the spread of flames, while solar control glasses (specifically coated and tinted) help reduce the effects of radiant heat from the sun. Patterned and obscured glasses afford a greater degree of privacy together with aesthetic quality.

Wastage varies depending on whether glass is bought pre-cut to the required size, or in large sheet which are cut to size on site or in the contractor's yard. Typical wastage figures are as follows:

(i)	Pre-cut glass	=	5%
(ii)	Uncut glass	=	10%
(iii)	Glazing compounds and sundries	=	10%

8.2 Sheet Glass

Because of the nature of its manufacture, sheet glass never has two surfaces perfectly parallel of flat; it thus transmitted and reflected light. This glass is manufactured in thickness of 2, 3, 4, 5 and 6mm (the 2mm thickness is not recommended for general glazing) and are usually in two common sizes, i.e., 0.60m x 0.90m and 0.90m x 0.90m. However, there are larger sizes used in the manufacture of aluminium doors and windows.

8.3 Material Constants in Glazing

Table 8.1 gives the approximate quantities of glazing compound for back and front fixing.

Table 8.1: Approximate Quantities of Glazing for Back and Front Fixing

Pane Sizes (m^2)	Wood Surrounds (Kg/m^2)	Metal Surrounds (Kg/m^2)
$\leq$ 0.15	3.00	4.00
> 0.15 to 0.5	2.00	2.66
> 0.5 to 1	1.00	1.33
> 1	0.75	1.00

N.B:

i. For back puttying only, 33.33% of above weights should be used.
ii. Louvre blades are enumerated in their different lengths.
iii. Glazing to door and window panes are measured in m^2.
iv. When estimating, the estimator has to consider the area of glazing and type required in the specification before proceeding.

Example 8.1:

Suppose it is required to determine the plain glass sheet requirement to glaze 2 No. Crittal – Hope window size 1.20m x 1.20m with 8 No. glass pane size 0.29m x 0.44m, using 3mm thick glass size 0.9m x 0.9m.

Solution:

Firstly, you are to calculate the area of window pane and then that of the plain glass to be used. Therefore;

Area of plain glass sheet = 0.9 x 0.9 = $0.81m^2$

Area of window pane = 0.29 x 0.44 = $0.13m^2$

Therefore; number of panes in 1 sheet = $\frac{0.81}{0.13}$ = 6.23

Therefore; for 2 No. window, we have 16 glass panes.

No. of sheets = $\frac{16}{6}$ = 2.670

Add 10% waste = 0.267

2.937 …… Approx. 3 sheets

Puttying Requirement:

From Table 8.1, the approximate quantity of glazing compound for pane size $\leq$ 0.15 on metal surrounds is $4Kg/m^2$ for back and front fixing. Since fixing to Crittal –

Hope window pane is back fixing only, 33.33% of above weight will be used. Therefore:

Total area of sheet	=	3 x 0.81	=	$2.43m^2$
Hence; puttying requirement	=	($2.43m^2$ x 4.00) @ 33.33%		
	=	3.24Kg		

<u>Example 8.2</u>:
Suppose it is required to determine the number of 6mm clear sheet glass louvre blade 150mm wide and 825mm long fixed to metal clip for 10 No. 8-blade louvre carrier jambs.

<u>Solution</u>:
Since each louvre carrier jamb carries 8 blades of 6mm clear sheet 825mm long glass, therefore:

10 No. carrier jamb will carry:	10 x 8	=	80 No.
	Add 5% waste	=	4 No.
	Total	=	84 No.

CHAPTER NINE

PAINTING AND DECORATION

Painting is the application of paint, gloss, emulsion, or textured on rendered wall, metal or wood surfaces. There are varieties of painting materials in the Nigerian market. These are emulsion, gloss oil finish varmish, wax, polyurethane laquer, linseed oil, etc. There are also varieties of decorative finishings. These are cullamix-tyrolean finish, sundtex-trowel or textured finish, etc.

Each type of paint and decorative finish has its own covering capacity per m^2. This covering capacity again varies between surfaces to be treated. Therefore, when estimating, the following must be taken into consideration.

(a) Type of paint.
(b) Covering capacity of such paint.
(c) Surface to be painted.

The following covering capacities will be useful guide (see Table 9.1).

Table 9.1: Covering Capacities per $100m^2$ for Decorative Work

MATERIAL	SURFACE	QUANTITY REQUIRED TO COVER 100m2 (Ltrs except as given)
Primer	Concrete	9.00
	Wood	8.00
	Metal	6.50
	Plaster	8.30
	Brick	12.50
Undercoat	Wood	7.20
	Metal	7.20
	Plaster	7.20
	Brick	7.20
	Concrete	7.20
Finishing Coat	Wood	8.30
	Metal	8.30
	Plaster	8.30
	Brick	8.30
	Concrete	8.30
Emulsion	Plaster	8.30
Varnish Size	Wood	7.00
Varnish	Wood	5.60
Knotting	Wood	0.75
Stopping (Putty)	Wood	2.50Kg
Sand Paper	Preparing	8 Sheets
Masonry Sealer	Roughcast	25
Masonry Paint	Roughcast	29

Example 9.1:

Suppose it is required to determine the gallon of Meyer Emulsion (Imperial) paint needed to paint $800m^2$ of plastered wall area at 3 coats.

Solution:

Since $100m^2$ required 8.3Ltrs of emulsion paint for 1 coat, therefore:

$800m^2$ requires (8.3 x 8) Ltrs = 66.4Ltrs

Then, at 3 coats, we have 66.4 x 3 = 199.2Ltrs

To convert to gallons, we divide by 4 since 4Ltrs make 1 gallon.

Therefore; number of gallons $= \frac{199.2}{4} = 49.8$ …... Approx. 50 gallons

Example 9.2:
Suppose it is required to determine the material needed to prepare, knot, prime, stop and paint two undercoats and finishing coat of gloss oil paint on $100m^2$ general surface of wood work.

Solution:
Preparing:
From Table 9.1, we need 8 sheets of sand paper for preparing wood surface.

Knotting:
From Table 9.1, we need 0.75Ltrs of gloss paint.

Priming:
8Ltr of gloss paint is required to prime $100m^2$ (see Table 9.1).

Stopping:
From Table 9.1, 2.50Kg putty is needed for $100m^2$.

1^{st} Undercoat:
From Table 9.1, 7.20Ltrs of gloss pain is needed.

Subsequent (2^{nd}) Undercoat:
From Table 9.1, 7.20Ltrs of gloss pain is needed.

Finishing Coat:
From Table 9.1, 8.30Ltrs of gloss pain is needed.
Therefore, to compute the paint requirement, we need to add up as thus:
$(0.75 + 8.00 + 7.20 + 7.20 + 8.30) = 31.45$Ltrs
To convert to gallon $= \frac{31.45}{4} = 7.86$ …… Approx. 8 gallons

Example 9.3:
Suppose it is required to determine the quantity of paint needed to prepare, prime and apply two undercoats and one finishing coat of gloss oil paint on $100m^2$ general surface of plywood door.

Solution:

Following similar procedure as in Example 9.2, we have:

Preparing	=	8 sheets sand paper
Primer	=	8Ltrs
1^{st} Undercoat	=	7.2Ltrs
2^{nd} Undercoat	=	7.2Ltrs
Finishing Coat	=	8.3Ltrs

Therefore, total paint requirement = (8 + 7.2 + 7.2 + 8.3) = 30.7Ltrs

To convert to gallon $= \frac{30.7}{4} =$ 7.675 …… Approx. 8 gallons

Example 9.4:

Suppose it is required to determine the quantity of paint needed for a total painting area of $800m^2$ using one coat of Meyertex Texture paint.

Solution:

From literature, Meyertex covers $25\text{-}30m^2$ per 20Ltr per coat depending on the desired texture.

