Utilization BIM For Integrating Cost Estimation and Cost Control in Construction Projects

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Abstract: **Cost was adapted before using manual quantity surveying by spreadsheet that estimator take the quantity from the 2D drawing and input data manually. With emerging Building Information Modelling (BIM) in Architecture, Engineering, and Construction (AEC) industry. The concepts has changed then and BIM became essential ruler in all phases of construction. allows project participants to design, analyse BIM, sequence, and explore entire project model in contrast to CAD drawing, the object in BIM has also physical properties that drive object.**

Traditional cost methods have been discussed and then BIM tools to show how it saved a lot of expected errors and time along with third application have been introduced with an emphasis on construction cost estimating and its relation to cost control without skipping 4D of scheduling as important key in decreasing or increasing the cost. Two approaches for 4D scheduling in BIM. For the cost estimating capability, two available methods have been discussed: i) list from the BIM tool to the estimating software such as MS Excel, ii) link BIM components to estimating software, a case study is provided to demonstrates the cost estimating processes in BIM based on the BIM model of a three-story training facility. The integrated cost database that builds with the model is the main key factor for more accurate estimate and the purpose of this research is to improve the workflow of cost estimation and cost control make it as a base for other researcher to work based on.

Keywords: **Cost integration, BIM Cost estimation , Cost Data base , Worksets and Cost coding.**

1. INTRODUCTION

BIM stands for Building Information modelling which is a computable representation of all physical characteristics of the building and its related information. BIM is also known for its uniqueness of extracting data and calculations which means what designer input can extract outputs. BIM provides a virtual view of the objects in the building with physical geometry (2D or 3D) and other functional parameters. etc. Designers compose these BIM objects together to define a building model, and this model incorporates both physical and functional information stored in the BIM objects. Once the building model is completed, all the information can be generated by users for fabricating, analyzing, construction scheduling (4D BIM) and cost estimating (5D BIM), and eventually, for facility management during operation phase of the building lifecycle.

1.1– Cost estimate and Cost control

Cost estimate can be defined as the process of predicting cost to perform the scope of work specified by a project. Precise cost estimation and effective cost monitoring are essential keys to construction project success. Project managers need to rely on cost estimating workflow that enable them to initiate budgets and manage financial plans.

The Association for the Advancement of Cost Engineering (AACE) defines cost estimate as; "A predictive process used to quantify cost and/or price of resources required by the scope of an asset investment option, activity, or project" (AACE International 2011).

Rad (2002) defines it as "the art and science of using historical data, personal expertise, institutional memory, and the project scope statement to predict the resource expenditure, and total cost of a project".

The cost estimate level of accuracy depends on the method that has been used and availability of cost data. With emphasize on proper monitoring and control because without them the project may fail. Monitoring is the process of tracking various operation during construction stage. Cost control indicates the direction of the changes in preliminary planning variable compared with actual performance with the goal of avoiding unacceptable variations. Cost control involve 'monitoring' costs and recording data then analyse the data in order to take suitable actions before it become late to adjust. Once the project starts, Control become the crucial stage for contractors which could affect substantially their profit.

For the cost control of a project, the construction plan and the associated cash flow estimates can represent the reference basis for later project monitoring and control. With schedules, the progress of individual activities and the achievement of milestone completions can be compared to the project schedule to monitor activity progress. Lists of contracts and services provide the criteria for assessing and ensuring the required construction quality. The final or detailed cost estimate provides a basis for evaluating financial performance during the project. To the extent that the costs are within the detailed cost estimate, the project is considered to be under financial control. Exceedances in specific cost categories signal the possibility of problems and provide an indication of exactly what problems are occurring. Certain items in the detailed estimate become order cost elements. Expenditure incurred over the course of a project is recorded in specific job cost accounts for comparison to the original cost estimates in each category. Thus, individual job cost accounts typically represent the basic unit of cost control. Alternatively, labor cost accounts can be disaggregated or broken down into work items that relate to both specific planned activities and specific cost accounts. In addition to the cost amounts, information about material quantities and labor input is usually also stored within each work account Project budget.

2. USING BIM FOR COST ESTIMATE

BIM technology would provide the potential for improving communication between participants involved in the construction project, improving the quality of information, the quality of services delivered, and reducing cost at every stage in the life cycle of a building (Smith and Tardif, 2009).

As today's technology grows more complex, building design has become more complicated. The involvement of the computer technology at the earliest phase of the design process is becoming more common. Difficulties of the design associated with the complexity of the building could provide many problems to not only the designer but also the engineers and the contractors who build it. BIM provides the ability for the designer to design the building with the modeling tool that creates object elements instead of different types of lines connected to make up a model. The 3D parametric model that BIM provides does not only provide the visualization of the model in three dimensions, but it also stores information about the elements that make up the building. This information includes its physical characteristics such as dimensions, locations, and texture of the objects. Functional characteristics could also be found in the parametric model, including the information about manufacturers and operating and maintenance procedures (Azhar et al., 2008) as shown in Figure 1.
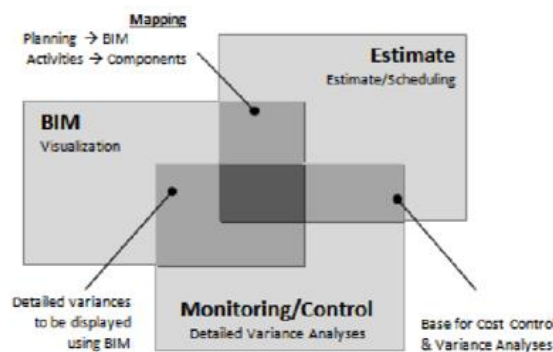

FIG 1: Proposed BIM based on Cost Estimate / Monitoring Framework

2.1 Quantity take-off (5D)

Time scheduling and cost estimations are both based on quantity information regarding e.g., building parts, materials, surfaces, and volumes. Today most quantity information is produced manually from 2D drawings, meaning that drawings are measured in order to calculate the quantities (Jongeling, 2008). This process is time consuming, and there is a risk for mistakes, which can lead to inaccurate quantity information. However, in BIM quantities can be extracted in detail with very accurate counts and calculations and time saving.

2.2 Cost estimation (5D)

It is vital for a construction contractor to make realistic project cost estimations during the tender stage. In order to make the estimation as realistic as possible, the estimator needs to have a good understanding of the project and good knowledge of production costs (Bengtsson and Jauernig, 2008). Cost estimation includes both direct costs, such as construction materials, and indirect costs, such as insurance, electricity, and waste disposal (Bengtsson and Jauernig, 2008). Additionally, costs for the use of central administration resources are added together with a margin covering other administrative costs and profit. BIM users can generate accurate and reliable cost estimates through automatic quantity takeoff from the building model and get a faster cost feedback on changes in design.

2.3 Monitoring (6D)

The purpose of the production process is to build in accordance with drawings, descriptions, laws and regulations, standards, production plans, and budgets (Gustavsson, 2006). Before the construction starts, several different plans are developed. These together with the project budget represent a production program, intended to guide the work. In order to make the project meets its goals it is important to follow the plans and monitor the process. The monitoring is conducted by comparing actual costs and spent time to budgeted costs and time. If deviations occur, they must be analysed to perceive how they affect the future of the project and to determine if any actions need to be taken (Gustavsson, 2006). For example, if the schedule cannot be followed, more resources may need to be allocated or the schedule needs to be revised.

