ISSN No:-2456-2165

Development of Computer Aided Model for Digital Estimation of Building Materials and Civil Engineering Quantities

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Abstract:- Over the years, there have been ineffective and inaccurate results being noticed to have been gotten over time when bill of civil and engineering quantities are computed manually. However, with the aid of a developed software package in calculating the bill of quantities, effective and efficient results would be gotten. From the foregoing this study aims at developing a computer aided model to digitally compute building and civil engineering quantities using C# programming language. The approach used in this study is developing the digital computation program and testing the computational program using the manual taking off from both residential building and road plans to validate the software. The results obtained from this study indicate that, with reference to the residential building plan, 100% of the substructure items found in the bill fall within 0 to 0.05 percentage difference and 75% of the superstructure items have 0 to 0.4 percentage differences. In road plan, 100% of the items in site clearing and earthworks (Bill no. 2) have 0 percentage differences, while 86% of the items in bill no. 3 (drainage and culverts) have 0 percentage differences. All items in bill no.4 (Pavement and surfacing) have 0 percentage differences between the manual and digital computation. Since there are little or no difference in the result obtained from manual computation and digital computation. Therefore, the developed digital computation program is efficient and reliable and can be used in lieu of the manual estimation.

I. INTRODUCTION

The recent development in the computer field, and the evolution of powerful and affordable microcomputers which now out-perform old minicomputers have created great potential for their use in the building and civil engineering industries. Computing is a very essential application in our day-to-day activity. Also, computing has come a long way in enhancing excellent results in engineering applications. Introducing the concept of computing to all professions has been a tremendous step in ensuring effective output/results for every input. In addition, the proliferation of construction related software has resulted in the development of more efficient decision support systems for the management of both the construction company and its construction sites.

Estimating of quantities and cost in building and civil engineering works is a very complex task to undergo, because it requires a careful and full understanding of the construction methods and construction materials to get a reasonable forecast due to the uncertainty in the price of item to be used for a construction project as a result of environmental change, change in political environment, price trend as well as change in technological demand of goods and services, estimating of quantities and cost of construction work as proven to be very complex, full of errors and time consuming (Oluyemi, 2016). These days, Information and Communication Technology (ICT) is responsible for the entire construction process from information being generated, transmitted and interpreted to enabling the project to be built, maintained and eventually recycled (Ikechukwu *et al*.,2011). Although communication is an essential value in construction projects, the construction industry is confronted with the importance and use of information and communication technology (ICT). As most firms in developed countries have increased and will increase further their investment in ICT, this has raised productivity within their construction industry and resulted in an increase in the quality and speed of work, financial controls, communications, and access to common data. Firms in the third world countries are yet to understand this essential value and its importance to the development of their construction sector (Ikechukwu *et al*., 2011).

This study aims to develop application software by using C# programming language for the measurement and quantification of building and civil engineering works by validating the software and comparing the results with manual computation.

II. AIM AND OBJECTIVES

The aim of this research is to develop application software for the measurement and quantification of building and civil engineering works.

The objectives are to:

- review the concept of quantity estimation.
- develop application software using Microsoft Visual SEE-SHARP (C#) programming language for digital computation and
- evaluate the software for suitability, reliability and recommend accordingly.

ISSN No:-2456-2165

III. MATERIALS AND METHODS

➢ *Materials Used*

In the course of this research, the materials used are:

- Microsoft Visual C# software.
- Building plan and construction processes.
- Road plan and construction processes.

➢ *Methods*

The method adopted in the development of the software can be divided basically into two:

- developing the digital computation program and
- testing the computational program

➢ *Bill Of Quantities*

A bill of quantities (sometimes referred to as a 'BoQ' or 'BQ') is a document, typically prepared by a cost consultant (often a quantity surveyor) that provides measured quantities of the items of work identified by the drawings and specifications in the tender documentation for a project. It is issued to tenderers for them to prepare a price for carrying out the works.

Manual estimating can be an inefficient use of time, and so cost consultants often use BoQ software packages to make the process easier and to reduce errors. Databases may already exist providing design information from a building model, and specifications, and so quantities can be calculated and tender documents generated. During the design process, new measurements can be filed and included, with the result that every item, as well as the totals, is updated automatically.

