

Development of Digital Computation of Building and Civil Engineering Quantities

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Abstract: *The work of Building and Civil engineering demands a greater knowledge, skill and precision in quantity estimation. The manual method of estimating quantities for building and civil engineering works has posed potential problem areas on work that is undertaken. The low reliability of manual estimation indicates discrepancies in the accuracy of quantities computed manually, hence, the introduction of a digital computation. It is envisaged that this method will greatly reduce the complexities of different aspects when computing quantities for projects, as well as reduce the time to complete the computation and therefore projects can be started earlier. The paper reviewed the procedures involved in the development of a computer program for the digital computation of Building and Civil engineering quantities. The program was developed using Microsoft Visual C SHARP (C#) programming language and Microsoft Visual studio. The steps/procedure used in achieving the development of the computer program was (1) designing the application interface, (2) adding controls to the window and (3) writing codes behind the interface. The digital computation was tested using a proposed Road project and a proposed administrative building and the results showed an average of 100% of the items has 0 to 10 percentage difference for the road and 92% for the building in the final outputs of the quantities obtained through the manual computation and the digital computation and the software could therefore be said to be accurate and reliable.*

Keyword: *Engineering, Estimating, Quantity, Microsoft, C SHARP.*

I. INTRODUCTION

The introduction of the microcomputer brought computing to all professions within the building and civil engineering industry. The cheap personal processing power of the microcomputer has provided the platform for the development of application software packages to meet the needs of the industries (McCaffer and Baldwin, 1991). Hence, the last decade according to Ekwueme (1997) has seen a considerable increase in the use of computers and associated information technology in all areas of the building and civil engineering industry. Although, comparatively fragile, computers have become in a very real sense construction equipment. For instance, in the area of construction management, computers are useful as aids in scheduling, planning and controlling projects of all sizes (O'Leary, 2007). The merits of applying computers in the area of construction management are numerous. Firstly, it can quickly provide vast amounts of information to the planner including large quantities of calculations under various assumptions likely to be encountered, to enable better informed engineering decisions to be made (Puerifoy and Ledbetter, 1985).

Computers are also currently being used by quantity surveyors in the preparation of bills of quantities and project estimate (Seeley, 1998). Civil engineering and Building works demands a greater knowledge, skill and precision in quantity estimation. This is due to the fact that the estimated quantities are major determinant of the estimated cost of a project (Douglas, 1972). The introduction of software usage in building and civil engineering industry has greatly reduced the complexities of different aspects in quantity estimation and valuation, as well as reducing the amount of time necessary to complete the preparation of the Bill of Quantities. Concurrently, this saves time and energy. More complex projects are now easily solved with the use of computers. Some of the available software systems also incorporate the Standard Method of Measurement (SMM) and the Civil Engineering Standard Method of Measurement (CESMM) (Acheny 1999). There are

various methods of data input available. The input method can incorporate traditionally prepared dimensions, suitably coded or the organization can use direct keyboard entry with automatic squaring or a fully integrated digitizer (Seeley, 1993). Most computer aided estimating systems are either based on spread sheets, or estimating packages. Computers equally contribute speed and accuracy which are both readily measured in terms of lower costs and/or better efficiency (Ekwueme, 1997).

Other areas where the application of computers is highly useful in the Building and Civil Engineering industry include: Architectural Design and draughting; Engineering design/detailing; Quantity survey/cost management, contract administration and so on. Architectural design may be aided by using the computer software which includes Computer Aided Designs (CAD) or computer Aided Design and Draughting (CADD). By using these software programs, an optimum solution in the architectural design may be reached since the architect can use the computer to examine a lot of designs before making a final choice (Achenu, 1999). From the foregoing therefore, it could be observed that computer has a wide range of applications in the building and civil engineering industry where it could be used for estimating, controlling, scheduling, procuring and purchasing, quality assurance, administering of contracts as well as improving productivity.

1.1 Aim and Objectives.

The aim is to solve the problem of fatigue and to limit potential errors in quantity estimation and bill preparation.