2.4 Project life cycle (Maintenance) (6D)

The last part of the building process is maintenance, which starts as the production is finished and the product is delivered to its owner to be used for its intended purposes (Nordstrand, 2008). Maintenance includes administration, such as planning, managing, and monitoring the operation, as well as preservation of the facility.

To collect the area of specialties that BIM can do this figure illustrates all dimensions of BIM.
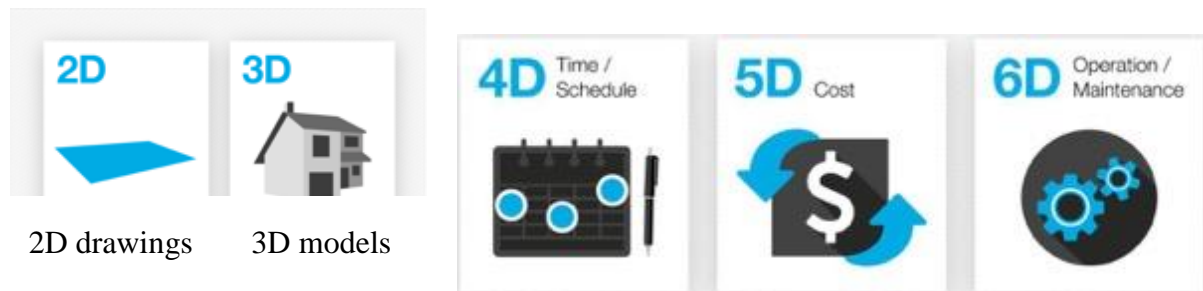
Fig 2: BIM Area specialities

2.5 Quantity Take-off and Estimating Tools

Different tools are used to calculate quantities that result from BIM modeling which will give us an idea about quantity take off in BIM itself without external application as shown in Table 1

Table 1: Comparison between different quantity take off tools

Product Name	Manufacturer	BIM Use	Manufacturer's Description	Primary Function
Nav_swoks	Autodesk	Quantity Takeoffs	With Naviswork, cost estimators can create synchronized comprehensive project views that combine information from Autodesk Revit applications	Generating takeoffs from multiple environments both 2D & 3D
DProfiler	Beck Technology	Conceptual Estimates	The company's flagship program, called DProfiler™, integrates conceptual 3D modeling with cost estimating intelligence enabling project teams to evaluate more alternatives in less time with better clarity before moving into design development	Conceptual 3D modeling with cost estimating and life cycle operational costs forecasting

Visual Applications	Innovaya	Estimating	Innovaya Visual Quantification performs object quantity takeoff accurately, quickly, and intelligently from Autodesk's Naviswork/Revit	Extracting quantities and building estimates from Naviswork & Revit files
Vico Takeoff Manage	Vico Software	Quantity Takeoffs	Vico Takeoff Manager™ generates quick and highly accurate model- and location-based quantity takeoffs derived from 3D models created with leading BIM authoring tools. Since quantity takeoff is a live view, newly published and activated model versions result in automatically updated quantities.	

3. BIM AND COST CODING

BIM is Information or Database of Building element that has

• Physics properties

 • Standard Code

Therefore, that can result in more organization for Building elements hierarchy & classification as shown in Figure 3. To organize that BIM has Protocol standards, which consist of library and standard code, which divide the building elements to categories or sub work.

Fig 3: The BIM application has the link with the standard codes

BIM comes with standard protocols and codes that can be chosen from as the following :

3.1 Standard protocol

National BIM Standard

• CSI (Control Sequence indicator)

• AEC UK (Architecture , Engineering and construction UK)

• National BIM Library

• Open BIM (xBIM)

3.2 Standard classification

• MasterFormat (work result)

• UniFormat (functional elements)

• OmniClass (building elements categorizes)

• Uniclass (For all aspects of the design and construction process)

3.3 MasterFormat (work result)

So one of the ways that quantity is organized is by division through Masterformat as shown in Figure 4

Fig 4: Shows a standard division for works

3.4 UniFormat (functional elements)

So another way that quantity is organized is by structures through Uniformat as shown in Figure 5

Fig 5: Shows a more generalized works division

So inside BIM those assembly codes is standardized and has building elements hierarchy. It can also be replaced as well with any external assembly codes.

4.   IMPLEMENTATION FOR COST CONTROL: BIM

This Is another example of using Uniformat in hierarchy as shown in figure 6

Fig 6: Shows hierarchy that can be used to identify cost by building elements

In another word this Uniformat hierarchy is organized in three levels , first by major category then by major group Elements then by group elements and then by individual elements as show in Figure 7

Level 1 Major Group Elements	Level 2 Group Elements	Level 3 Individual Elements
A SUBSTRUCTURE	A10 Foundations	A1010 Standard Foundations A1020 Special Foundations A1030 Slab on Grade
	A20 Basement Construction	A2010 Basement Excavation A2020 Basement Walls
B SHELL	B10 Super Structure	B1010 Floor Construction B1020 Roof Construction
	B20 Exterior Enclosure	B2010 Exterior Walls B2020 Exterior Windows B2030 Exterior Doors
	B30 Roofing	B3010 Roof Coverings B3020 Roof Openings
C INTERIORS	C10 Interior Construction	C1010 Partitions C1020 Interior Doors C1030 Fittings
	C20 Stairs	C2010 Stair Construction C2020 Stair Finishes
	C30 Interior Finishes	C3010 Wall Finishes C3020 Floor Finishes C3030 Ceiling Finishes
D SERVICES	D10 Conveying	D1010 Elevators & Lifts D1020 Escalators & Moving Walks D1090 Other Conveying Systems
	D20 Plumbing	D2010 Plumbing Fixtures D2020 Domestic Water Distribution D2030 Sanitary Waste D2040 Rain Water Drainage D2090 Other Plumbing Systems
	D30 HVAC	D3010 Energy Supply D3020 Heat Generating Systems D3030 Cooling Generating Systems D3040 Distribution Systems D3050 Terminal & Package Units D3060 Controls & Instrumentation D3070 Systems Testing & Balancing D3090 Other HVAC Systems & Equipment
	D40 Fire Protection	D4010 Sprinklers D4020 Standpipes D4030 Fire Protection Specialties D4090 Other Fire Protection Systems
	D50 Electrical	D5010 Electrical Service & Distribution D5020 Lighting and Branch Wiring D5030 Communications & Security D5090 Other Electrical Systems
E EQUIPMENT & FURNISHINGS	E10 Equipment	E1010 Commercial Equipment E1020 Institutional Equipment E1030 Vehicular Equipment E1090 Other Equipment
	E20 Furnishings	E2010 Fixed Furnishings E2020 Movable Furnishings
F SPECIAL CONSTRUCTION & DEMOLITION	F10 Special Construction	F1010 Special Structures F1020 Integrated Construction F1030 Special Construction Systems F1040 Special Facilities F1050 Special Controls and Instrumentation
	F20 Selective Building Demolition	F2010 Building Elements Demolition F2020 Hazardous Components Abatement

Fig 7: ASTM UNIFORMAT II Classification for Building Elements (E1557-97)

5.   COST ESTIMATE METHODS

During the first half of the twentieth century six methods of estimating were used (Fig 8).The methods are much the same today. The main difference is the current popularity of elemental cost models, which are used by quantity surveyors and contractors alike, in advising clients on their likely building costs, and helping designers to work within a budget.