Assuming we use a minimum coverage area of 30m2 (because of dilution). Therefore; $800m^2$ will require 800 = 26.6 or 27 pails of 20Ltrs

CHAPTER TEN

UNDERPINNING

10.1 Introduction

Underpinning deals with alteration cum improvement to an existing foundation within existing building. The purpose for which this operation may be required for many buildings may be the same, but the nature and condition of each building may differ from one to another. Therefore, any pre-estimate may be inaccurate. However, each work had got to be undertaken by specialist contractor, in which case, quotations will have to be obtained from such contractors before a choice is made. In checking such quotations, it should be remembered that the cost of materials will remain the same, but cost of labour will vary from normal work. This is due to working in a confined place. For best assessment, labour in underpinning operation is best undertaken on daywork basis. This will remove unnecessary arguments that may result under negotiation.

10.2 Worked Examples on Underpinning

The following examples will be useful guide:

Example 10.1:

Excavate below existing foundation not exceeding 2m deep commencing 3m below existing ground level – m^3.

Solution:

Excavate = 21.600 hours
One staging = 1.625 hours
23.225 hours

			=N= : K
Therefore; 23.225 @ =N=285.714		=	6,635.708
Add: 25% profit & overhead		=	1,658.926
	Cost/m^3	=N=	8,294.634

Example 10.2:

Wedge and pin blockwork to existing with 2 layers felt bedded in cement mortar (1:3) 225mm wide – m.

Solution:

Materials:		=N= : K
2 layers felt 225mm @ =N=500/layer	=	1,000.000
$0.02m^3$ cement mortar @ =N=15,000/m^3	=	300.000
		1,300.000
Add 5% waste	=	65.000
Labour:		
2.30 hours @ =N=500.000	=	1,150.000
2.30 hours @ =N=285.714	=	657.142
		3,172.142
Add: 25% profit & overhead	=	793.036
Cost/m	=	3,965.178

N.B:

(i) There are many other materials that can be used for this work such as slate, copper, lead, etc. The treatment is similar to this example.

(ii) Cutting or breaking up existing concrete foundation, block wall and the like, output per gang shall be 9 hours and 6 hours respectively.

CHAPTER ELEVEN

RUBBLE WALLING & MASONRY WORK

11.1 Introduction

This kind of material (i.e., for rubble walling) is not very common nowadays, both in Europe and Nigeria because of economy. It is very expensive to build walls in stone. It can only be seen in old buildings such as churches, town halls, castles, post offices, police stations and palaces, where building stones like sandstone, limestone and granite were used entirely for building the walls.

The only current use is as facing to other materials; either bonded to the backing which may be blockwork or brickwork or built against concrete work or brickwork, etc. with the use of mortar and cramps. These days for building and construction works in general, heavy machineries are used in quarries to break and saw the stones whether igneous, sedimentary or metamorphic into required sizes and thickness. Thus, this had become a specialist work quotation had to be obtained for the supply of the material. Building stonewalls as well is a highly specialized work. As such this work can be absolutely sub-contracted.

However, for checking such quotations or such work if measured in bill of quantities, the following guide will be useful. The estimator when pricing must consider:

1. The type of materials required as specified on the drawings whether it is:
    a) Random rubble or snecked rubble (Figures 11.1 and 11.2).
    b) Coursed or uncoursed (Figures 11.1 and 11.2).
    c) Squared or not (Figures 11.1 and 11.2).
    d) Ashlar (Figure 11.3).

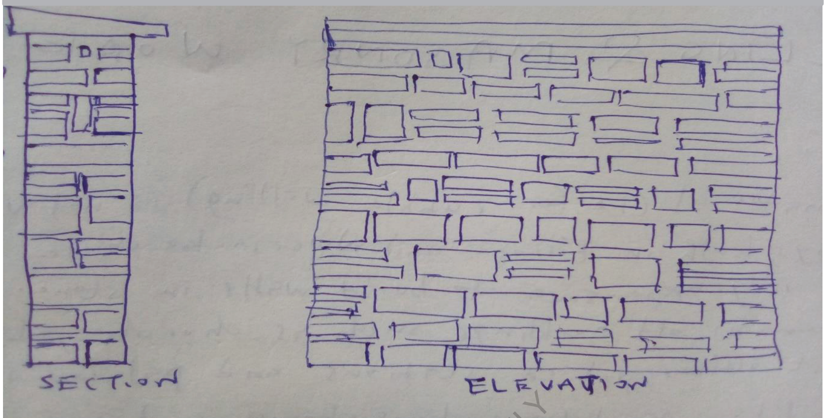


Fig. 11.1: Snecked or Squared/Random Rubble Built to Course

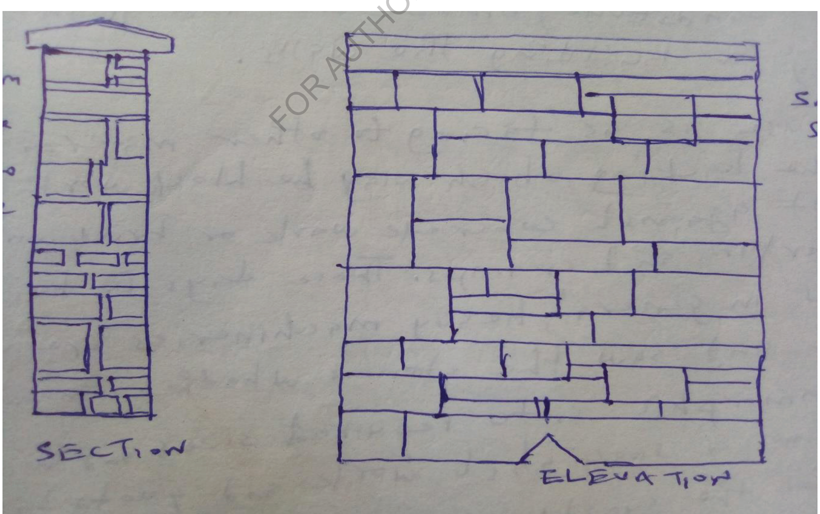


Fig. 11.2: Snecked or Squared/Random Rubble Built to Course

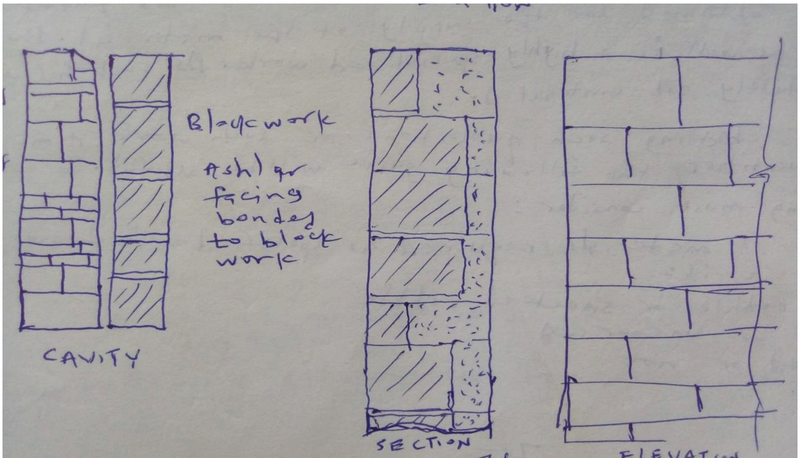


Fig. 11.3: Blockwork Ashlar Facing Bonded to Blockwork

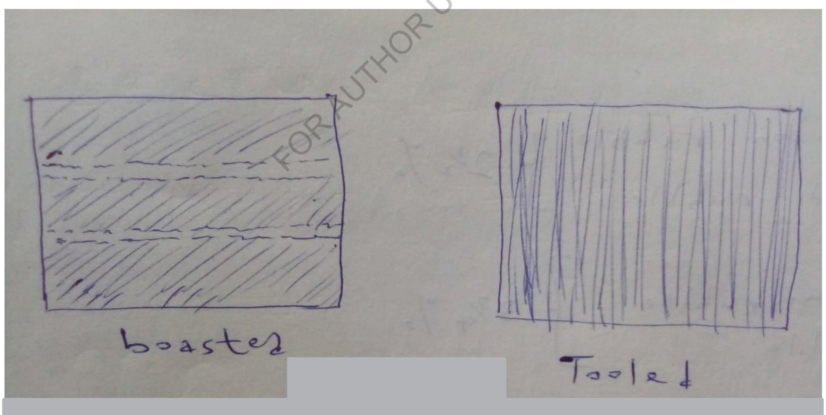


Fig. 11.4: Finishes to Rubble Walling

2. Type of stone specified, as they are more expensive than one another.
3. The kind of dressing required whether hammer dressed, boasted (Figure 11.4), tooled (Figure 11.4) or picked finish.
4. Cement mortar and type required.
5. Type of cramps, bronze or copper.