The objectives are to:

- i review the subject matter of quantity estimation;
- ii use Microsoft Visual C SHARP (C#) programming language for the development of a digital computation software;
- iii test the software on both building and civil engineering works and compare the results with manual computation and
- iv recommend the use of the software if found to be accurate and reliable.

1.2 Justification

The aim of the bill of quantities is to set down the various items of work in a logical sequence and recognized manner, so that they may be readily priced by contractors and provide good basis for tendering. Stark (1983) indicated that actual quantities frequently vary from the estimated quantities listed in the proposal, and because receipts are based upon actual quantities, such variations have an obvious impact on the contractor's cash flow. The manual practice of calculating the bill of quantities begins after the completion of the working drawings and with the preparation of a draft of the general specifications. Manual computation of quantities is a time-consuming task and hence to prepare this tedious task successfully, detailed drawings, explicit general specifications, and a clever estimator are required (Ogunlana 1991). The manual method of estimating quantities for building and civil engineering works has posed potential problem areas on work that is undertaken. The low reliability of manual estimation indicates discrepancies in the accuracy of quantities computed manually.

To produce quantities that are reliable, accurate and less time consuming, the need for digital computation comes into play. The work of quantity estimation requires a lot of precision. This is mainly due to the fact that the final result directly affects the overall approximate cost of work; hence accuracy becomes a critical issue. The development of digital computation will greatly reduce the complexities of different aspects when computing quantities for complex projects, as well as reduce the time necessary to complete the computation and therefore projects can be started earlier. The calculation component in computation programs facilitates the decision making and creative thinking by allowing the estimator to quickly recall and review issues relevant to the task at hand (Kim, 1989). The digital computation will accelerate the work timeframe in quantity computation and ensure accuracy without decreasing the reliability and efficiency of the result (Eben-Saleh and Ravinder, 1998).

II. MATERIALS AND METHODS

The programming language used for the production of the digital computation is the Microsoft Visual C SHARP (C#). Microsoft Visual C# is a premier language for Microsoft Visual Studio.Net Development. A combination of good programming in C# and good use of Microsoft Visual studio allows an artistic application to be created, visually appealing and dynamically interactive. Microsoft C# was chosen for this project mainly because of its advantage of presenting a visually appealing and interactive graphical user interface as well as a powerful language to create code that properly executes the desired tasks when properly programmed.

2.1 Developing The Digital Computation Program

2.1.1 Designing the Graphical interface

The first step that was taken in the development of the computation program was the design of the users interface. Extensible Application Mark up Language (XAML) was used to implement the appearance of the application while code-behind was used to implement its behavior. The graphical interface was created using a windows application WPF in Visual studio. Net.

2.1.2 Adding controls to the Window

The next step that was taken was adding controls to the window. In general, the functionality of a window is expressed by two types of items: controls and menus. It is through these items that a user interacts with the program. The design process started by adding different controls from the toolbox to the application. Windows defines many different types of controls, including pushbuttons, check boxes, radio buttons, and list boxes, to name just a few. Although each type of control is different but they all work in more or less the same way.

2.1.3 Writing of Codes Behind the Interface

The last step was writing the code behind the interface. Before the application can be capable of performing the tasks and responding to user interaction, the codes have to be written. Visual C# is an event-driven language, which means that code is executed in response to events. These events might come from users, such as a user clicking a button and triggering its Click event, or from Windows itself. The codes written for the developed application were triggered by the Button Click event. Generally, in the application, codes were written to achieve the following tasks;

- i. Computation of the Quantities.
- ii. Generation of the cost.
- iii. Saving of Output to Database in form of bill of Quantities.