A contractor may use a combination of estimating methods in developing a cost for a design and build project. For example, a client could be given a cost range for construction using the unit method and an elemental cost plan would be produced when the client's outline brief is received. Approximate (or builder's) quantities are used to produce a formal tender and when a
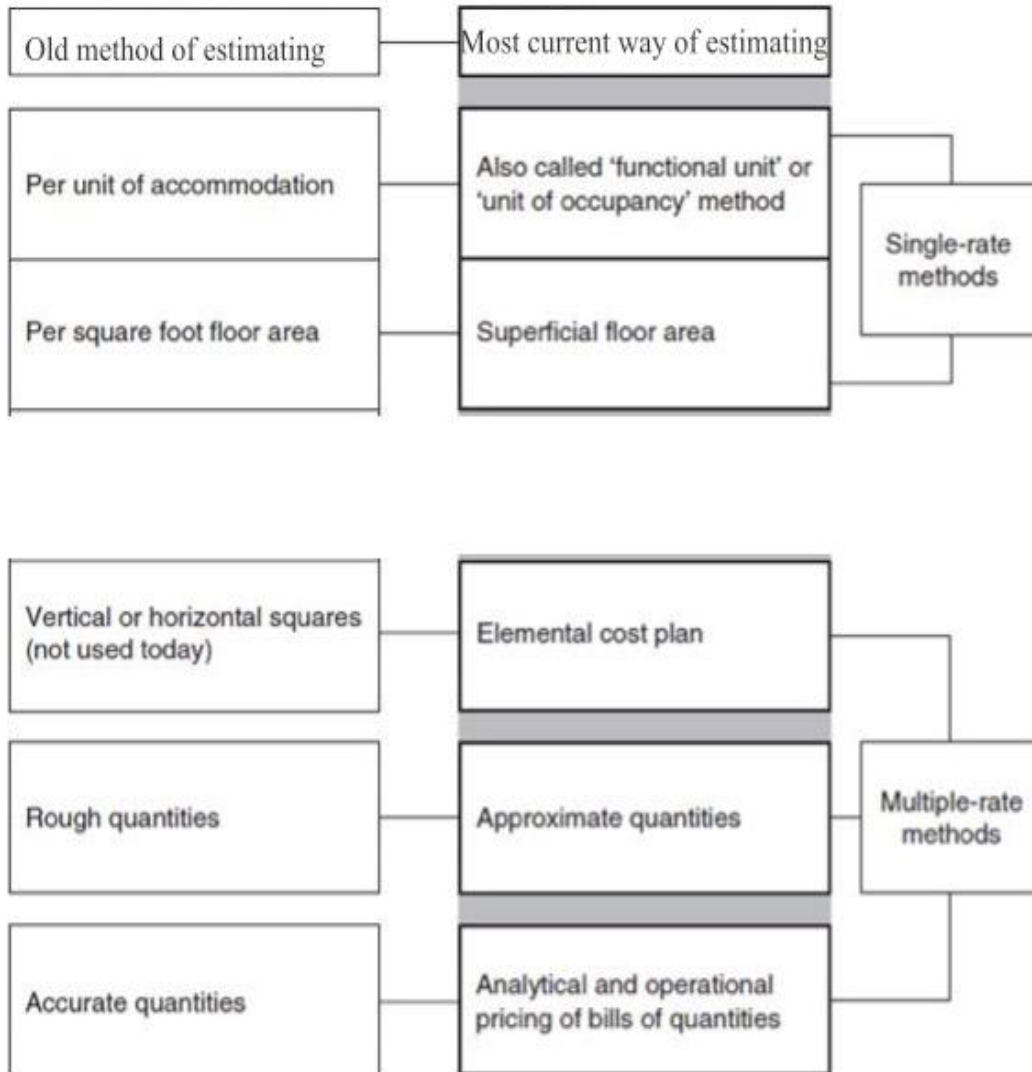
Fig 8: one of the cost estimate methods

contractor has received an order a full bill of quantities may be written for financial control during construction. The two main benefits of cost planning are:

1. To ensure tenders received do not exceed the budget. This is achieved by making design decisions early with advice from the cost team. Changes made early in the design process can be accommodated without too much effect on other elements. Examples like Per square foot or horizontal squares (not used today) Also called 'functional unit' or 'unit of occupancy' method Superficial floor area Elemental cost plan Analytical and operational pricing of bills of quantities

2. To collect cost information from a number of buildings, at various stages of development, thus improving the quality of cost data for future projects.

The first step in cost planning is to advise a client of a budget at the beginning of the project. An example of a development budget for construction costs is given in Figure 9 and 10

5.1 Single-rate approximate estimating

Development Financial Summary

	Hall (GIFA: 200 m^2) refurbishment		Budget	Actual cost	Notes
	Total costs				
1	Development costs	Concept architect	6 500		Concept architect taking early retirement
		Planning consent fees	600		Check for other application
		Building regulation fees	1 500		Check for other application
		Additional insurances during construction	500		Amount not known
		Photocopying costs	150		Tender documents
2	Professional fees	Architect – pre-contract	9 000		
		Architect – post-contract	10 000		Includes inspection role
		Structural engineer	3 850		Includes unrecoverable VAT
		Planning supervisor	600		
		Quantity surveyor	2 250		Produce valuations and value variations
		Risk assessment – fire	650		Develop spec for fire alarms
3	Construction costs	Main contract	320 565		New hall and refurbishment excluding VAT
4	Value added tax	Unrecoverable VAT	16 000		Refurb portion of the works
5	Direct suppliers – fit out	Costs for furniture	11 000		Self-financing (see 6)
		Loose furniture	5 000		
6	Cost recovery	Sale of land (old hall)	−65 000		Net income from sale and agent's fee

Fig 1: Example of a development budget for functional unit

Elemental cost plans

CB Construction Limited, Northbridge

Proposed Workshop for Fast Transport Limited		GIFA (m^2)	2 310
	Element	**Cost £/m^2**	**Element cost**
1	**Substructure**	65	151 210
2	**Superstructure**		
	Frame	66	153 280
	Roof coverings	32	74 560
	Roof drainage	4	9 450
	External walls	33	75 410
	Windows	13	29 550
	External doors	5	11 850
	Internal walls	7	15 201
	Internal doors	6	13 541
3	**Internal finishes**		
	Wall finishes	11	24 856
	Floor finishes	4	8 513
	Ceiling finishes	4	8 145
4	**Fittings and furniture**	2	3 990
5	**Services**		
	Sanitary appliances	3	6 050
	Internal drainage	−	inc
	Hot and cold water	−	inc
	Heating	12	28 560
	Electrical installation	9	21 650
	BWIC	1	1 520
6	**External works**		
	Site works	39	89 525
	Drainage	11	25 140
	External services	3	7 520
7	**Preliminaries**	40	92 850
8	**Contingencies**	16	37 150
9	**Budget total**	£ 385	£ 889 521

Fig 10: Example of multiple rate cost estimating

The forecast cost of each element can be calculated in two ways:

1. By measuring the approximate quantity of each element like in figure 11and applying a unit rate.

2. By calculating the proportion of total cost for each element on a similar building and using this ratio to divide the budget for the proposed building into its elemental breakdown.