Stones are supplied by weight, because some are heavier than others, it is necessary to establish the cubic content of the stone per tonne. The various weights are:

- Granite stone such as Corrennie Aberdeenshire or Penzance Larmona or Olumo rock weighs approximately 2,750Kg/m^3.
- Sandstone such as Darley dale, or Derbyshire approximately weighs 2,350Kg/m^3.
- Limestone such as Ancaster Lincolnshire oolitic limestone or Dorsel Portland stone weighs between 2,400 and 2,500 Kg/m^3.
- Metamorphic stone such as is heavily deposited in Igbetti, Oyo State, Nigeria is another kind in use.

11.2 Mortar Requirement

Uncoursed and coursed random rubble work average 0.25m^3 mortar per m^3 of stone will be required. Regular coursed work average 0.20m^3 mortar per m^3 of stone will be adequate. The following allowances for waste will be adequate:

Uncoursed Random Rubble	=	2 ½ %
Regular Coursed Rubble	=	2 ½ %
Ashlar (Snecked Random Rubble)	=	3 ¾ %
Ashlar (Random Rubble)	=	3 ¾ %
Kentish Rag	=	5%

Table 11.1 shows the output/m^3 based on gang of 3 masons & 2 labourers.

Table 11.1: Output/m^3 Based on Gang of 3 Masons & 2 Labourers

DESCRIPTION	SKILLED (Hour)	UNSKILLED (Hour)
150mm thick random rubble wall	1.00	0.65
225mm thick random rubble wall	1.40	0.80
150mm thick coursed random rubble wall	1.10	0.70
225mm thick coursed random rubble wall	1.60	1.00
150mm thick regular coursed random rubble wall	1.00	0.60
225mm thick regular coursed random rubble wall	1.25	0.90
150mm Kentish rag	1.50	0.85
225mm Kentish rag	2.00	1.25
150mm thick snecked rubble wall	1.40	0.80
225mm thick snecked rubble wall	1.75	1.20
100mm Plain Ashlar wall	1.70	0.85
150mm Plain Ashlar wall	2.00	1.00
Rake out and point	0.35	0.25

Example 11.1:

225mm coursed random rubble wall in outer skin of hollow wall bedded and jointed in cement mortar (1:3) – m^2.

Solution:

Material: =N= : K

2,500Kg limestone/m^3 (m^3 @ =N=13,750)	=	13,750.000
Add 3 ¾ % waste	=	515.625
0.25m^3 mortar @ =N=20,500/m^3	=	5,125.000
Add 5% waste	=	526.250
		19,646.875

=N= : K

Therefore; 225mm wall = $\frac{225}{1,000}$ x =N=19,646.875 = 4,420.547

Labour:

1.60 skilled hour @ =N=500/hour	=	800.000
1.00 unskilled hour @ =N=285.714/hour	=	285.714
		5.506.261
Add: 25% profit & overhead	=	1.376.565
Cost/m^2	=	6,882.826

<u>Example 11.2</u>:

150mm snecked rubble bonded to block wall and bedding jointing and pointing in cement mortar (1:3) – m^2.

<u>Solution</u>:

<u>Material</u>:			=N= : K
Stone and mortar as in Example 11.1 =	19,646.875		
Therefore; 150mm = $\frac{150}{1,000}$ x =N=19,646.875		=	2.947.031
0.01m3 bedding mortar to backing @ =N=20,500/m3		=	<u>205.000</u>
			3,152.031
<u>Labour</u>:			
1.40 skilled hours @ =N=500/hour		=	700.000
0.80 unskilled hour @ =N=285.714/hour		=	228.571
Extra labour bonding & bedding on wall:			
40 skilled hour @ =N=500/hour		=	20,000.000
25 unskilled hour @ =N=285.714/hour		=	<u>7,142.850</u>
			31,223.452
<u>Add</u>: 25% profit & overhead		=	<u>7,805.863</u>
Cost/m^2			=N=<u>39,029.315</u>

<u>N.B</u>:

It is necessary to add extra labour for bedding and bonding the facing stone to the backing wall because bedding mortar must be applied on the backing wall before laying such facing on the backing.

<u>Example 11.3</u>:

100mm thick Dorsel Portland stone boasted Ashlar bedded and jointed in cement, lime and sand mortar (1:1:6) with a neat flush joint as work proceeds.

<u>Solution</u>:

<u>Material</u>:			=N= : K
1m^2 dressed Portland stone delivered to site		=	4,850.000
Add 2 ½ % waste		=	121.250
<u>Mortar</u>:			
Bedding:	0.0112m^3		
Pointing:	<u>0.0091m^3</u>		
	0.0203m^3 @ =N=20,500	=	416.150

Copper cramps: 4No. @ =N=250		=	1,000.000
Labour:			
1.70 skilled hour @ =N=500/hour		=	850.000
0.85 unskilled hour @ =N=285.714/hour		=	242.857
		=N=	7,480.257
Add: 25% profit & overhead	=	=N=	1,870.064
Cost/m^2	=	=N=	9,350.321

CHAPTER TWELVE

ANALYSIS OF RATES IN SANITARY APPLIANCES FITTINGS

The analysis of rates in sanitary appliances and fittings will be undertaken under two elaborate examples in this chapter.

Example 12.1 (Wash Hand Basin):
550 x 400mm Wash Hand Basin complete with brackets, chromium plated top, including plug & Chain.
N.B: Consider 1 No. Wash Hand Basin.

Solution:

Material Cost	N : K
▪ 550 x 400mm wash hand Basin (1 No) @ N4,500 - -	4,500.00
▪ Cast-iron Bracket, tap, plug & Chain Included in the purchase price	
▪ Wooden plugs (6N0) @ N3 - - - - - -	18:00
▪ Screws (6N0) @ ₦3 - - - - - - -	18:00
▪ Jointing materials say - - - - - - -	100.00
Allow 5% waste & breakages - - - - - -	4,636.00

Labour Fixing Cost:

- Consider a gang size of 1 tradesman & 1 mate
  = Gang cost @ 785.714/hours

▪ 5½ gang hours @ 785.714	4,321.43
add 25% Profit & Overhead - - - - -	9,189.23
Total Cost =	**₦11,486.54**

Example 12.2 (Water Closet):
Vitreous China Low Level Water closet suite complete with cast iron cantilever brackets and wooden plug fixed to concrete floor (No).
N.B: Consider 1 No W/C Suite.

Solution:

Materials Cost:	**N : K**
▪ W/C Suite complete (1N0) @₦16,000.00	₦16,000.00
▪ Cast iron cantilever brackets for flushing	

System (2N0) @ N250 each - -		500.00
▪ Wooden plug (6N0) @ N3.00 - -		18.00
▪ Jointing materials to soil pipe @ ₦300		300.00
		17,318.00
Add 5% waste - - - - -		865.90

Labour Fixing Cost:

- Consider a gang strength of 1 tradesman & 1 mate Including unloading & stacking of W/C:

  ⇒ gang cost is ₦785.714/hr.