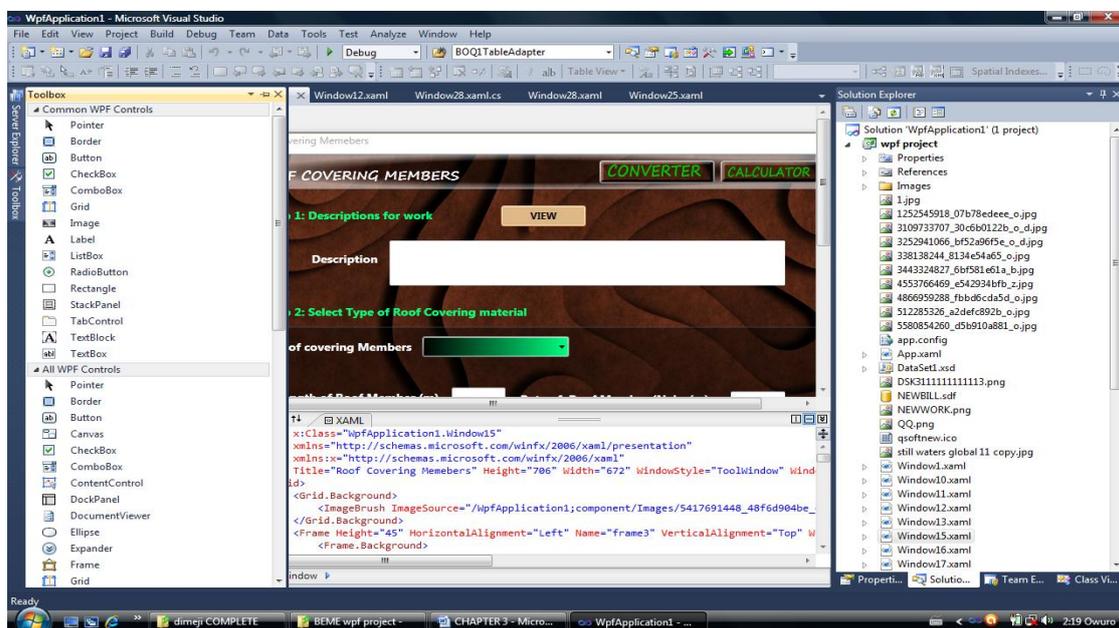


Plate 1: A view of the graphical interface in Csharp environment during design process.

Plate 2.2: A view of the graphical interface showing the controls

2.1.4 Testing the Digital computation program

The developed computation program was tested on a Proposed Building project for the computation of quantities for following items;

- i. Site Clearing
- ii. Excavation and Backfilling
- iii. Concrete works and Reinforcements
- iv. Masonry and Block works
- v. Roofing
- vi. Surface finishes

It was also tested on a Road project for the computation of quantities for the following items;

- i. Site Clearing and Earthworks
- ii. Culverts and Drains
- iii. Pavement and Surfacing

Data such as length, width and depth were inputted into the software and the program instantaneously calculates and displays the results on the screen using the above parameters:

- i. Quantities (sq.m or cu.m or Nr or Lm)
- ii. Amount (Naira)

The data such as length, width and depth used in the calculation were extracted from both the Architectural drawing and the engineering road layout.

2.2 Application Flow Chart

A Typical flow diagram showing the step by step process to compute quantities and generate cost is shown below.