	CB Construction Limited, Northbridge Factory for Hitech Cables Limited	**COST FEEDBACK** GIFA (m²) 3 120	
	Element	Element cost	Rate £/m²
1	Substructure	186 450	60
2	Superstructure		
	Frame	207 410	66
	Roof coverings	120 360	39
	Roof drainage	11 520	4
	External walls	96 580	31
	Windows	23 950	8
	External doors	16 580	5
	Internal walls	8 780	3
	Internal doors	15 340	5
3	Internal finishes		
	Wall finishes	17 860	6
	Floor finishes	10 050	3
	Ceiling finishes	5 960	2
4	Fittings and furniture	7 250	2
5	Services		
	Sanitary appliances	7 410	2
	Internal drainage	inc	–
	Hot and cold water	inc	–
	Heating	25 550	8
	Electrical installation	36 870	12
	BWIC	3 630	1
6	External works		
	Site works	126 550	41
	Drainage	33 210	11
	External services	5 120	2
7	Preliminaries	144 550	46
8	Contingencies	56 280	18
9	Budget total	£ 1 167 260	£ 374

Fig 2: example of measuring quantity for every element

The second method is better shown by example. If a contractor has built some portal-framed factories he will know the costs of each element and can express this information as costs for each unit of floor area. Figure 12 illustrates a typical analysis for a factory building. The site team has been asked to feedback cost information to the estimator by converting package values to elemental costs.

	CB Construction Limited, Northbridge	**COST FEEDBACK** Hitech Cables GIFA 3 120		**NEW PROJECT** Pluto Blinds 2 860
	Element	Element cost	Cost £/m²	New budget
1	Substructure	186 450	60	170 913
2	Superstructure			
	Frame	207 410	66	190 126
	Roof coverings	120 360	39	110 330
	Roof drainage	11 520	4	10 560
	External walls	96 580	31	88 532
	Windows	23 950	8	21 954
	External doors	16 580	5	15 198
	Internal walls	8 780	3	8 048
	Internal doors	15 340	5	14 062
3	Internal finishes			
	Wall finishes	17 860	6	16 372
	Floor finishes	10 050	3	9 213
	Ceiling finishes	5 960	2	5 463
4	Fittings and furniture	7 250	2	6 646
5	Services			
	Sanitary appliances	7 410	2	6 793
	Internal drainage	inc	inc	inc
	Hot and cold water	inc	inc	inc
	Heating	25 550	8	23 421
	Electrical installation	36 870	12	33 798
	BWIC	3 630	1	3 328
6	External works			
	Site works	126 550	41	116 004
	Drainage	33 210	11	30 443
	External services	5 120	2	4 693
7	Preliminaries	144 550	46	132 504
8	Contingencies	56 280	18	51 590
9	Budget total	£ 1 167 260	£ 374	£ 1 069 988

Fig 12: Elemental cost plan for similar factory building

5.2 Approximate quantities

There are many ways in which approximate quantities are used depending on who uses them and for what purpose. Measurements will be concentrated into as few items as possible for grouped work components. A simple example is a cavity wall measured and priced with both skins included in the unit rate. The rate will include forming the cavity, wall ties, plastering and pointing. Rates for composite items can be found in price books, calculated from rates in priced bills of quantities like in figure 13. The accuracy of this method is related to how far the design has developed. At least the quantities are based on the planned construction and not a previous job and realistic allowances are made for plan shape, height of building, type of ground, quality of finishes etc. For these reasons it is widely used and being developed with computer systems using database and spreadsheet software to produce standard bills for repetitive building types. The danger is the cost calculated using approximate quantities can appear to be as accurate as a full bill of quantities based on working drawings. It is more likely to be an underestimate of the cost of construction unless a generous contingency is added for small components, fittings, fixings and design development.

	CB Construction Limited				
	Builder's quantities for Pluto Blinds				
	Description	Quant	Unit	Rate	Total
A	Excavate to reduce level	332	m^3		
B	Excavate for foundations ne 1.0 m deep	248	m^3		
C	Excavate machine pits ne 4.0 m deep	112	m^3		
D	Disposal of surplus from site	445	m^3		
E	Backfilling with selected exc material	247	m^3		
F	DOT type 1 under slab; 400 mm thick	1 330	m^3		

Figure 13: Example of builder's quantities

In common with all approximate estimating techniques there are some difficulties which need to be recognized when advising clients. Some of the difficulties to be faced are:

1. The reliability of historical data must always be questioned.

2. Preliminaries are usually unique to a particular job and should be calculated whenever there is deviation from an identical scheme.

3. Incoming services are seldom the same on different sites and can only be assessed after detailed consultation with service providers.

4. Contract conditions can vary markedly between projects; the requirements for bonds, insurances and liquidated damages can be particularly onerous.

5. The contingency sum for design development must be estimated for each job.

5.3 Analytical estimating

Analytical estimating is a method for determining unit rates by examining individual resources and the amounts needed for each unit of work.

Analytical pricing of bills of quantities is more than just applying resources to items of work to produce a unit rate. The constituents of a rate are inserted in the bill; and totalled for each page, each section, and carried to the summary, so that the contractor has a complete picture of the resource costs at the final review meeting. Figure 15 shows a typical printout from a contractor's bill where the rates and totals are shown between the item descriptions.

Factory for Hitech Cables Limited				February 2004		
Description			**Quant**	**Unit**	**Rate**	**Total**
Breakdown	*Lab rate*	*Plt rate*	*Mat rate*	*Sub rate*		
	LAB	PLT	MAT	SUB		
a Excavate to reduce level			332	m^2	4.00	1 328.00
	1.14	2.86				
	378.48	949.52				
b Excavate for foundations ne 1.0 m deep			248	m^3	5.25	1 302.00
	1.71	3.54				
	424.08	877.92				
c Excavate machine pits ne 4.0 m deep			112	m^3	6.63	742.56
	2.29	4.34				–
	256.48	486.08				–
d Disposal of surplus from site			445	m^3	17.91	7 969.95
	5.71	12.20				–
	2 540.95	5 429.00				–
e Backfilling with selected excavated material			247	m^3	4.34	1 071.98
	1.14	3.20				–
	281.58	790.40				–
f DOT type 1 under slab 400 mm thick			1 330	m^3	20.09	26 719.70
	1.14	3.20	15.75			
	1 516.20	4 256.00	20 947.5			
Total to summary						39 134.19
Breakdown	*5 398*	*12 789*	*20 948*			*39 134*