Elbetalgi (2014) indicated that the objective of preparing the Bill of Quantities is to assist estimators to produce an accurate tender efficiently and to assist the post contract administration to be carried out in an efficient and cost-effective manner. It should be noted that the quality of the drawings plays a major part in achieving theses aims by enabling the taker-off to produce an accurate bill and also by allowing the estimator to make sound engineering judgments on methods of working.

➢ *Cost Estimate*

Cost estimating is a fundamental ingredient for budgeting and preparation of bid for any construction project. A good estimate depends on many factors including time given to the estimator, estimator's experience, and a wide range of assumptions regarding the project. Construction cost estimating involves collecting, assaying, and recapitulating all available data for a construction project.

A construction cost estimate is a vaticination of the total cost of a construction project. It is the estimator's responsibility to help the owner of the project to plan and budget for the construction of the project.

➢ *Odays Technologies Associated For Detailed Cost Estimate*

As one can see, detailed cost estimating is a clumsy process that involves a lot of data and calculations. Today's estimating technologies include, but are not limited to, spreadsheets, cost estimating software, digitizing tablets, on-screen digitizing systems, and the yet to be matured 3-D CAD parametric estimating software (Samphaongoen, 2010).

➢ *Programming Language*

Coded language used by programmers to write instructions that a computer can understand to do what the programmer (or the computer user) wants. The most basic (called low-level) computer language is the machine language that uses binary („1" and „10") code which a computer can run (execute) very fast without using any translator or interpreter program, but its tedious and complex. The high level languages (such as basic, c, java) are much simpler (more English like) to use but need to use another program (a complier or an interpreter) to convert the high-level code into the machine code, and are therefore slower.

There are dozens of programming languages and new ones are being continuously developed (programming language, 2016). Also called computer language, the computer language used in this project is a C# programming language.