- 3 gang hours @ N785.714/hour - - -	2,357.14	
	20,541.04	
Add 25% profit & overhead - - - - -	5,135.26	
▪ Total cost =	**₦25,676.30**	

CHAPTER THIRTEEN

PLUMBING AND MECHANICAL ENGINEERING INSTALLATIONS

13.1 Labour Output

Before worked examples will be taken on the estimation for plumbing and mechanical engineering installations, the required labour outputs needed for the computation would be stated. Therefore, the following are the various outputs that will be used to estimate the cost of labour for plumbing and mechanical engineering installations in this chapter.

<u>**PVC Gutter**</u> <u>**Plumber/Apprentice**</u>

100mm – 150mm gutter - -- - 0.75 hour/m
Fittings - - - - - - - 0.35hour each
Soil & Waste Pipes
50mm – 75mm pipes - - - - - 0.75hour/m
100mm pipes - - - - - - 1.20 hours/m
50mm – 7.5mm Bend - - - - - 0.75hour each
100mm Bend - - - - - - 1.30hours each
100mm Branch - - - - - 1.50 hours each
100mm Bend W/C connector - - - - 2. 00hours each
50mm 75mm traps - - - - - - 1.75hours each

32mm Tubing

Fixing with clips - - - - - - 0.5hour/m
Fixing elbows - - - - - - 0.45hour each
Fixing tiles - - - - `- - - 0.75hour each
Asbestos
100mm pipes - - - - - - 1.26m/hour

- Gutter: 3m Length (a) ~~N~~500 Each - - - - 1,500.00

2 gutter unions (a) =100mm bends - - - - - - - 0.75hr each
100mm branches (single) - - - - - 1.00hour each
100mm branches (poodle) - - - - - 1. 50hour each
Example 1: P V C Gutter

115mm PVC Half Round Devas gutter jointed with gutter unions in the running length fixed with brackets @1m c/c. Calculate the cost/m length.

13.2 Worked Example

Example 13.1 (Gutter):
Consider 3m length of gutter.
Solution:
Materials cost:

		₦ : K
▪ ₦200 Each	- -	400.00
▪ 3bracket & Screws (a) ~~₦~~600 Each	- - -	18.00
Add 5% waste	- - - - - -	1,918.00
		95. 90
		2,013.90

Labour Fixing Cost

- 0.75 x 3length of gutter;

=>2.25 hour for 1 pl number $1 apprentice/3m length 0785.714 = 1,767 .86

	3,781.76
	945.44
Cost /m Length =	₦4,727 .20

Example 13.2 (Soil and Ventilation Pipe):
100mm PVC Soil and ventilation pipe work with ring seal joint in the running length, fixed with supports, to be priced separately. Calculate the cost/m
N.B: Length of soil pipe = 8ft = 2.4m

Solution:
Materials Cost:

		₦ : K
Pipe/m: Price of a length/2.4		
=> ₦1,400/2.4	- - - - -	583.33
Add 5% waste	- - - - - -	29.17
* 1 Ring @ ₦ 450	- - - - - -	450.00
		1,062.50

Labour Cost:
* 1.2 hours for 1 plumber & 1 apprentice @785.714/hour s - 942.86

		2,005.36
Add 25% Profit & Overhead - - - - -		501.34
	Cost/m =	₦2,506.70

Example 13.3 (Branch of soil and Ventilation Pipe):
Calculate the extra cost of 100mm PVC branch over the cost of 100mm PVC pipe work.

Solution:

Materials Cost: ₦ : K

- 1 branch @ ₦200 - - - - 200.00
- Waste on branch 2 ½ % - - - - 5.00

Labour Cost:

1 plumber & 1 apprentice @ 1.5hrs @ gang cost ₦785.714/hour - 1,178.57

1,383.57

Add 25% profit & overhead - - - - - 345.89

₦1,729.46

Extra Cost of Branch:

₦ (2,506.70 – 1,729.46) = ₦ 777.24.

Example 13.4 (Tubing Pipe):
32mm PVC tubing with couplings in the running length, fixed with clips @ 1m c/c. Calculate the cost/m.

Solution:

Materials Cost: ₦ : K

- Tubing pipe 1m length @ ₦ 1,500 full length (5m)

$\Rightarrow$ 1m length = ₦1500/5 - - - - - - 300.00

- Coupling (i.e., Union Connector) - - - - 300.00
- Clips & screws @ N100 - - - - - 100.00

700.00

Add 5% waste - - - - - - - 35.00

Labour Cost:

1 plumber & 1 apprentice @0.5hr @ gang cost N785.714 / hr - 392.86

1,127.86

Add 25% Profit & Overhead - - - - - 281.96

Cost/m = ₦1,409.82

CHAPTER FOURTEEN

ELECTRICAL INSTALLATIONS

14.1 Labour Output

Before worked examples will be taken on the estimation for electrical installations, the required labour outputs needed for the computation would be stated. Therefore, Table 14.1 shows the various outputs that will be used to estimate the cost of labour for electrical installations in this chapter.

Table 14.1: Outputs for Estimating the Cost of Labour for Electrical Installations

OPERATIONS	ELECTRICAL/APPRENTICE
• Switch gear/switch unit	1hour each
• Trunking/mild steel	3hrs/m
• Couplings& caps on trunking	0.75 hour
• Fixing to concrete	4m/hour
• 20mm steel conduit clips	5.0m/hour
• 1.5mm2 PVC Cable in 20mm conduit	40m/hour
• Erect & connect light fittings	2.5hours each
• Erect & connect light & power switches	0.75hour each

14.2 Worked Examples on Electrical Installations

<u>Example 14.1 (Switch Unit)</u>:

13 Amp, 1 way, 3 gang surface switch unit fixed with plugs to block wall. Calculate the cost of 1 switch unit.

<u>Solution</u>:

<u>Materials Cost</u>: ₦ : K

- 13A, 1 Way, 3 Gang surface switch @ N300 — 300.00
- Add 5% waste - - - - - - 15.00

315.00

<u>Labour Cost</u>:

- 1 hour for 1 Electrician & 1 apprentice @ N785.714/hour 785.714

1,100.714

Add 25% Profit & Overhead - - - - - 275.179

<u>₦1,375.893</u>

Example 14.2 (Steel Conduit):

20mm heavy gauged steel screwed conduit fixed to concrete or block in chases. Calculate the cost/m. ''Quote 20mm conduit'' 625/m – (1500/2.4)

Solution:

Materials Cost:

			N : K
❖ PVC Cable/m	=	₦70.00	
Add 5% waste	=	₦ 3.50	
	=	₦73.50	73.50

Labour Cost:

❖ 40m/hour for 1 Electrician & Apprentice	
1/40 hours @ gang cost (₦785.714/hour)	19.64
	93.14
Add 25% profit & overhead - - - - -	23.29
Cost/m - -	₦116.43

Example 14.3 (2.5mm PVC Cable - N150/m):

2.5mm twin core PVC Cable in conduit. Calculate the cost/m. ''Quote: PVC Cable (2.5mm = ₦150/m).

		Solution	N : K
Materials cost:			
❖ PVC cable/m	=	₦150.00	
Add 5% waste	=	₦ 7.50	
		₦157.50	₦157.50

Labour cost:

40m/hour for 1 Electrician & 1 Apprentice:

1/40hr @ gang cost (₦785.714/hour) - - - -	19.64
	177.14
Add 25% profit & overhead - - - -	44.29
Cost/m =	**₦221.43**

Example 14.4 (Fluorescent Lamp Light Fixture):

Calculate the cost of supplying, erecting and connecting up the fluorescent lamp lighting fixture 40W, 1230mm.