Fig 14: Contractor's bill of quantities priced analytically

	Weighbridge foundation for Hitech Cables Limited				13.2.04			Analysis of rates					
	Surface weighbridge (15 m long)	quant	unit	rate	total	lab	plt	mat	s/c	LAB	PLT	MAT	S/C
A	Excavate to reduce lev ne 1.0 m dp	23	m^3	8.94	205.62	3.97	4.97			91	114		
B	Excavate for thickening & downstand	9	m^3	24.85	223.65	19.88	4.97			179	45		
C	Load and remove to tip on site	17	m^3	7.96	135.32		7.96				135		
D	Backfill with selected material	15	m^3	5.64	84.60	2.32	3.32			35	50		
E	Level and compact	79	m^2	0.74	58.46	0.58	0.16			46	13		
F	Earthwork support	6	m^2	3.23	19.38	1.07	2.16			6	13		
G	Hardcore (Free Issue)	18	m^3	5.64	101.52	2.32	3.32			42	60		
H	Blind with dust (Free Issue)	62	m^2	0.66	40.92	0.33	0.33			20	20		
J	Soil stabilization mat	79	m^2	1.33	105.07	0.42		0.91		33		72	
K	Concrete grade 40 N in foundation	17	m^3	96.12	1 634.04	23.20		72.92		394		1 240	
L	Concrete grade 40 N in ramps	15	m^3	99.44	1 491.60	26.52		72.92		398		1 094	
M	Concrete grade 40 N in upstands	6	m^3	129.27	775.62	49.72		79.55		298		477	
N	Concrete grade 40 N in plinths	1	m^3	120.98	120.98	41.43		79.55		41		80	
P	Rebar 12 mm (upstand & downstand)	0.6	t	1 068.89	641.33	356.29		712.60		214		428	
Q	Rebar 16 mm	0.12	t	994.32	119.32	331.44		662.88		40		80	
R	Fabric A393	280	m^2	6.79	1 901.20	1.41		5.38		395		1 506	
S	Dowel bars 25 mm	30	nr	3.30	99.00	1.65		1.65		50		50	
T	Form plinths 900×900×250 mm high	4	nr	32.32	129.28	21.55		10.77		86		43	
U	Sawn formwork to sides of founds	47	m^2	34.80	1 635.60	23.20		11.60		1 090		545	
V	Sawn formwork to sides of upstands	17	m^2	38.10	647.70	24.85		13.25		422		225	
W	Cast in service duct	1	nr	16.58	16.58	9.95		6.63		10		7	
X	Grouting baseplates on return visit	1	item	256.87	256.87	207.15		49.72		207		50	
Y	Steel bumper stops	284	kg	3.15	894.60	0.67		2.48		190		704	
				TOTALS	11 338			check	11 338	4 287	450	6 601	–

Figure 15: Contractor's spreadsheet for weighbridge foundation

6. COST DATABASES

There is a number of ways to accurately estimate construction projects using Pre-Setup data bases either by using from similar previous projects or manual (catalogues or books) or online or Pre setup programme that has collaboration with BIM programmes.

Estimators have to be very cautious about using other similar projects that are old, because the cost estimation would be old and reflecting the actual current costs.

The way that manual work is using the help of the printed book that has national average like RSMeans for North America. For instance, to find a cost of specific material in cost data book in RSMeans like construction steel for office project. Using the index of RSMeans cost book and narrowing in to steel or by using masterformat classification system like to flip division 5 (metals). Once the line for the required division is found and the type of the building for the steel by ton, then estimator can take that specific price. The RSMeans for example will mention that 1 ton for structural steel for 1-3 stories for office building is 2700$ for materials alone and 3900$ that includes the overhead and profit for installing contractor which is the national average price. In order to adjust for specific city, estimator can go to the back of the book and use the city cost index in the back of RSMeans which cover more than 900 locations through U.S and Canada. For example if estimator willing to calculate the cost of material in Boston then in the back of the book the factor of percentage is 100.2 so to calculate 1 ton for construction steel cost 1.002 x 2700$ which results in 2705 $ which is the cost of steel cost in Boston without include overhead or contractor fees. So, estimator will go through the same process of finding the line items in the book and transfer them into spreadsheet.

The same process for manual apply for the online but more quicker and efficient. The way it works through RSMeans online by just entering the required data like the city and choosing the division for material.

RSMeans cost data is used with some third parties software developers who tried to make a link between BIM software (for example: Revit) and RSMeans cost data.

Example:

Sigma estimate software plugin will try to add type codes that is empty in current project as in figure 15.
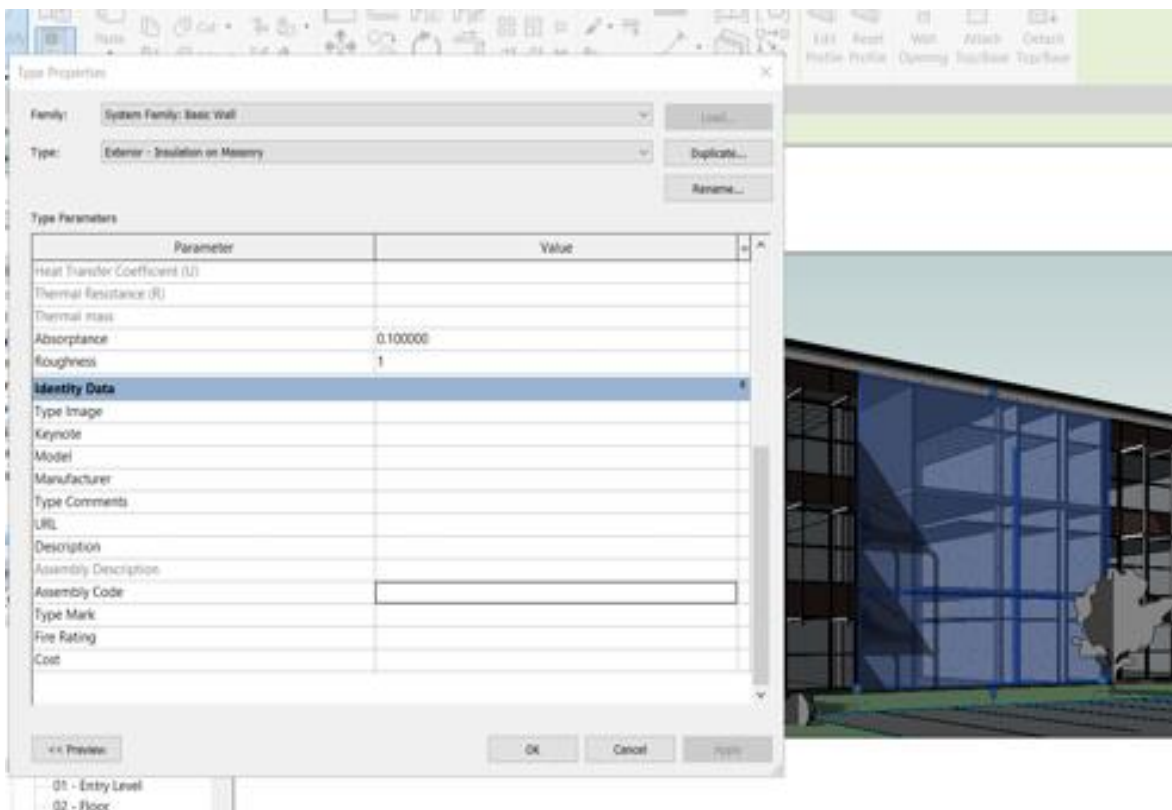

