International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 2 Feb 2021, pp: 184-189 www.ijaem.net ISSN: 2395-5252

Bill of Engineering Measurement and Evaluation (Beme); a Case Study of Critical Components of a Box Culvert Constructed Across Asphalt Pavent Highway

Engr. Akwenuke O. Moses
B. Engineering (Civil), M.Sc. Ph. D, FNSE, FNICE, FNEE, COREN

Submitted: 02-02-2021 Revised: 15-02-2021 Accepted: 18-02-2021

ABSTRACT: A bill of engineering measurement and evaluation list the total material quantities needed to complete a civil engineering project. In this presentation, the project is a box culvert. At the end, a near total cost of constructing the culvert will be known in a summary table that will display all quantities of each item of activities, unit measurement, rate. For accuracy, a market survey for on-going present rates of material within the project location must be carried out.

Keywords: Bill, measurement, Evaluation, units, Quantities, Asphalt, concrete, Reinforcement, timber, granite, cement, BEME format, Box culvert, highyield steel, wall, apron, material quantities, grand total, highway, rates, pricing, standard methods of measurement, code of practice, milestone phase, activities, market survey, first principle.

I. INTRODUCTION

The BEME which can also be referred to as the bill, is a measurement and evaluation tool which is used as means of assessing and valueing the cost of construction project/works and comprising of the works' materials, equipments, labour and any other resource needed for the satisfactory completion of the works unlike the BOQ which is usually for building projects such as residential, schools, recreational buildings, hospitals and industrial building works. The BEME is basically an evaluation tool for civil engineering works like roads, retaining walls, drainages, bridges, culverts, dams and railways amongst others.

II. OBJECTIVE AND PURPOSE

i) Purpose

The purpose for BEME preparation is to provide the quantities of the work items for pricing to make available a priced bill to be used for evaluation of work executed routinely or periodically for the purpose of control of the project and as a guard for preparing interim and final payment certificates during work-in progress and at completion of project. It also serves the purpose dispute settlement document regarding compensation.

ii) Objectives

a) It provides rates and prices that enable negotiation for variation and extra work executed
b) It enables comparison of pricing of vendors during tendering process.
c) It gives an idea of the cost of the project.
d) Provides information for planning as it involves available budget.
e) To determine if cost is to be reviewed to accommodate available fund.
f) To achieve the purpose and objective of BEME, the activities are broken in milestones or phases and in each miles stone the activities are itemized.

Measurement and estimation

This is the taking off process in which the items or activities of works are identified and measured which are later priced.

a) Standard method of measurement.

This usually varies from region to region depending on the region code of practice. During this stage, the elements of work are identified and then broken into activities and separately measured and then describe with expression of the units of the quantities of each of the items. The usefulness of the standard method of measurements includes:

i) It provides very comprehensive detailed guidelines for the measurement of the works.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 2 Feb 2021, pp: 184-189 www.ijaem.net ISSN: 2395-5252

ii) As a result, reduces the possibility of measurement related disputes before and during construction stages.
iii) It contains a comprehensive list of work activity items.
iv) It provide uniform competitive platform for the bidders
v) Reduces pricing risks for the bidders.

b) Estimating and Evaluation

After the taking-off process in which measurement of the works items are now known, estimating and evaluation begins with the known measurement and the known rates. At this stage, the drawings must be well understood; calculation of the quantities must be accurate. The format must be develop into milestone or phrase. Each phase must define the quantity of material item. Then it is important to carefully check for omissions and possible errors before putting the estimated quantities in BEME format table which must include the item description, quantity, unit, rate and sometime labour and then amount.

The presentation format

There is usually a professionally acceptable format for BEME presentation but depending on the purpose. The presentation format for BEME comes in tabular form just like it is for BOQ. Depending on the engineer, the BEME table could depict the units either in volume, area, kilogram, bag; length, number etc which depend on whether the BEME is of a material quantity or the conventional bill of quantity format. The following table explains this better.

Table 1: Format for BEME in conventional units

Item	Description	Qty	Unit	Rate	Amount	
					₦	K
	The activity		M^3 M^2 K			

Table 2: format for BEME in material quantity presentation.

Item	Description	Qty	Unit	Rate	Amount	
					₦	K
	Understanding the activity	As required from site for example: how many bags of cement, trip of sand , trip of granite etc	Bag, length, trip, etc	Amt per material in specific of number of items		

Table 3: The BEME bill format that includes labour cost.

Material					Labour + Miscelleaous				Total	Re ma rk
Item	Description	Qty	Unit	Amount	Qty	Unit	Rate	Amount		

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 2 Feb 2021, pp: 184-189 www.ijaem.net ISSN: 2395-5252

Table 4: Whether conventional or any other innovative format, the BEME table may also include the calculation or take-off column.

Item	Taking-off using results from scoping	Description	Qty	Unit	Rate	Amount	
						₦	K
	e.g vol. = bxlxh No. of bars = $\frac{l}{\text{spacing}} + 1$						

Market survey for rate fixing

This should be done within the location that the project is located. For the purpose of this presentation's case study, the survey should be on ongoing rate of reinforcement, cement, granite, timber for formwork, asphalt, concrete cast rate per cubic metre of concrete, iron bending works rate, carpentry work rate amongst others.