Solution:	N : K
❖ 40w, 1230mm Fluorescent lamp lighting fixture	
@ N2,500	₦2,500.00
Add 5% waste	₦125.00
	₦2,625.00
	₦2,625.00
Labour cost:	
2.5 hours for 1 Electrician & 1 Apprentice @ ₦785.714/hour	₦1,964.29
	4,589.29
Add 25% Profit & Overhead - - - - -	1,147.32
	₦5,736.61

CHAPTER FIFTEEN

PRICING OF THE ITEMS OF PRELIMINARY SECTION OF THE BILL OF QUANTITY (BOQ)

15.1 General Information Required for Estimating the Preliminaries

The following are the general information which are vital in the pricing of preliminary section of the BOQ:

1) Check the standards or conditions of contract applicable. Examine any amendment made to these conditions and see that they are fair and workable.
2) Note the starting and the completion date.
3) Check if there is a time limit for completion and whether there are liquidated damages for non-completion on time.
4) Access when the bulk of outside work will need to be done and consider the effect of this on guarantee time and completion date.
5) Check if the contract has to be executed in any particular sequence.
6) Consider any requirements regarding special insurances in terms of the contract.
7) Note the period of interim payment, when the final account will be certified and the limit of retention funds.
8) Check if the opportunity will be given to quote for any nominated sub-contractors work applicable to his firm.
9) Note the location of the site. If it is in a rural area, consider transport rate, access and availability of labour. If it is in the town, consider access, unloading and storing of materials.
10) Check if the contract is on a fixed price basis.

15.2 Constants Used in Estimating Preliminary Items

Table 15.1 presents the vital labour and material constants used in estimating preliminary items in construction works:

Table 15.1: Labour and Materials Constants Used in Estimating Preliminary Items

S/N	TRADE	LABOUR	MATERIALS
1	Exaction & earthwork	90%	10%
2	Concrete work	20%	80%
3	Brick/blockwork	33%	67%
4	Roofing	20%	80%
5	Wood work	40%	60%
6	Metal work	20%	80%
7	Plumbing work	25%	75%
8	Electrical work	33%	67%
9	Plastering work	65%	35%
10	Glazing	25%	75%
11	Painting and decorating	35%	65%
12	Drainage.	33%	67%

The proportions in Table 15.1 can be of great advantage if calculation is necessary to determining the likely cost range of a trade, either materials or labour cost increase and a quick assessment is required. Therefore, it will be useful when considering the cost of a new similar project when increase in the cost of labour or materials is known in terms of percentage as shown in the following examples.

Example 15.1:

The block work section of a bill of quantities is N40,500. How much is the builder expected to pay for labour and materials:

Solution

Block Work (BOQ) = ₦40,500

Deduct: 25% Profit & Overhead (P/O) = ₦10,125

₦30,375

N.B:
Divide 40,500 BY 1.25 = 32,400
25% of 32,400 = 8,000
= 32,400 + 8,100 = **₦40,500**

Labour/Material Ratio (33:67):

Amount for Labour = 33/100 x ₦30,375

= ₦10,023.75

Amount for materials = ₦(30,375.00 - 10,023.75)

= ₦20,351.25

Example 15.2:

A Contract was awarded in 2014 for the sum of ₦3,195,000.00. A similar contract is being proposed in 2018. Material fluctuation is 30% increase while labour is 20%.

What is the likely cost of the new contract assuming that the original contract sum included 25% profit and overhead?

Solution:

2014 contract sum = ₦3,195,000.00

Deduct 25% P/O = ₦ 798,750.00

= ₦2,396,250.00

- Labour/Material ratio:
- 40:60 (using wood work)
- 2014 labour cost = 40 x 2,396,250 = ₦95,850,000
- Amount of labour increase in 2018:

  $\frac{20}{100}$ x 95,850,000 = ₦ 19,17,0000 --- ₦19,170,000

  ₦115,020,000

  Material Cost:
- 2014 Material Cost = ₦ (2,396,250 - 958,500) = ₦ 1,437,750
- Amount Of Material Increase in 2018 $\frac{30}{100}$ x 1,37750 = ₦431,325

  ₦1,869,075

  Summary
- Labour cost in 2018 = ₦115,020,000.00
- Material cost in 2018 = ₦1,869,075.00

  = ₦116,889,075.00
- Add 25% profit $ overhead = ₦29,222,268.75
- Contract sum as @ 2018 = ₦3,146,111,343.75

CHAPTER SIXTEEN

WORKED EXAMPLES OF SELECTED ITEMS OF THE PRELIMINARY SECTION OF THE BILL OF QUANTITIES (BOQ)

Example 16.1 (Site Supervision):

It is the contractor's agent on the site who supervises the whole of the project. he also coordinates the work of the sub-contractors and receives instruction from the architect on behalf of the main contractor the estimator may also include here the cost of maintaining purchasing clerk store keeper ted boy etc., who serve under the site agent for the smooth running of the project .it is possible that all these personnel may be dealing with more than one contract at a time. Therefore, such cost may be shared among they such contract. However, this example assumes that they are employed on one contract, the calculation of cost is now carried out as follows.

			₦ : k
Supervisor:			
❖ Supervisor's salary/month	= ₦150,00		
❖ Housing allowance	= ₦ 10,00		
❖ Transportation allowance	= ₦ 10,00		
	= ₦170,000	→	170,000.00
Purchasing Clerk:			
❖ Salary /month	= ₦ 90,000		
❖ Housing allowance	= ₦ 5,000		
❖ Transportation	= ₦ 5,000		
	₦ 100,000	→	100,000,0
Store Keeper:			
❖ Salary /month	= ₦ 90,000		
❖ Housing allowance	= ₦ 5,000		
❖ Transportation	= ₦ 5,000		
	= ₦ 100,000	→	100,000.00
Tea Boy:			
❖ Salary /month	= ₦ 45,000		
❖ Housing allowance	= ₦ 5,000		
❖ Transportation	= ₦ 5,000		
	= ₦ 55,000		

- Contract Period = 15 months
  Add 1 month before $ 3 after = <u>4 months</u>
  <u>19 months</u>
- Cost/contract period = ₦ 425,000 x 19 month =8,075,000.00
  Add 25% profit & over head <u>=2,018,750.00</u>
  <u>₦10,093,750.00</u>

<u>Example 16.2 (Programmer of Works)</u>:
A contractor is expected to prepare the programmer of work for submission to the architect for approval and air collate copies to the consultants and mount one copy on the site notice board. This programmer can be revised form time–to–time as condition on the site entails. The contractor should price this item thus:
<u>Pricing</u>:

a) The cost of paper work
b) The cost of the time taken by a contractor /expert in preparing the programmer.
c) The cost of mounting the programmer inducing maintenance
d) Profits and overheads.

<u>Example 16.3 (Temporary Access Road)</u>:
The contractor will construct a temporary access road to the site form existing permanent road this is to facilitate access to the site for workers consultants and the like including vehicles and materials.
<u>Pricing</u>:

a) Cost of labour and plant clearing the road.
b) Cost of labour and materials forming such road
c) Cost of maintaining such road including maintaining and making good adjacent permanent road.
d) Cost of clearing away such temporary road, if not required at the completion of all works on the site and making good ground disturbed.
e) Profit and overhead.

<u>Example 16.4 (Setting Out of the Works)</u>:
The contractor will set out the position of the building on the site before commencement of any actual work to the satisfaction of the Architect.

Pricing:

a) The cost of pegs, templates and ropes.
b) The hiring cost of theodolite, the precise level of the like instrument to be employed.
c) The cost of bringing to site and removal of all the above from the site.
d) The cost of the time taken by the contractor's engineer or the assisting team.
e) Profit and overhead.

Example 16.5 (Hoarding and Barriers):

The contractor may be required to construct hoarding and barriers where necessary. He may even be required to erect fence and gantries.