Figure 16: Revit project with no type code

Sigma software estimate will match up the cost data prices for RSMeans with the wall type.
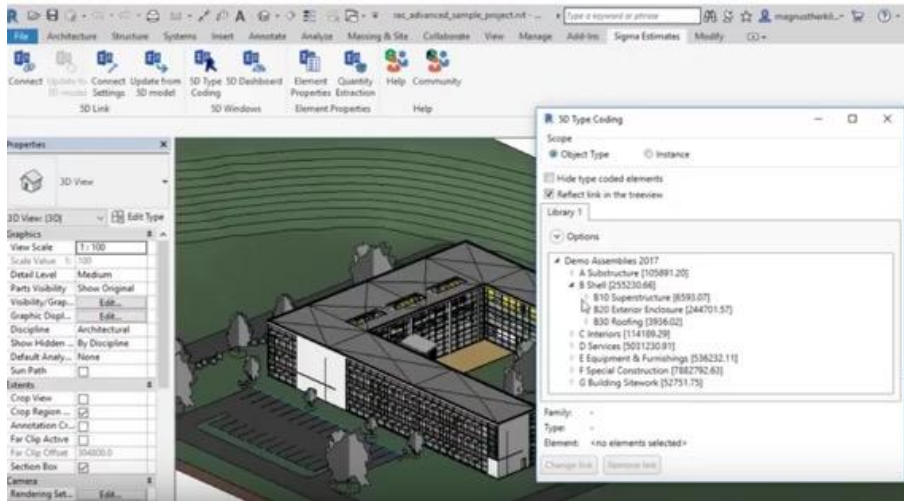

Figure 17: RSMeans cost data catalogue to match with the right wall type

So in Sigma estimator highlight the wall that match closely with cost data catalogue and beside it the price per unit as in the below figure 18
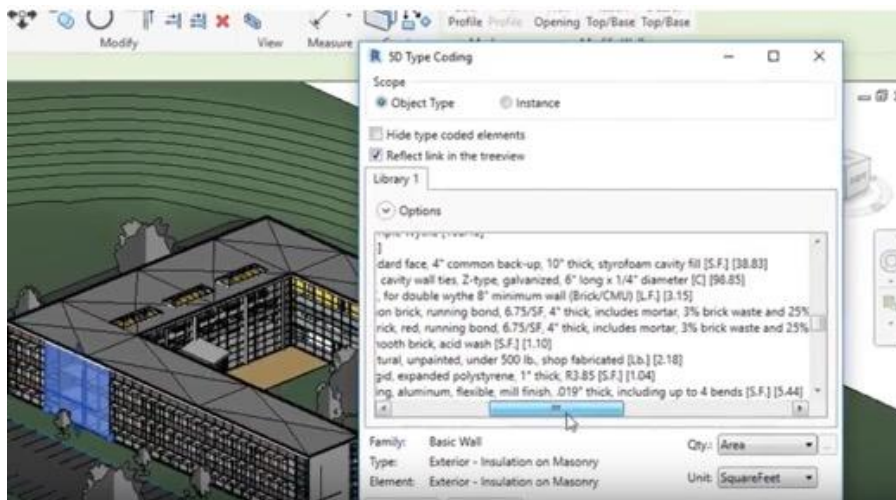

Fig 18: matching the selected wall type with the plugin

The plugin also prove tracking for all missing elements that is not type coded for cost prices like in figure 19 so the probability of any error for estimator is less.
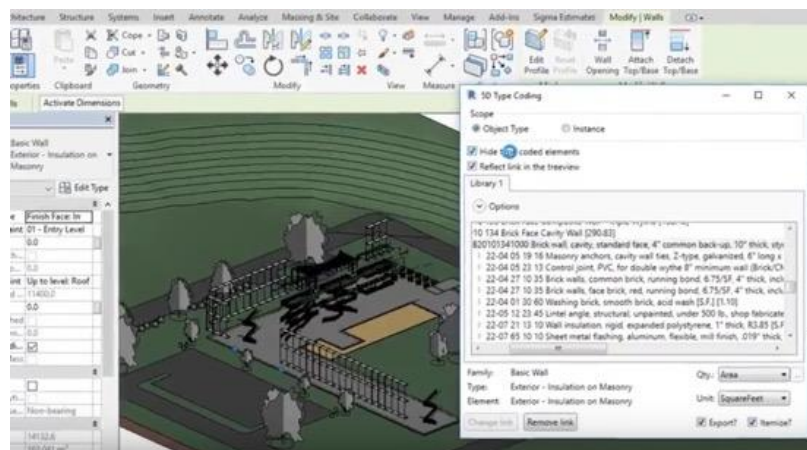

Fig 19: Tracking of all type coded elements

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The type codes which has been added to the wall as in the below figure 20 allow us select update from library and automatically get the right assembly from the price book in the estimate as shown in figure 21, 22 and 23
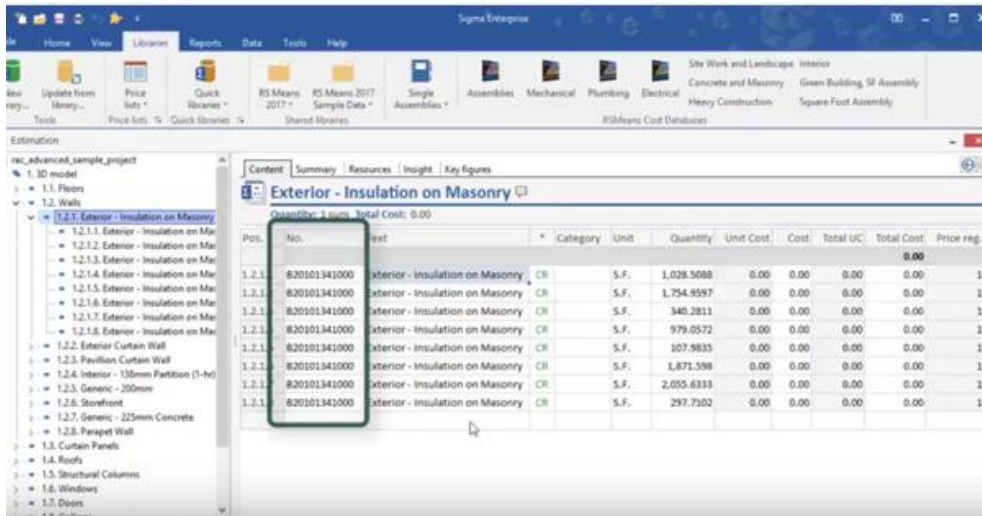