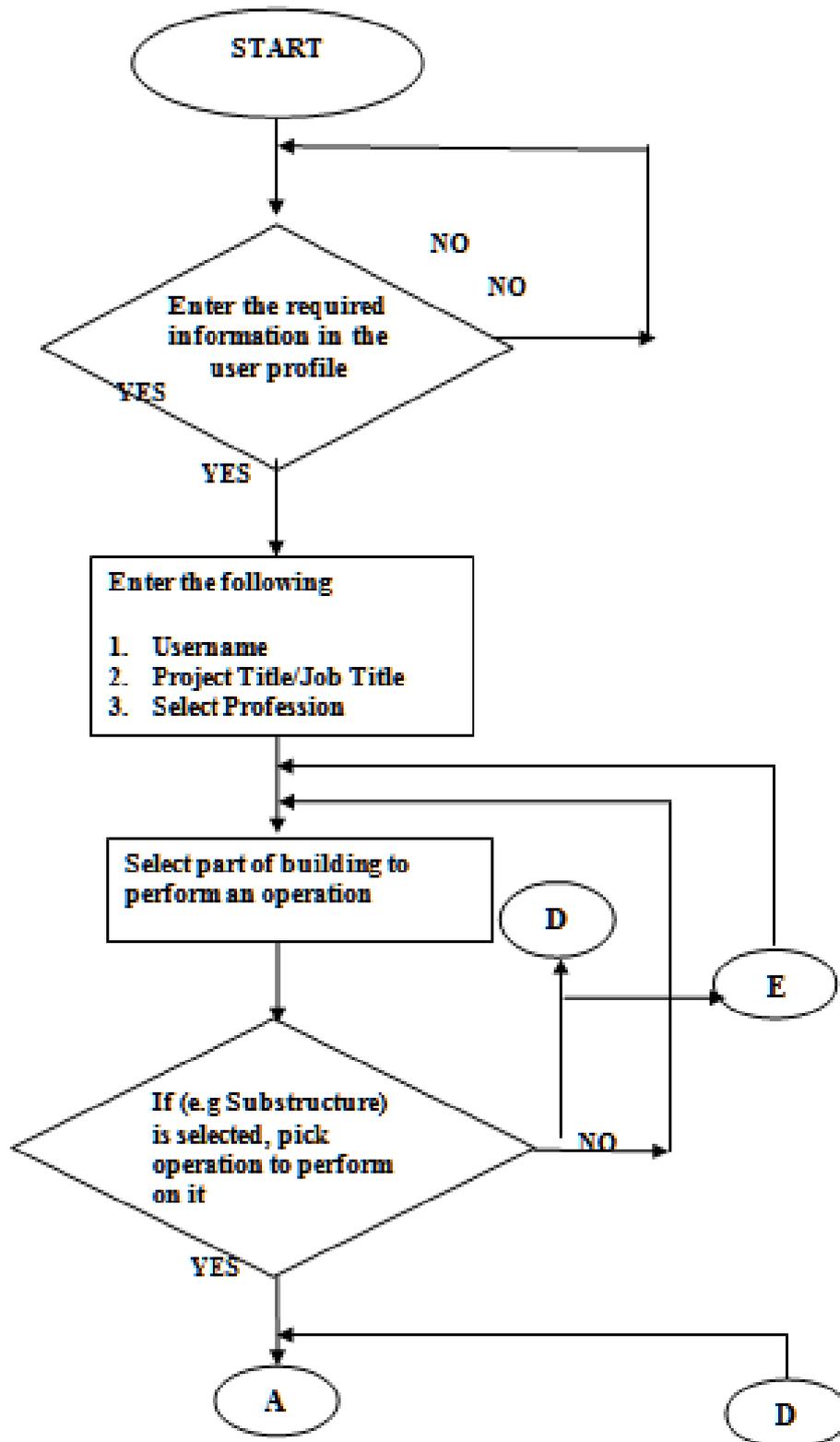


FIG. 1: A Typical Flow Diagram Illustrating step by step process of the Building Program

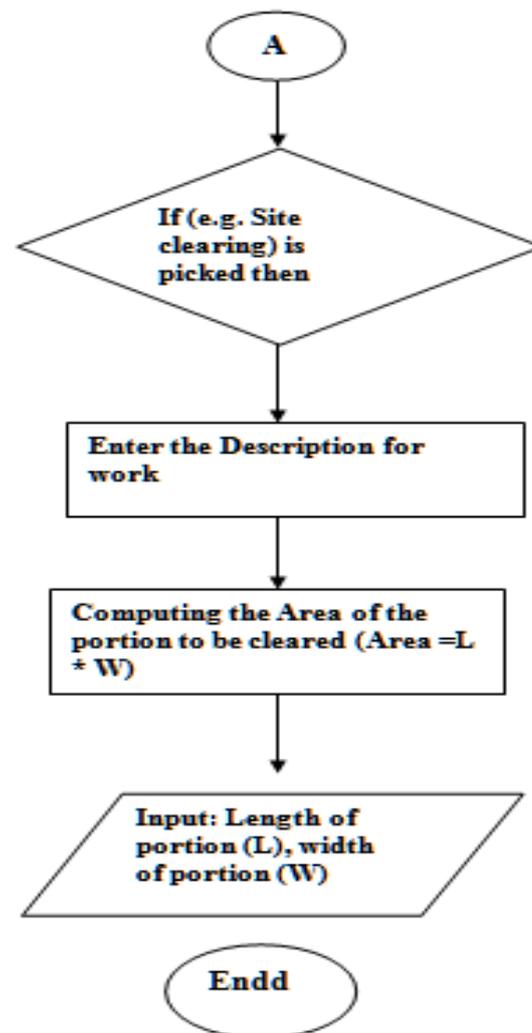


FIG. 1: A Typical Flow Diagram Illustrating step by step process of the Building Program