Pricing:

a) Cost of labour and materials for constructing such.
b) Cost of maintenance.
c) Cost of removal and making good.
d) Profit and overhead.

Example 16.6 (Site Meeting):

The contractors are expected to make all necessary arrangement for meeting to be held on site and those attending must be made reasonable comfortable

Pricing:

a) Cost of providing refreshment for each of the meeting
b) Cost of attendant
c) Profit and overhead

Example 16.7 (Temporary Store):

The contractor will construct a lockable store for the safe keeping of materials on site. Such storage facility must be protected from damage by weather.

Pricing:

a) Cost of labour and materials constructing such store.
b) Cost of electrical lighting installation.
c) Cost maintaining a store including electric bill.
d) Cost of removal and making good ground the store on completion of all workers.
e) Profit and overhead.

Example 16.8 (Site Offices):

The contractor must provide site offices for his site agent and consultant such as Architect, Engineers, Q/S, etc. especially if they are required to be resident on site. Such offices must be provided with table, fans, air-conditioning unit and drawing boards where necessary.

Pricing:

a) Cost of purchasing mobile cabin or caravans cost of maintaining such removal on completion minus (-) resale value or cost of hiring maintenance removals cost of labour and materials for constructing the temporary offices.
b) Cost of furniture including fans and air –conditioning
c) Cost of electrical installation
d) Cost of maintenance
e) Cost of removal and making good ground disturbed
f) Profit and overhead.

Example 16.9 (Temporary Electric Power and Lighting):

The contractor must provide temporary electric power and lighting necessary for the execution of work on site.

Pricing:

a) Cost of hiring stand by generator or cost electricity connected to existing power lines.
b) Cost of cables and wiring
c) Cost of electrical bills or feeling of generator
d) Cost of maintaining either electricity lines or generator.
e) Cost of removal and making good or disconnection.
f) Profit and overhead.

Example 16.10 (Water for the Works):

The contractor must provide on-site water for necessary execution of the work . this can be done in either of the following:

1) Borehole
2) Supply by water tankers
3) Pipe – borne water

Pricing:

Supply by water tanker

a) Cost of water supply by water tanker
b) Cost of labour and material constructing temporary water storage on site .
c) Cost of providing gee –pee tank on site
d) Removal of water storage and making good ground disturbed
e) Profit and overhead.

Example 16.11 (Vehicle for the Project):

Assume 5-No. of Toyota corolla cars; 5-No. of Hilux vans; and 2-No. of Peugeot 406 cars.

Pricing**:**

❖ 5-No. of Toyota corolla (a) ₦3,000,000/No	-	15,000,000.00
❖ 5-No. Hilux vans (a) ₦6,000,00/No - -	-	30,000,000.00
❖ 2-No. Peugeot 406 (a) ₦1,200,000/No -	-	2,400,000,00
		47,400,000.00

Deduct:

- Resale value after 2 years:

o 5 Nos Toyota Corolla @N1,200,00/No:	= 6,000.00		
o 5 Nos Hilux @N2,000,000/No	= 10,000.00		
o 2 Nos Peugeot @N400,000/No	= 800,000	=	16,800,000.00
			30,600,000.00
o Maintenance & fueling @ N5,000,000			5,000,000.00
o Driver's salary @N35,000 x 12 x 12 x 12 - -	-		10,080,000.00
			45,680,000.00
o Add: 25% Profit & Overhead - -	-		11,420,000.00
			₦57,100,000.00

Example 16.12 (Transport for Site Workers):

A contractor must provide transport for his operators depending on the location of the site and source of his operatives, who may likely reside at a far distance from the site. This can be done in two ways.

Pricing:

Option 1: (Assume 2 years)

Here the contractor can decide to purchase a bus if so many of the operatives have to be lifted to site.

Computation:	N : K
• Cost of 2 Nos Coastal Buses @N10,000,000/No	20,000,000.00
• Deduct resale value of 2 No @N2,000,000/N0	4,000,000.00
• Drivers: 2 Nos @840,000 each for 2 years.	3,360,000.00
	27,560,000.00
Add 25% profit & overhead - - -	6,890,000.00
	₦34,450,000.00

Option 2:

In this option, the contractor may decide to pay traveling allowance if the operatives are not much.

N.B: Assume 100 workmen/week @N100/day for 2 years contract.

Computation:

- Cost/week = 100 x N100 x 6 (i.e., 6 working days)
- Assuming 2 years contract = 2 (52 – weeks) = 96 weeks practical working days.

∴ payment to operatives:

= 100 x ₦100 x 6 days x 96 weeks = 57,600,000.00

Add 25% profit & overhead = 14,400,000.00

₦72,000,000.00

CHAPTER SEVENTEEN

ESTIMATING FOR CIVIL ENGINEERING WORKS: INTRODUCTION

17.1 General Introduction

For any construction project it is required to forecast its probable cost. This probable cost is also known as the estimated cost. For all engineering works, small or big, heaving or light construction works, it is necessary to know the probable cost beforehand. This can only be known by estimating. If the estimated cost is greater than the money available, then attempts are made to reduce the cost by reducing the work or by chancing the specifications.

From the above, it is clear that a correct estimate is that in which during the actual execution of work, there are:

i. No deviations in the estimated quantities of different items of work;
ii. No extra and additional items;
iii. No increase in the cost; and
iv. No provision of lumpsum items.

All the above depend upon the knowledge of the estimator. The calculations of different items of works (i.e., quantities) are carried out with the help of the drawings, specifications and designs.

Accuracy in estimate is very important, if estimate is exceeded it becomes a very difficult problem for engineers to explain, to account for and arrange for the additional money. Inaccuracy in preparing estimate, omission of items, changes in designs, improper rates, etc., are the reasons for exceeding the estimate, though increase in the rates is one of the main reasons. In framing a correct estimate, care should be taken to avoid omissions of any kind of work or part thereof. The rate of each item should also be reasonable and workable. The rates in the estimate provide for the complete work, which consist of the cost of materials, cost of transport, cost of labour, cost of scaffolding, cost of tools and plants, cost of water, taxes, establishment and supervision cost, reasonable profit of contractor etc.

17.2 Metric System and Units

Metric system is very simple as the units are multiplies of ten or one-tenth of the other. The most important advantage of the metric system is the tremendous simplification of calculations. The adoption of the metric system has much simplified the arithmetical operations of addition, subtraction, multiplication and division, and also has saved much useful time being quicker. The foot pound system of calculations by fraction in almost all topics which for civil Engineering Works the units which are commonly used are:

i. Metre for length
ii. Square metre for area
iii. Cubic metre for volume
iv. Kilogram for mass, and
v. Litre for capacity.

The sub unit are named by addition the suitable prefixes as milli (one thousandth) cent; (one-hundredth) by addition the prefixes as deca (ten times), hector (hundred times) and kilo (thousand times).