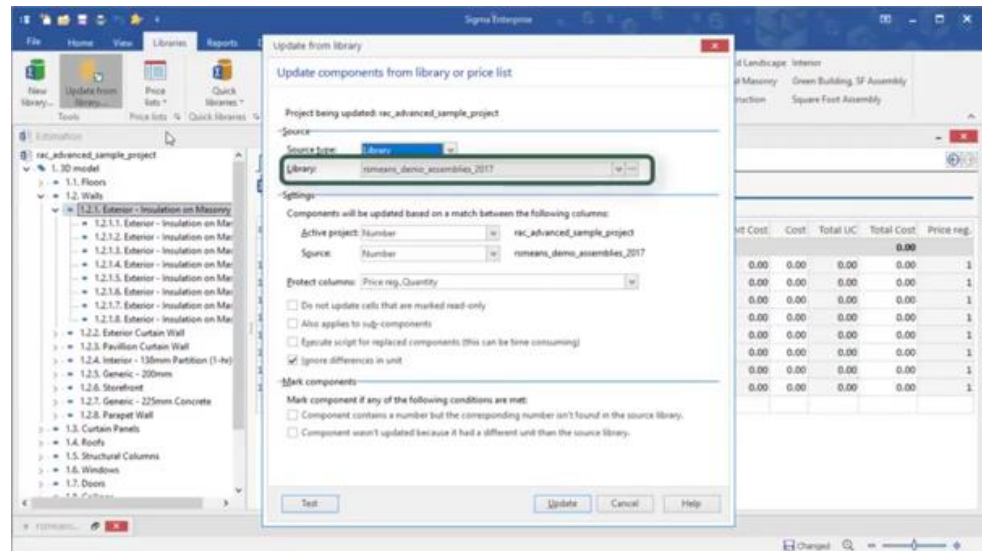**Fig 20: Assigned code elements that can read from cost data library**

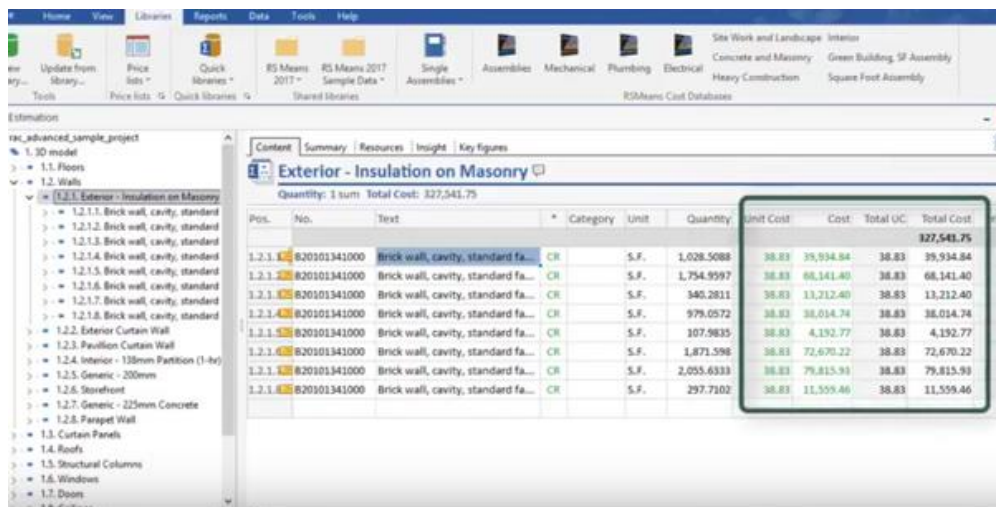**Fig 21: linking assigned code elements with the library of RSMeans assemblies**

Fig 22: Assemblies has now total costs for all quantities of the assigned code wall elements

Fig 23: Prices included building parts

Fig 24: That can include resources explanation for how total cost is being calculated

7. RELATION OF ESTIMATE TYPES WITH BIM

As explained there are multiple estimates types among them that is used by BIM is model estimating which can be linked directly to any specialized estimating software and then it can be linked to cost database provided by company like RS means that have updated item price catalogue according to standard division as shown in figure 24. But estimator has to be aware of project condition and check because if for example the installation of waterline in standard catalogue is priced up to four feet while the condition on the project is eight feet that will be underestimating of actual calculation. RS mean does not just provide price of items in specifications they publish annual guide for square foot cost which is also relating to square foot estimate type.To explain more about the procedures that happens in BIM , illustration shown in figure 25 shows the workflow that is used in estimation software with model based BIM that leads finally to the cost.
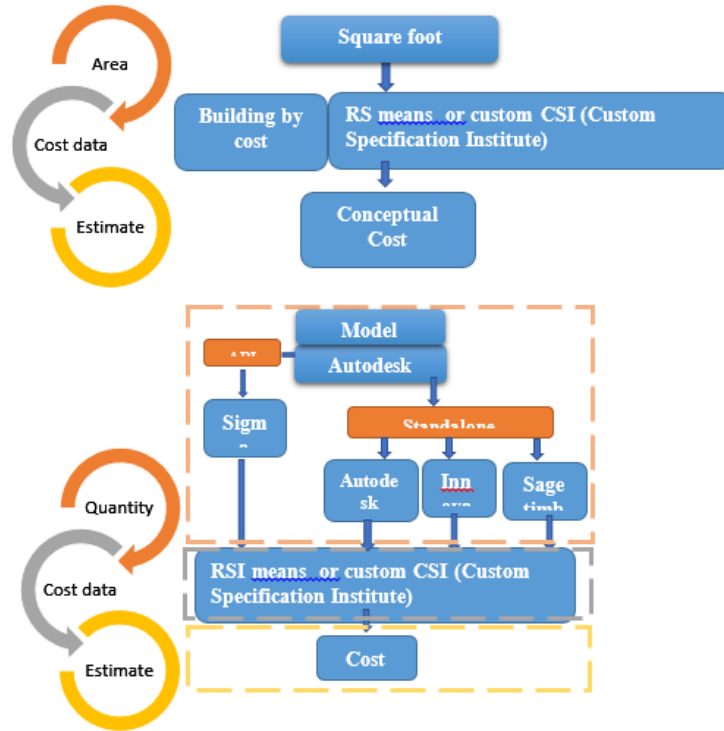
Fig 25: Model base estimate using BIM with specialized estimation software

8. IMPACT OF WORKSETS ON COST CONTROL

Multiple issues such as decrease in labour Productivity, poor recognition of construction needs, and lack of consistent and professional construction management are hampering the construction industry.