III. DISCUSSION OF RESULTS

The process of developing the digital computation of building and civil engineering quantities followed the same style and procedure as one would generally follow in a manual elementary calculation. The result got from the implementation of this study is the development of a digital computation of building and civil engineering quantities to ease quantity estimation. Throughout the execution of the computer program, ease-of use and flexibility was a major consideration. A lot of effort has been put together to make the program simple to understand and straight-forward for the users. That is, inputting the parameters and rate for building and road quantities from architectural or engineering drawing will instantaneously produce the results in an understandable manner.

3.1 Testing the Digital Computation Program

The developed program was tested using a proposed Akugbene Road Project in Delta State and a proposed Administrative Block at Adekunle Ajasin University, Akungba-Akoko Ondo State and the program was found to be accurate and reliable. The whole process of the digital computation followed the same style and procedure as one would generally follow in a manual calculation. The efficiency of the software was analysed by computing the two projects manually. The results are shown in Tables 1 and 2. From the Table 1, it is seen that 60% of the items in clearing and earthworks has 0 to 5 percentage difference and 40% has 6 to 10 between the manual and digital computation. This means that 100% of the items has 0 to 10 percentage difference. This 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. Similarly, the Table shows 67% of the items under culvert and drains, pavement and surfacing (separately) has 0 to 5 percentage difference and 33% has 6 to 10

percentage difference meaning that 100% of the items has 0 to 10 percentage difference in the final outputs of the quantities obtained through the manual computation and the digital computation for the project.

Table 1: Proposed Akugbene Road Project in Delta State

Item	Description	Manual Computation	Digital Computation	Difference	% Difference
		QTY	QTY		
Bill No 2: Site Clearing and Earthworks					
2.01	Clearing of site of all rubbish, grass, bush, shrubs and all trees.	20,000m ²	20,600m ²	600	3
2.02	Cut down large trees	5 No.	5No	0	0
2.03	Excavate and dispose all unsuitable material below subgrade in cut or fill area.	2000 m ³	2140m ³	140	7
2.04	Excavate in any material except rock to formation levels in cuttings and side drains	1 m ³	1 m ³	0	0
2.05	Excavate from approved borrow pits.	2000m ³	2160 m ³	160	8
Bill No 3: Culvert and Drains					
3.01	Excavate in any material and to any depth for culverts.	405 m ³	405 m ³	0	0
3.02	Level and compact bottom of excavation, provide and place concrete grade 10 as blinding (50mm thick) to box culverts only.	405m ²	405m ²	0	0
3.03	Provide, place & compact concrete grade 20 in box culverts, walls and aprons	810m ³	859m ³	49	6
3.04	Provide and fix high tensile reinforcement in box culverts, all walls, staircases, cover slabs, etc.	1780 kg.	1922 kg.	142	8
3.05	Provide and lay trapezoidal concrete – lined drain 100mm thick, in grade 20 concrete	405m	421m	16	4
3.06	Provide, place & compact reinforced concrete drains with internal dimensions 500mm deep x 450mm wide.	200m	210m	10	5

Also from Table 2, it is also seen that 58% of the items in the substructure has 0 to 5 percentage difference, 25% has 6 to 10 and 17% has 11 and above percentage difference between the manual and digital computation. This means that 83% of the items has 0 to 10 percentage difference and 17% of the items has percentage difference more than 10. Similarly, the Table shows 60% of the items for superstructure has 0 to 5 percentage difference and 40% has 6 to 10 percentage difference meaning that 100% of the items has 0 to 10 percentage difference in

the final outputs of the quantities obtained through the manual computation and the digital computation for the proposed building project. Therefore, the developed digital computation 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.