ISSN No:-2456-2165

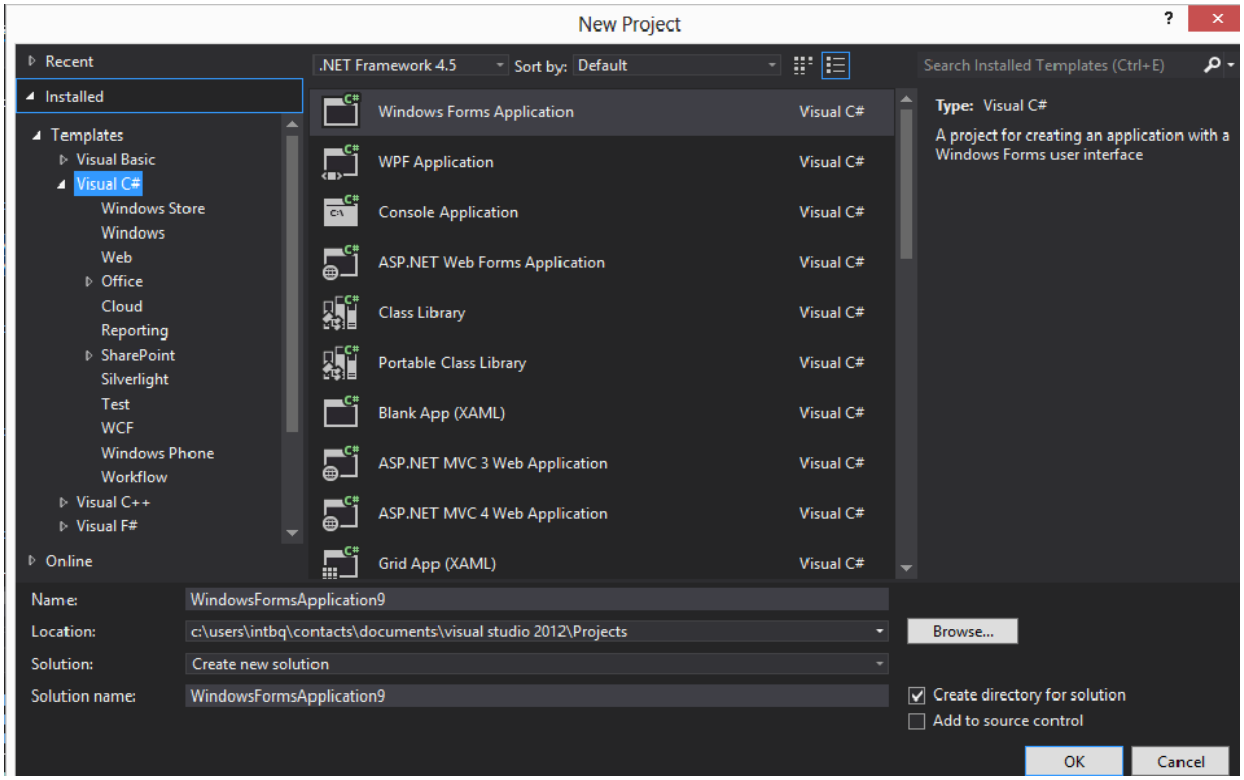

Fig 1: An excerpt of the graphical interface in C# environment

Fig 2: Computerized design of digital computation

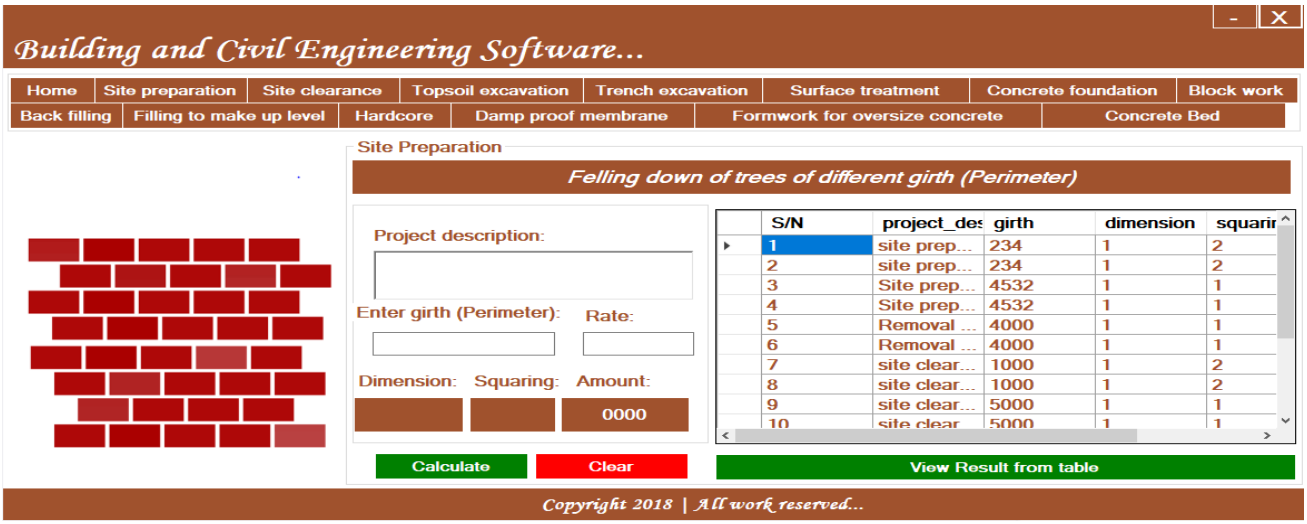

Fig 3: Computerized design for checks

ISSN No:-2456-2165

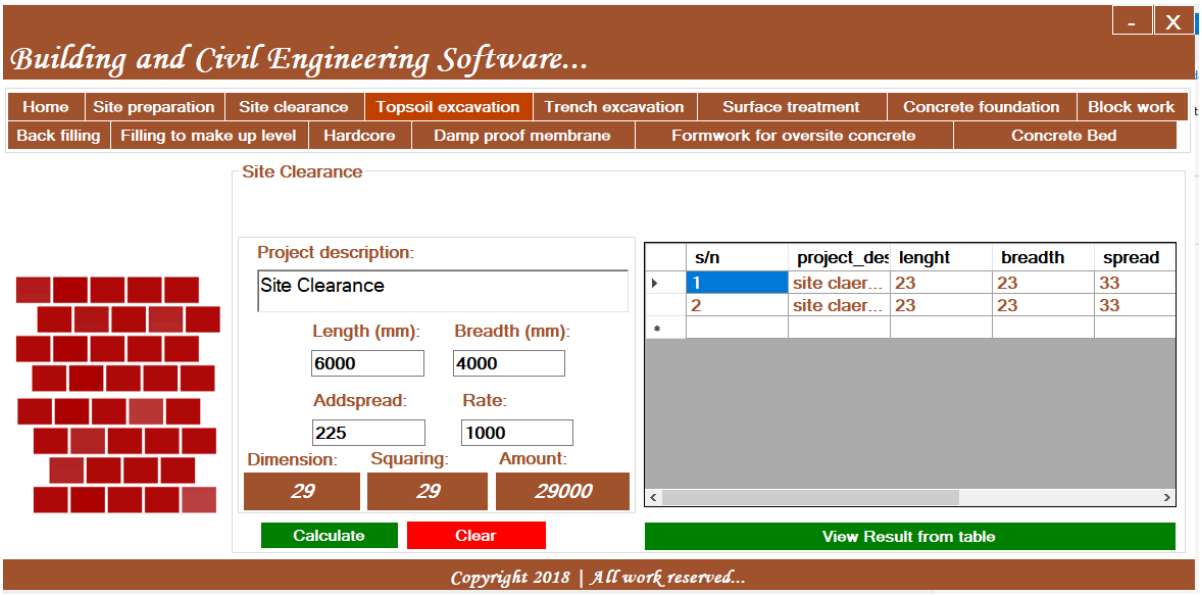

Fig 4: Validated output for checks

➢ *Application Flow Chart*

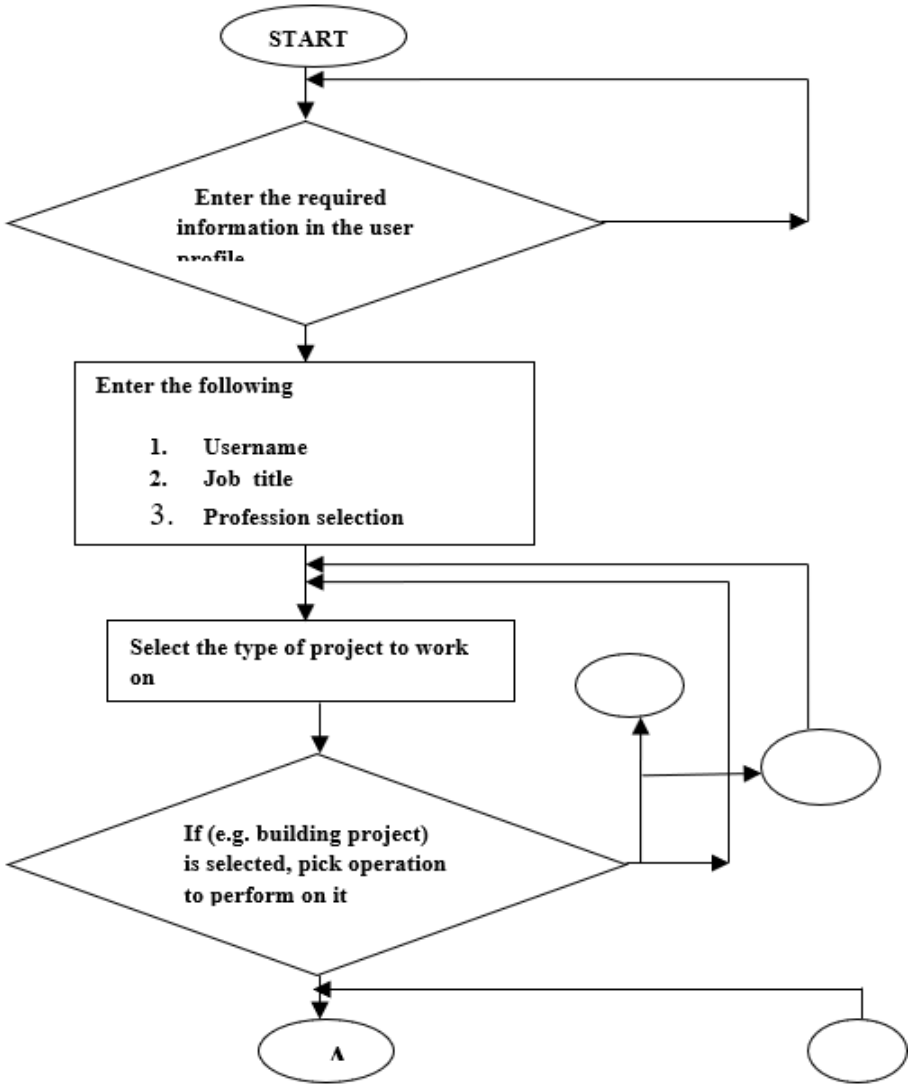

Fig 5: A Flow Chart Diagram Illustrating step by step process of the Building Program

ISSN No:-2456-2165

IV. RESULTS AND DISCUSSION

The methodology adopted in accomplishing the aim of this project involves two steps; developing and validating the computational program. The process of validating the computational program in order to measure the efficiency of the digital estimation of building materials and civil engineering quantities followed the same style and procedure normally used in a manual calculation. With this package, one can slot in any value provided the value falls within the validity of the model of the program. The result obtained from