BEME Estimation from first principle standards

Estimating from first principles becomes very important when the site engineer is asked to sumbit material quantities for the project. If our case study is the BEME of the critical components of a culvert (top slab, bottom slab side walls and the asphalting of the top floor), then other than the usual computation for concrete in cubic metres, reinforcement in kg/m, asphalt in square meter, and timber works in areas, the client is more interested in specific numbers, such as; how many bags of cement, how many lengths of reinforcement and their sizes, how many trips of granite, sand and asphalt. Hence it is important to begin with the first principle approach.

Cement, Sand and Granite

i) We will assume that a concrete mixer has the capacity of producing 1m^3 of concrete per batch, let us also consider a general mix ratio of 1:2:4 concrete. If we as well assumed a shrinkage value of 25% when cement has its contact with water, then the volume of concrete produced from the concrete mixer of 1m^3 volume now becomes 1.25m^3. Hence the proportion dividend of each material in the concrete now becomes

$\frac{1.25}{7}$ (1): $\frac{1.25}{7}$ (2) $\frac{1.25}{7}$ (4)

ii) Let us now consider a mix proportion measuring box device (which is equivalent to 1 bag of cement) when batching by volume and whose volume is 300 x 350 x 350mm (say 0.037m^3), this being so therefore, the quantity of cement in bags per cubic meter of concrete in our mixture now becomes:

iii) $\frac{1.25}{7\text{x}0.037}$ (1) bags of cement

$\left[\frac{1.25}{7\text{x}0.037} + \frac{20}{100}\left(\frac{1.25}{7\text{x}0037}\right)\right]1$: $\left[\frac{1.25}{7} +\right.$ 201001.2572: 1.257+201001.2574

$= 5.791$ bags: 0.43m^3(sand): 0.86m^3(granit

Water

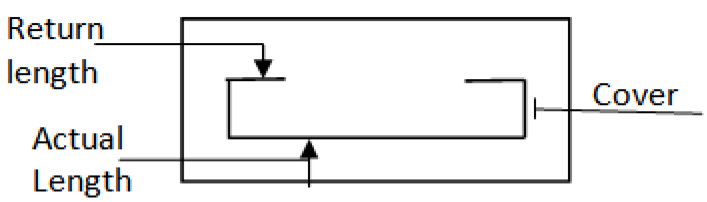
Therefore, one complete mixture of concrete with 6 bags of cement weighing 50kg each, will have a total weight of 50 x6 = 300kg. Assuming the water cement ratio to be 40% and assuming also that the aggregates are free from moisture content, the amount of water to mixing a 1:2:4 mixture segregation will therefore be 300 x 4.0 litres and this will give $\frac{300 \text{ x } 0.4}{4.546}$ gallons of water (that is 26.4 gallons). Approve the use of 25 gallons on the day it rained.

Reinforcement

i) **Computing a Length of Reinforcement**

a) Number of bar = $\frac{\text{lenght}}{\text{spacing of bars}} + 1$

b) Bar length = actual length – 2 (cover) + 2 (return length)



c) Total length = number of bars x bar length

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 2 Feb 2021, pp: 184-189 www.ijaem.net ISSN: 2395-5252

d) Cost of bar = $\left(\frac{\text{total length}}{11.5\text{m}} + \right.$
1 x amount per piece of Ymm bar

ii) **Computing weight of reinforcement steel per metre length**

Weight of reinforcement steel per metre of steel is usually derived from first principal as explained below:

Let M & A (directly proportional)

So that M = kA - - - - - - (1)

Where M =Mass of steel

A =area of steel

K =a constant to be computed for

Take a 12mmθ reinforcement bar whose known standard weight is 0.88kg/m

From equation (1) above:

$0.888 = k \times \pi r^2$

$= k \times \pi 6^2$

So $k => 0.888/\pi r6^2 = 0.00785$

Therefore for any bar of known size, its weight or total length can be computed. For example, for a reinforcement bar of 25mmθ, its weight per metre length becomes.

$0.00785 \times \pi r^2 = 3.855$kg/m

And its total weight for one full length will

3.855 x 9m for a mild steel

= 34.7kg

and 3.855 x 12m for a high yield steel

=46.26kg

1.1 Asphalt

Depending on the thickness spenfied, if we know the square are of the road that will be covered by 1 ton of asphalt then we can compute the total quantity of asphalt needed for 1 ton of asphalt equivalent to $0.44m^3$

Table 5: Therefore is a guide

Table: Asphalt coverage per square metre of Road

Asphalt	Thickness	Area of road to be covered 95 m^2
	12.7mm	
	25.4mm	$48m^2$
	50.8mm	$12m^2$
	101.6mm	$12m^2$
Note: $5m^3$ tipper = 11.4 ton		

Timber for formworks

i) Total area to be covered is computed and then divided by the area of one number plank timber in the dimension available to get the required total number.

ii) Number of bracing timber is/are depended on the total number of plan timber

Critical components of culvert construction as a case study

Let us consider a culvert across a highway road whose dimensions are as indicated in figure 1