The prefixes for formation of multiples of units are as given below:

Prefix	**Multiplying Factor**	
tetra (T)	1 000 000 000 000	$= 10^{12}$
giga (G)	1 000 000 000	$= 10^{9}$
mega (m)	1 000 000	$= 10^{6}$
kilo (K)	1 000	$= 10^{3}$
hector (h)	100	$= 10^{2}$
deca (da)	10	$= 10^{1}$

prefix multiplying factor

deci (d) 0.11 - - - - - - - $= 10^{-1}$
centi (c) 0.01 - - - - - - $= 10^{-2}$
milli (m) 0.001 - - - $= 10^{-3}$
micro(u) 0.000 001 - - - - - $= 10^{-6}$
nano (n) 0.000 000 00 1 - - - - - $= 10^{-9}$
pice (p) 0.000 000 000 00 1 - - $= 10^{-12}$
femto (f) 0.000 000 000 000 00 1 - - - - $= 10^{-15}$
atto (a) 0.000 000 000 000 000 00 1 - - - $= 10^{-18}$

Illustrations:

1 kilometer = 1 km = 1x 10^3 m = 1000 metre

1 kilogram = 1 kg = 1x10^3 g = 1000 gram

1 kiloliter = 1 –kl 1x10^3 l = 1000 litre

1 millimeter = 1mm = 1 x10^3 = 0.00 1 m

1 milligram = 1mg = 1x 10^{-3} = 0.00 1 gram

1 milliliter = 1 ml = 1x 10^{-3} l -0.00 1 litre

17.3 International System of Unit – SI Unit

The Traditional Metric System (Mksa System – Metre Kilogram, Second, Ampere system) does not include the unit of their Mo dynamic temperature and the unit of Luminous Intensity. The international conference has adopted the International Units (System of International Unit – SI unit) which includes six basic unit with their symbols are:

i. Metre (m) for length
ii. Kilogram (kg) for mass
iii. Second (s) for time
iv. Ampere (a) for electric current
v. Degree kelvin (k) for thermo-dynamic temperature
vi. Candela (cd) for luminous intensity

The SI unit covers the coherent units of the system (the basic unit , supplementary unit and the coherent derived unit and decimal multiples and sub-multiples of the unit formed by the uses of the prefixes (see page 93) most of the advanced countries have adopted SI unit .adoption of SI unit has little effect on the M K S A system as the four unit of meter, kilogram, second and ampere , remain the same and only two more independent basic unit have been added .

CHAPTER EIGHTEEN

ESTIMATING FOR CIVIL ENGINEERING WORKS: METHOD OF ESTIMATING

18.1 Introduction

Before undertaking the construction of a project, it is necessary to know its probable cost which is worked out by estimating an estimate is a computation or calculation of the quantities required and expenditure likely to be incurred in the execution of work. For the preparation of detailed estimate drawings designs specification and schedule of rates prevailing in that locality or city are needed for calculation work 'details of measurement form abstract of cost form abstract of quantities form material statement form and labour statement form etc., are needed these are given below in Tables 18.1 - 18.4.

Table 18.1: Details of Measurement Form

S/No	Description of items	No.	Length (L)	Breadth (B)	Height or Depth (H)	Contents	Total	Remarks

Table 18.2: Abstract of Cost Form

S/No	Detail of work	Quantity	Unit	Rate N : K	Amount N : K	Remark

Table 18.3: Abstract of Quantity Form

S/No	Particular of work	Cement	MS Bar	Sand	Bricks	Grit	Wood Lime	Paint

Table 18.4: Labour Statement Form

S/No	Particular of work	Mistry	Mason	Carpenter	Fitter	Black smith

Forms shown above as Table 18.1 – 18.4 are used for calculating the details for different items of work, cost quantities, material and labour required. The abstract of quantity, ‘‘materials statement’’ and ‘labour statement’ are needed for the planning and execution of work with the help of ‘network planning and scheduling’ (cpm or other methods). Detail about the resources, i.e., money, manpower, material and machinery required are also known.

18.2 Reducing Calculations

In order to save the time and labour for estimating, there are certain items where detail calculations can be avoided with the help of the calculated items. The quantities of such items are reduced in the following ways:

1) Foundation Concrete = Quantity of earthwork in

$$\frac{\text{Excavation in foundation}}{\text{Depth of excavation}} \times \text{Height of sand filling}$$

2) Sand filling under floors = $\dfrac{\text{Quantity of earth filling in plinth}}{\text{Height of earth filling}} \times \text{Height of sand filling}$

Similarly, the quantity of lime concrete under floors can be calculated:

3) Inside white washing, quantity is equal to the inside plastering.
4) Outside colour washing. Quantity is equal to the outside plastering or painting.

18.3 Deduction for Openings

Deduction on account of openings is given below:

Deduction for openings in masonry.

1) Rectangular openings: Doors, Window and ventilators.
   Quantity to be deducted = h (m) x b (m) x Thickness of wall (m)
   = …. m^3 (see Figure 18.1)

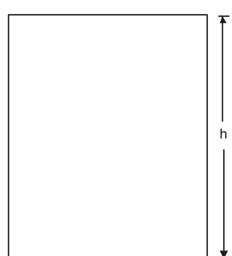


Fig. 18.1

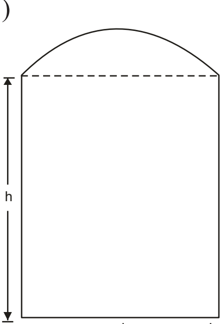


Fig. 18.2

2) Doors and windows with small segmental arches: Quantities to be deducted = h (m) x b (m) x Thickness of wall (m) = …. m^3
   Segmental portion is considered as solid to cover the additional expenses in the arch masonry (see Figure 18.2).
3) Segmental arch openings:
   R is the rise
   Area of semi-circular portion = ¾ x b x 4
   Quantity to be deducted:
   = h x b x Thickness of wall + ¾ x b x R x Thickness of wall
   = {h x b + (3/4 x b x R) } x Thickness of wall (see Figure 18.3).
4) Semi-circular arch openings:
   Quantities to be deducted = (Area of Rectangle of Area of Semi-circle)
   x Thickness of wall
   = $\{(b \times h) + \pi (b/2)^2 \times ½\}$ x Thickness of wall
   = $\{(b \times h) + \pi (b/2)^2 \times ½\}$ x Thickness of wall (See Figure 18.4)

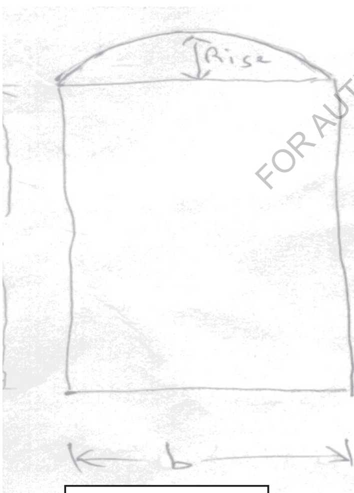


Fig. 18.3

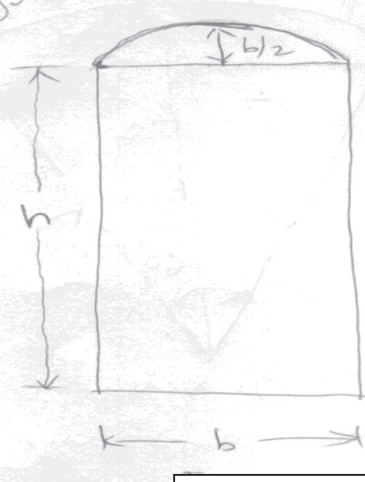


Fig. 18.4

5) Elliptical Openings:

Major axis AC = D

Major axis BD = d; then A = ¼ π Dd = o.7854 Dd

Deduction = <u>AC</u> x <u>BD</u> x π x Thickness of wall = …. m^3 (See Figure 18.5).

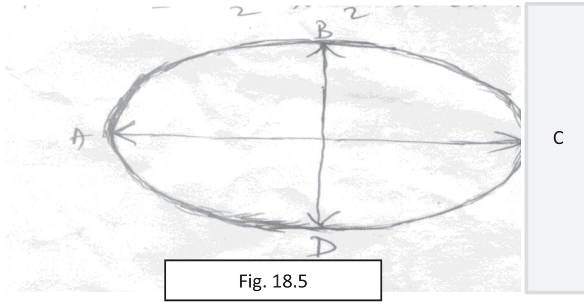


Fig. 18.5

18.4 Masonry Works in Arches

a) Masonry wok in the arch:

= mean length (cm) x Thickness of arch (t) x Thickness of wall

= …. m^3 (See Figure 18.6)

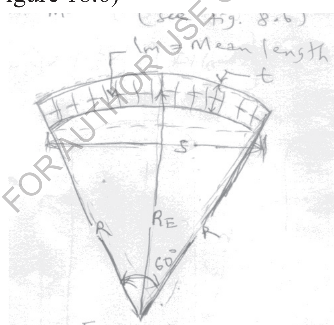


Fig. 8.6

b) Arch over doors and windows is generally segmental with angle of 60° at the centre arch forms an equilateral triangle, with two radii and span as its sides.