This situation made the industry revaluate its performance and look into ways for improvement. Project integration is essential for success; designers and constructors must collaborate and communicate effectively to keep budgets and schedules on the right track. Technology is slowly breaking through construction management practices and new contractual methods are emerging. One of these ways are worksets where dataset can be linked also to control the source of the major portions and looking more closely to the elements by colours as shown below in figure 26.
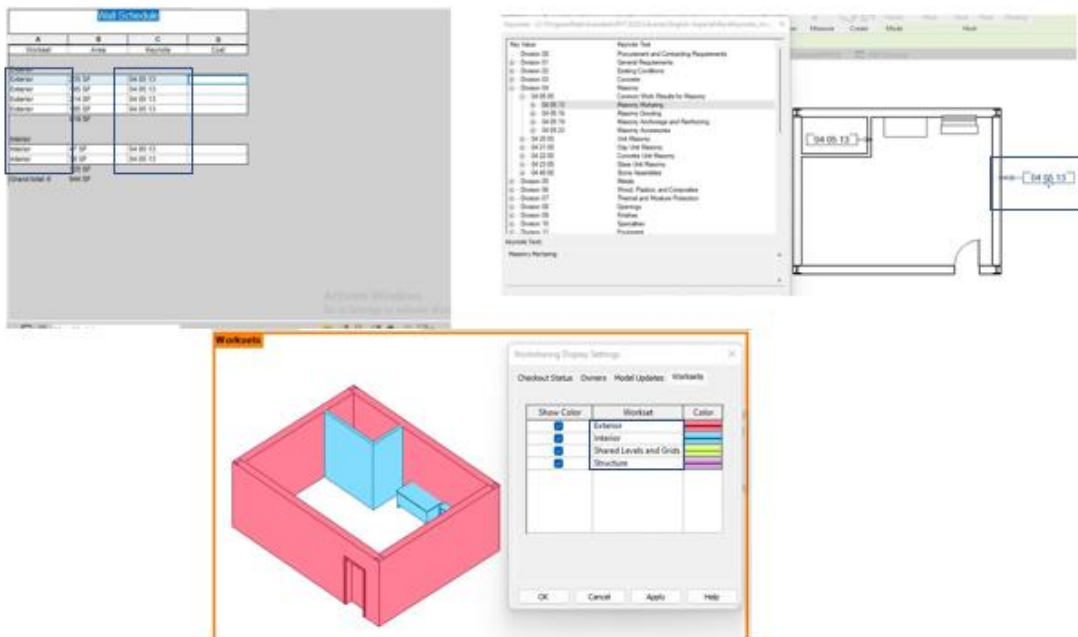

Fig 26: Model base estimate using BIM with specialized estimation software

BIM improves technical work at the design stage by creating 3D models that integrate all building's features and it better represents the infrastructure's requirements. Those models can also be enhanced if linked with schedule (4D) and costs (5D); the construction can thus be better planned almost entirely at the design phase. Time and cost controls are very important for any construction organization. Johansen and Wilson [3] questioned the necessity of intense construction planning in the design phase; they reached a conclusion that there is reluctance within the industry to accept first planning initiatives. Their major finding is that there is a lack of convergence between the design and construction team planning ideas, thus preventing achievement of project success.

As WBS is activities assigned to building components in the project, these activities has duration and using such activities concurrently can effectively reduce the cost.

As can be seen from figure 27. BIM model is used as the starting point of our process. Cash flow forecasting requires the three processes of quantity takeoff, scheduling, and cost estimating. Stevens [6] Presented the integrated cost/schedule performance curve that achieves cost and schedule control against project plan. Used as a visualization summary tool, it can also be used as a model for predictions and forecasts. Perera and Imriyas [7] proposed the combined usage of MS Access (database) and MS Project (scheduling) software as a project time and cost control system.

in construction. The author found that obtaining true values for tasks' completion rate can be difficult and needs to be developed along guidelines rather than actual measurements.

Cost data can be difficult to gather for the EVM model; such difficulties can thus alter the schedule variance and index.

The above referred to time, cost, and EVM control systems are proven resourceful for managing construction projects. BIM is being increasingly present in the mind of construction practitioners. Eastman [16] presented BIM as a more integrated design and construction process that results in better quality buildings at lower cost and reduced project
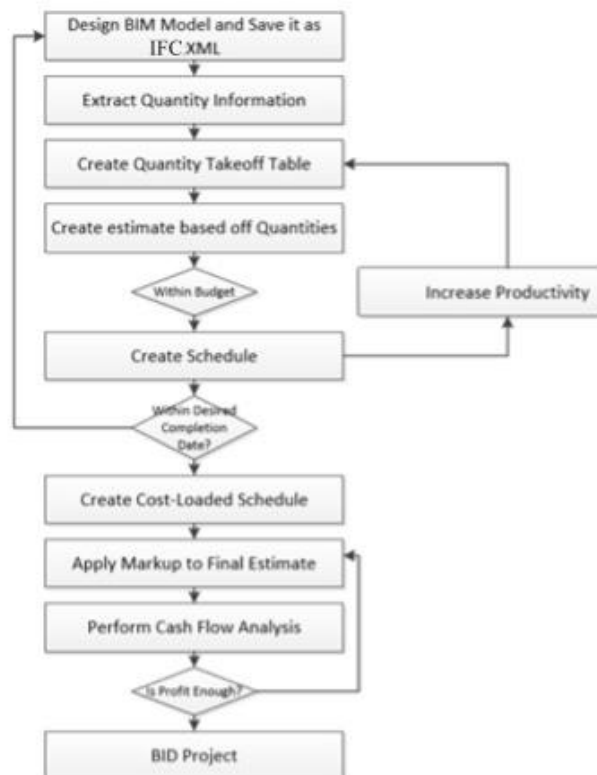
Fig 27: Cash Process Flow Diagram

9. CONCLUSION

The overall objective of this research is to elaborate the connection between cost estimation and cost control in BIM technology and also worksets integration in filtering the needed data for specific cost item. In feasibility stage client tries to determine the size of the project which would meet his budget. The estimation of the project at this point is very rough. Using BIM tools approximate building model can be linked to cost database and project price would be calculated more

efficiently along with model creation/modification process. The feature of using digitalized estimation that assemblies or building elements can be tracked individually through highlight feature. Therefore, estimator can hide what has been estimated and not missing what is still not estimated which will decrease errors in estimation. The variation between what is planned as a cost and what is in the actual is the major problem that in this research building information modelling played a role in minimizing that huge variance before. The process suggests starting from general estimating by square meter to more detail through cost data references and stimulation the construction virtually to compare different processes. The link that facilitate between quantities in BIM and cost data reference that results in the total price for specific proposal is the major update for estimator in reducing their time and controlling the cost more than before.

10. RECOMMENDATION

The Integrated time and cost has the potential to improve the actual construction practices but more improvement is needed through linking to cost data base in default with connection to worksets all together which is what is the new impact in this research and all what it is about. Multiple benefits are identified from applying it to the actual project such as ability to associate detailed cost values to each of the building model components during the design phase. facilitated estimating process with automated outputs. Creation of a time and cost baseline that serves as a reference for EVM (Earned value management) performance reporting at any time during the construction. Virtual design and construction already have breakthrough but we can improve more based on this new system proposal, Engineering and construction managers must promote its benefits first and drive its integration in the industry's practices. Although, there are various benefits when using BIM side by side with other estimation software programs for cost control, the learning curve required and the initial cost for adapting multiple programmes could be the main barriers for the spread of this advanced technology which why integration all of this elements in one platform is essential. In summary, the impact of BIM on cost estimation and cost control is all about minimizing cost and accelerating progress which what this research is to accomplish.

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