the implementation of this study is the development of a rational procedure for the estimation of building materials and civil engineering quantities to ease the rigor of quantity estimation. In the course of execution of the computer program, ease-of use and flexibility was a major consideration.

The developed program was validated using a proposed residential development at Sunshine estate, Oba Ile, Akure, Ondo State and an assumed road plan. The table 1 below shows the draft billing obtained from the manual computation of the proposed building while table 2 shows the draft billing obtained from the digital computation of the proposed building.

Table 1: Draft Bill Obtained From the Manual Computation of the Proposed Building

SUBSTRUCTURE

ITEM	DESCRIPTION	QUANTITY	UNIT
A	Site Clearing	229.00	m^2
B	Top Soil Removal	183.30	m^2
C	Trench Excavation	88.20	m^3
D	Level and Ram	73.49	m^2
E	Foundation Blinding	73.49	m^2
F	Foundation Concrete	16.91	m^2
G	Foundation Block work	129.70	m^2
H	Backfilling	49.72	m^3
I	Cart away	79.98	m^3
J	Laterite Filling	43.35	m^3
K	Hardcore	43.35	m
L	DPM and BRC Mesh	73.50	m^2
M	Formwork for Oversite	54.00	m^2
N	Concrete Slab	25.60	m^3

SUPERSTRUCTURE

ITEM	DESCRIPTION	QUANTITY	UNIT
A	Block wall	225.00	m^2
B	Lintel Concrete	2.25	m^3
C	Formwork for Lintel	9.94	kg
D	Reinforcement	388.40	kg

Table 2: Draft Bill Obtained from the Digital Computation of the Proposed Building

SUBSTRUCTURE

ITEM	DESCRIPTION	QUANTITY	UNIT
A	Site Clearing	229.00	m^2
B	Top Soil Removal	183.30	m^2
C	Trench Excavation	88.00	m^3
D	Level and Ram	73.40	m^2
E	Foundation Blinding	73.40	m^2
F	Foundation Concrete	73.40	m^2
G	Foundation Block Wall	129.70	m^2
H	Backfilling	50.00	m^3
I	Cart away	79.98	m^3
J	Laterite Filling	43.35	m^3
K	Hardcore	43.35	m
L	DPM and BRC Mesh	73.50	m^2
M	Formwork for Oversite	54.00	m^2
N	Concrete Slab	26.00	m^3

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SUPERSTRUCTURE

ITEM	DESCRIPTION	QUANTITY	UNIT
A	Block wall	225.00	m^2
B	Lintel Concrete	2.20	m^3
C	Formwork for Lintel	9.90	Kg
D	Reinforcement	388.40	Kg

Table 3: Comparison of Draft Bill Results for the Proposed 3-bedroom flat at Oba Ile, Akure, Ondo State.