Lm = Mean Length of the Arch

Rm = Mean Radius

S = Span

R = Radius

R = S

And Rm = R + $\frac{t}{2}$

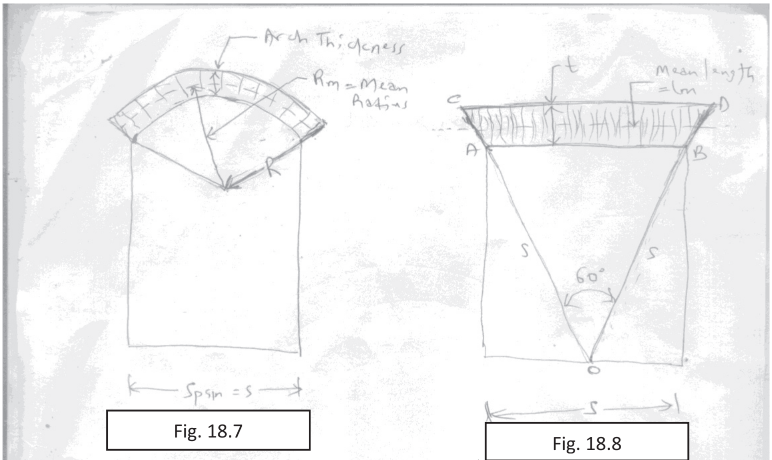


Fig. 18.7

Fig. 18.8

$$\therefore \frac{Lm}{\text{Circumference (mean)}} = \frac{60^o}{360^o} = \frac{1}{6}$$

Lm = 1/6 x 2π Rm = 1/6 x π x diameter (Mean Arch)

quantity of masonry = Lm x breadth of wall x Thickness of arch

= Lm x Breadth of wall x t

Doors, windows and ventilators have lintels. The length of ventilator or door plus bearing on each end, which is generally from 10 – 15cm.

Quantity of lintel = Length x Thickness of lintel x Thickness of wall

= …. m^3 (see Figure 18.7)

c) Flat arches:

Flat arch subtends an angle of 60° at the centre

OA = AB = OB = 5

OAB and OCD are two equilateral triangles.

Lm (Mean Length) = s + t/2

Quantity = Lm x b x t = (s + t/2) x b x t

CHAPTER NINETEEN

PRO-RATA RATE

19.1 Introduction

Pro-rata rates are sometimes referred to as analogous rates. In contract administration; especially at final account stage, there exist a number of items, which vary from the finished work as per the hills. The items, which vary from the finished work as per the bills. The items which differ only in output or quality of materials, are usually related to contract rates on a pro-rata basis.

Basically, unit rate comprises elements of labour, materials, plant and profit/overhead and these are not readily adjustable by simple proportionate methods. However, there exist about three main methods of assessing pro-rata rates and the reliability of any of the methods is function of skill and experience of the quantity surveyor.

19.2 Methods of Assessing Pro-Rata Rates

The following are the basic methods of assessing pro-rata rates:

1) **By Definition**:
   This method involves the derivation from two or more similar unit rates. This is simple and straight forward method of obtaining a pro-rata rate.
2) **By Analogy**:
   This method is fundamentally based on the quantity surveyor's knowledge of pricing and building operations. It sometimes involves the discovery of items of different description; or even trades, which are related and equivalent in labour, or even labour and material to the item for which a unit rate sought.
   For instance, rates for roof members of different description of treated hardwood to that given may be required. On investigation, it may be found that the cost of raw materials remains the same including the degree of workability. It follows that the consensus will be that no variation in rates exists.
3) **By Reconciliation of Analysis:**
   The reconciliation approach is by far the most frequent in use and easily acceptable. This method perhaps considers the current market prices of materials and agreed measured quantities. Also considered are wages, insurance, etc. the only variables as per the contract bills are the labour outputs and perhaps the profit/overhead mark

up. However, the mark-up is relatively easily taken care of thereby leaving the labour item as the crux of the matter.

<u>Example 19.1</u>:

Prepare and apply two coats of approved quantity emulsion paint on a given area of 668m2 rendered wall (Bill) rate: ₦168.13/m^2)

<u>Solution</u>:

<u>Breakdown of Bill Rate</u>:

* Bills rate---------------------------------- = ₦168.13

<u>Deduct</u>:

25%for profit & overhead (gross)

To drive at het,1/6th of ₦ 168.13 is deducted

Thus: 1/6th =16.66%   17%

⇒17% of ₦ 168.13---------------------------------- = <u>₦28.58</u>

Net cost of labour and material = ₦ <u>139.55</u>

<u>Material</u>:

(1) <u>Paint</u>

(a) First cost = 13ltr/m^2

(b) Second cost = <u>18ltr/m^2</u>

<u>31ltr/2m^2</u>

Therefore; quantity of paint = 31 litres per 2 metres square

Hence; 2 coat painting = $\frac{668 \times 2 \times 2}{31}$ = 86.19litres

= <u>4.31litres</u>

Add 5% waste = <u>90.50 litres</u>

Cost = $\frac{90.50}{200} \times \frac{6000.00}{1}$ = 27,150.00

<u>N.B</u>: 20 litres drum = N6,000

(2) Brush

If 13 Nr. 100mm size was used, therefore:

Cost of brush = N13 x N150 = N1,950.00

Labour:

Considering total man-days as 38.17 @ N1,591.52, therefore:

Labour cost = 38.17 x =N=1,591.52 = =N=60,748.32

Summary:

Material:

Paint = =N=27,150.00

Brush = =N= 1,950.00

=N=29,100.00

Cost/m^2 = =N=29,100.00 / 668 = =N=43.56

Cost/m^2 of labour = =N=(139.55 – 43.56) = =N=95.99

Example 19.2:

Prepare and apply two costs of approved quality textcote paint on a given area of 668m^2 rendered wall.

Solution:

Build-up of Unit Rate:

Material:

(1) Paint

(a) First coat 8 litres

(b) Second coat 5.5 litres

13.5litres/2m^2

Therefore; 2 coats painting involves = $\frac{668 \times 2 \times 2}{13.5}$ = 197.93 litres

Add: 5% waste - - - - = 9.89 litres

207.82 litres

If cost of 20 litres (drum) = =N=8,500.00, therefore:

267.82 litres will cost: $\frac{N8,500 \times 207.82}{20}$ = =N=88,323.50

Cost/m^2 = =N=$\frac{88,323.50}{668}$ = =N= 132.22

(2) Brush

Take 1 roller brush to cover 150m^2

668m^2 will require $\frac{668}{150}$ = 4.45 ≅ 5 brushes

If a roller costs =N=300.00, therefore:

5 Roller will cost 5 x =N=300.00 = =N=1,500 .00

Cost/m^2 = $\frac{1,500}{668}$ = =N=2.25

<u>Labour</u>:

(a) First coat 16 man-hours per 50m^2

(b) Second coat 14 man-hours per <u>50m^2</u>

∴ 668m^2 will require $\frac{30}{100}$ x $\frac{668}{1}$ = 200.4 hours

1m^2 will require $\frac{200.4}{668}$ = 0.33 hours

Therefore, cost/m^2 = 0.30 x 198.94 = =N=59.68

<u>Summary</u>

Material: - - - - -	N132.22
	N 2.25
Labour - - - - - -	<u>N 59.68</u>
	N194.15
<u>Add</u>: 5% profit % overhead - -	<u>N 48.54</u>
	<u>N242.69</u>
Pro –rata =	N242.69 per m^2

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