Item	Description	Manual Computation	Digital Computation	Difference	% Difference
		QTY	QTY		
Bill No 4: Pavement and Surfacing					
4.01	Provide, spread, shape and compact to 100% sub-base course .	3,750m ³	3,750m ³	0	0
4.02	Provide, spread, shape and compact approved granite crushed stone base.	2,250m ³	2,273m ³	23	1
4.03	Provide and lay MC1 to carriageway and shoulders at the rate of 1.1litres/m ² .	7,300 m ²	7,300 m ²	0	0
4.04	Provide, lay and compact surface dressing on shoulders using cut-back bitumen S-125 at 1.12litres	3,000 m ²	3,120 m ²	120	4
4.05	Provide, lay and compact asphaltic concrete wearing course for a compacted thickness of 40mm.	7,300 m ³	8,030 m ³	730	10
4.06	Provide, lay and compact asphaltic concrete binder course for a compacted thickness of 40mm as specified.	7,300m ³	7,957m ³	657	9

Table 1Cont'd :Proposed Akugbene Road Project in Delta State.

Table 2: Proposed Administrative Block in AdekunleAjasin University, Akungba-Akoko, OndoState(Substructure)

Item	Description	Manual Computation	Digital Computation	Difference	% Difference
		QTY	QTY		
A	Excavate to remove top soil	70m ²	72m ²	2	3
B	Excavate trench to receive foundation	22m ³	21m ³	1	5

C	Filling to excavation	14 m ³	13 m ³	1	7
D	Filling to make up levels do with granite	45 m ²	46 m ²	1	2
E	Filling to make up levels do with laterite earth filling	13 m ³	14 m ³	1	8
F	Pour mass insitu concrete in foundation footing	9 m ³	9m ³	0	0
G	Pour mass insitu concrete in Blinding	1 m ³	1m ³	0	0
H	Pour mass insitu concrete in Oversite concrete	8 m ³	9 m ³	1	13
I	Lay high tensile reinforcement bars sizes;12mm in diameter	12kg	11kg	1	8
J	Lay high tensile reinforcement bars sizes;12mm in diameter	56 kg	58kg	2	4
K	Lay high tensile reinforcement bars sizes;10mm in diameter	5 kg	6 kg	1	20
L	Lay 225mm thick solid blockwork in foundation	37 kg	38 kg	1	3

Table 2 Cont'd: Proposed Administrative Block in AdekunleAjasin University, Akungba-Akoko, Ondo State (Superstructure).

Item	Description	Manual Computation	Digital Computation	Difference	% Difference
		QTY	QTY		
A	Pour mass insitu concrete in columns	1 m ³	1 m ³	0	0
B	Pour mass insitu concrete in beams	1 m ³	1 m ³	0	0
C	Pour mass insitu concrete in Lintel	1 m ³	1 m ³	0	0
D	Reinforcement:column starter 12mm diameter	34kg	37kg	3	9
E	Reinforcement:column starter 10mm diameter	21 kg	23kg	2	10
F	Reinforcement:Beam 12mm diameter	32 kg	35kg	3	9
G	Reinforcement:Beam 10mm diameter	22 kg	23kg	1	5
H	Reinforcement:Lintel 12mm diameter	66 kg	68kg	2	3

I	Reinforcement:Lintel 10mm diameter	53 kg	56kg	3	6
J	Lay 225mm thick block in wall up to 1.5m height.	113 m ²	117 m ²	4	4

The program was also able to perform the following tasks:

- i. Squaring of dimensions and display of quantities.
- ii. Display of cost summaries during estimation process.
- iii. Storing of results in a database
- iv. Display of result in a Bill format.
- v. Printing of output as at when due.

IV. CONCLUSION.

The developed program will be able to 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. The software was developed using a combination of good programming in Microsoft Visual C SHARP (C#-version 2010) and Microsoft Visual studio Environment (version 2010), which allows an artistic application to be created, visually appealing and dynamically interactive. A typical flow chart representing the relationships between the tasks involved in the development of the software was developed, in order to identify the required computer sequence of operation to be used and translate the logical sets of programs. The software was tested and the results found to be accurate and reliable for both building and civil engineering works and can therefore be used in place of manual computation.

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