SUBSTRUCTURE

ITEM	DESCRIPTION	MANUAL COMPUTATION QANTITY/UNIT	DIGITAL COMPUTATION QUANTITY/UNIT	DIFFERENCE	% DIFFERENCE
A	Site Clearing	229.00 m^2	229.00 m^2	0.00	0.00
B	Topsoil Removal	183.30 m^2	183.30 m^2	0.00	0.00
C	Trench Excavation	88.20 m^3	88.22 m^3	0.02	0.02
D	Level and Ram	73.40 m^2	73.40 m^2	0.00	0.00
E	Foundation Blinding	73.40 m^2	73.40 m^2	0.00	0.00
F	Foundation Concrete	73.40 m^2	73.40 m^2	0.00	0.00
G	Foundation Block work	129.70 m^2	129.70 m^2	0.00	0.00
H	Backfilling	49.72 m^3	49.73 m^3	0.01	0.02
I	Cart away	79.98 m^3	79.98 m^3	0.00	0.00
J	Laterite Filling	43.35 m^3	43.35 m^3	0.00	0.00
K	Hardcore	43.35 m	43.35 m	0.00	0.00
L	DPM and BRC Mesh	73.50 m^2	73.50 m^2	0.00	0.00
M	Formwork for Oversite	54.00 m^2	54.00 m^2	0.00	0.00
N	Concrete Slab	25.60 m^3	25.60 m^3	0.00	0.00

SUPERSTRUCTURE

ITEM	DESCRIPTION	MANUAL COMPUTATION QUANTITY/UNIT	DIGITAL COMPUTATION QUANTITY/UNIT	DIFFERENCE	% DIFFERENCE
A	Block wall	225.00 m^2	225.00 m^2	0.00	0.00
B	Concrete in Lintel	2.25 m^3	2.20 m^3	0.05	2.27
C	Formwork for Lintel	9.94 kg	9.90 kg	0.04	0.40
D	Reinforcement (12mm)	388.40 kg	388.40 kg	0.00	0.00

The result shown in table 3 can be summarized as follows;

Substructure- 100% of the 14 items found in this bill fall within 0 to 0.05 percentage difference.

Superstructure- 75% of the items has 0 to 0.4 percentage difference. From the summary above, the result shows that there are little or no difference in the final outputs of the quantities obtained through the manual computation and the digital computation for the project. Therefore, the developed digital estimation program can be said to be efficient and accurate in its final outputs and can be used in place of manual computation with its other advantages.

V. CONCLUSION AND RECOMMENDATION

The development of the software was achieved using a combination of good programming Microsoft visual C SHARP (C# version 2012) and Microsoft visual studio Environment (version 2012), which allows an artistic application to be created, visually appealing and dynamically interactive. The application has the capability to accept, run, perform, execute and give the final answers to numerical iteration method adopted, thereby computing quantities and costs.

The results obtained indicate that substructure has 100% of the 14 items found in this bill falls within 0 to 0.05 percentage difference, Superstructure 75% of the items have 0 to 0.4 percentage difference. Also, from Bill no.2, site clearing and earthworks, 100 percent of the items in this bill have 0 percentage difference, Bill no.3 drainage, 86% of the items in this bill has 0 percentage difference and 14% has 1.354 percentage differences in it.

Therefore, it is recommended to use the application software developed using a combination of Microsoft visual C SHARP (C# version 2012) and Microsoft visual studio Environment (version 2012) as it is proven to have the following:

- The developed program will solve the problem of fatigue and limit potential errors in quantity estimation and bill preparation as well as reduce the time consumed.
- The program was designed in such a way that the users

will be guided through the computation stages in a straight forward and understandable manner as it is visually appealing and dynamically interactive.
- Improves the accuracy and reliability of cost estimation.
- Reduces the manual work necessary for preparing an estimate

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