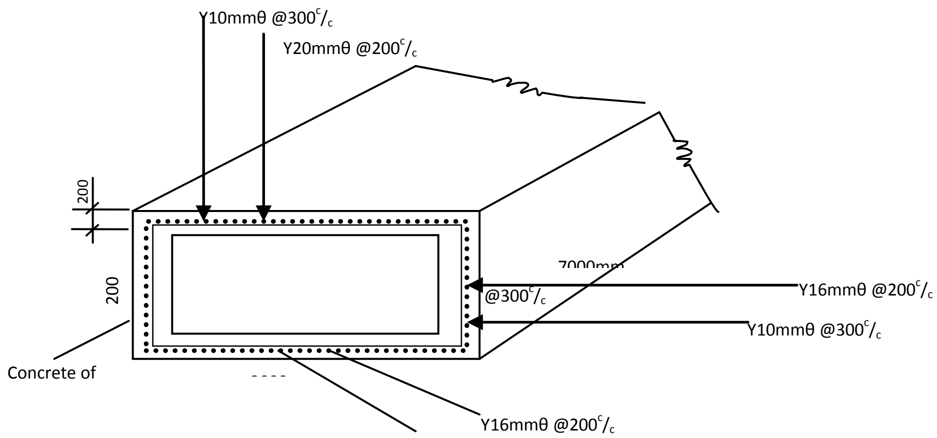


Figure 1: Box culvert as a case study for the preparative of bill of engineering measurement and evaluation.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 2 Feb 2021, pp: 184-189 www.ijaem.net ISSN: 2395-5252

Table 6: Bill of Engineering Measurement and Evaluation (BEME): a case study of critical component of a box culvert constant construct across an asphalt pavent highway

Item	Taking off	Description	Qty	Unit	Rate	Amount ₦	Amount K	Remark
1.		Clear site of all unsuftable materials and cartaway including removal of all stamps						
2.		Add any other preliminaries						
3.		Excavation for foundation to receive culvert walls u to 2.4m depth as re drawing including shorting application						
4.	3.4x7=24 2x2x7=28 52m2	Provide form work	52	M^2				
5.	7x3.6x0.05 = 14m3	Provide concrete grade 15(1:3:6) 50mm thick blinding to receive bottom slab	1.4	M^3				
6.	2(3.4+2)2 =10.8 = 10.8 x 6.2x7 15.12m3	Provide and place concrete grade 25(1:2:4) in box culvert	15.2	M^3				
7.	(7/12 + 1) x (3+2)17 lengths 2.47x12 x17 = 504kg	Provide 20mm diameter high yield steel for top slap of culvert	504	Kg				
8.	(1+1) x (2.4 +1) = 23 lengths hence = 23x2.47 x 12 = 682kg	Provide 20mmø for bottom slab of culvert	682	Kg				
9.	(7/2+1) x (3+2) 11= 17 1.58 x 12x17 =	provide 12mm for bottom slab of culvert	323	Kg				
10.	(03/0/3 + 1) (7+4) +2 (2/1/3+1) x 7 ÷11 + (3/0.3+1) x (3+2) ÷ 11 = 40 x12 x 0.62	Provide 10mm ø distribution for all sides of culvert	298	Kg				
11.	7-1.5+1.5 x 2.4	Provide and lay 50.4mm thick asphalt on reinforced concrete finished top slap of culvert	17	M^2				
12.		Add contingencies say (5%)						
Grand total								

III. SUMMARY AND CONCLUSION

Table 7: Bill of Engineering Measurement and Evaluation (BEME): a case study of critical component of a box culvert constant construct across an asphalt pavent highway

Item	Description		Qty	Unit	Rate	Amount ₦	Amount K	Remark
1.	Clear site of all unsuftable materials and cartaway including removal of all stamps			Lumpsum		20,000		
2.	Add any other preliminaries			Lumpsum		380,000		
3.	Excavation for foundation to receive culvert walls u to 2.4m depth as re drawing including shorting application			Lumpsum		100,000		
4.	Provide form work		52	M^2	1,200	62,000		
5.	Provide concrete grade 15(1:3:6) 50mm thick blinding to receive bottom slab		1.4	M^3	30,000	42,000		
6.	Provide and place concrete grade 25(1:2:4) in box culvert		15.2	M^3	40,000	104,800		
7.	Provide 20mm diameter high yield steel for top slap of culvert		504	Kg	185	93,240		
8.	Provide 20mmø for bottom slab of culvert		682	Kg	185	126,170		
9.	provide 12mm for bottom slab of culvert		323	Kg	185	59,755		
10.	Provide 10mm ø distribution for all sides of culvert		298	Kg	185	55,130		
11.	Provide and lay 50.4mm thick asphalt on reinforced concrete finished top slap of culvert		17	M2	852	14,501		
	Total				77719	1,554,389		
12.		Add contingencies say (5%)						
Grand Total						**1,632,108**		

International Journal of Advances in Engineering and Management
ISSN: 2395-5252

IJAEM

Volume: 03 Issue: 02 DOI: 10.35629/5252

www.ijaem.net

Email id: ijaem.paper@gmail.com