RATIOS FOR COST CONTROL

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ABSTRACT. The design of buildings takes place in phases representing a development from rough to precision planning. Estimates are made in order to test whether the result is still within the budget set by the client or developer. In this way, the decisions taken during the design phase can be quantified and expressed in monetary terms. To prevent blaming the wrong person when an overrun is discovered, the cost control process has to be improved. For that purpose, two new procedures have been developed: (i) a new 'translation' activity; and (ii) ratios by which quantities can be characterized. 'Translation' is the opposite of estimation. A monetary budget is converted - 'translated' - into quantities, reflecting the desired quality of the building materials. The financial constraints of the client are thus converted into quantities - the building components used by the designers. Characteristic quantity figures play an important role in this activity. In working out an estimate, the form factor (i.e., the ratio between two characteristic values of a building component) has to be determined. The unit cost is then tested against that ratio. The introduction of the 'translation' activity and the use of characteristic quantity figures and form factors enhance existing estimation methods. By implementing these procedures, cost control becomes considerably more reliable.

1. Introduction

In an overview of the development of approaches to building cost and price forecasting, Raftery (1987) identified first, second and third-generation models. Models of the second (use of regression analysis) and third (probabilistic estimates and knowledge-based computer systems) generation represent attempts by researchers to improve the quality of cost data. But the practitioners in the field in the UK still prefer first-generation models, such as the floor-area model and the elemental model. Ter Haar (1991) comes to the same conclusion for the Netherlands in his comparative analysis of methods used for costing in the early planning stages.

Skitmore (1992) compared more than 30 estimating techniques. He found that the reliability of estimates generated by the traditional model is a function of the reliability of each quantity value, the reliability of each rate value, the number of items, and the collinearity of the quantity and rate values. He concluded that the last factor is often overlooked in assessments of reliability; these tend to assume that the errors made in estimating quantity and cost value are independent. To enhance the reliability of cost values, ratios called characteristic cost figures have been developed. In this paper, I will present ratios that can be used to characterize quantities. This particular use of ratios was first introduced in the 1950s in the Storey Enclosure method (Bathurst and Butler 1980). To make the cubic method more realistic, this estimation method employs factors that account for storey heights, basements, and areas of enclosing walls.

In the United Kingdom, the Building Cost Information Service (BCIS) was set up in 1962. This organization created a data bank of building cost analysis with ratios that took the gross floor area into account. In the Netherlands, Misset (Poortman 1990) publishes cost analyses with ratios also related to the gross floor area and the cubic metre. Bathurst and Butler also give examples in the chapter describing cost analysis because "the relations between the costs and the method of

H. Timmermans (ed.), Design and Decision Support Systems in Architecture, 123–136.

comparing the values would hold true if the figures had been produced from the tender sum by the addition of the costs of those items associated with quantities of elements. ... The full effect of plan shape is not always easy to establish, but a simple method can be devised of relating the amount of external cladding elements to the superficial floor area of the building so as to reveal the effect of different plan shapes. The relationship can be expressed as a ratio of the area of the external cladding elements to the floor area of the building, and is commonly referred to as the external cladding to floor ratio" (Bathurst and Butler 1980).

All this was sufficient reason to examine the total process of designing buildings, including the ratios that may play an important role in cost control. In doing so, I have developed a new activity, which I call 'translation', where a budget couched in monetary terms is converted - 'translated' - into quantities based on the desired quality of the building materials. This operation is the opposite of making an estimate. In other words, it is the opposite of the check with hindsight, i.e., after the decisions have been taken, which can only reveal whether the decisions were right or wrong. In 'translation', characteristic quantity figures play an important role; in preparing an estimate, the form factor has to be used. Characteristic quantity figures and form factors will be discussed in the next sections.

2. Cost Control

The term 'budget' refers to the assets available for a particular item or activity. The term 'assets' has a different connotation for the diverse parties involved in the building process. To the client, the budget is a sum of money that he is prepared to spend on the building. To those implementing the order (contractors, installers), it is the means of production - labour, materials, and equipment. For both parties, the budget is expressed in terms of the assets allocated to the object. We could say that the client buys the building from parties who have used their means of production to construct it.

client →	money
designer →	building components (element groups, elements)
contractor →	means of production (labour, materia,, equipment)

Figure 1. The parties involved and their budgets
Source: Poortman (1990)

But what are the assets of the designers (architects, builders, installation consultants)? What do they actually spend these assets on? The answer is straightforward: building components! During the design process, they take all kinds of building components from a storage cupboard, so to speak. These components are used to construct a technically, functionally and aesthetically acceptable product. Of course, this is a conceptual procedure; their product - the drawing - shows what building components have been used. These items play an important role in cost control. In principle, the designers should be able to give full attention to the selection of building components. However, as they are accountable to and have to communicate with the client, they must also take the budget into consideration. Cost-conscious design is mainly a question of making good use of the tool of cost control. In the beginning of the design process, the overall making good use of the tool of cost control. In the beginning of the design process, the overall costs can be influenced to a large extent. Towards the end, the influence of cost-conscious design is slight (UGCB 1985). Figure 2 illustrates this change in its impact on cost.

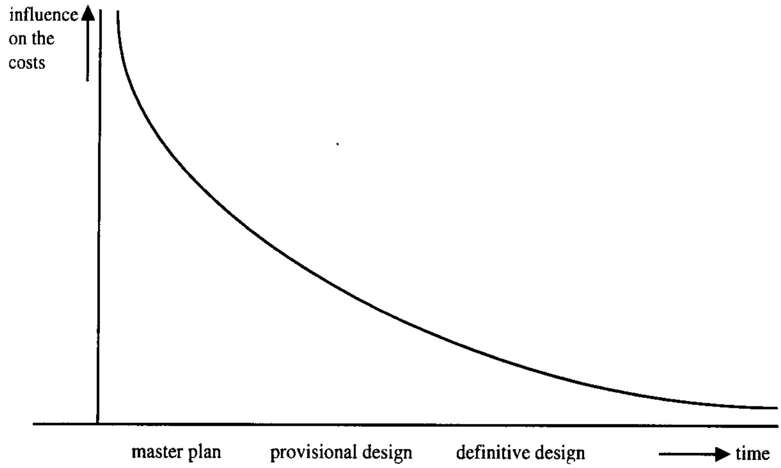


Figure 2. The effect on costs during the design process

Cost control can be reduced to two essentially different activities: estimation and 'translation'. The design process proceeds in three steps (BNA 1988): master plan, provisional design, and definitive design. In the course of these steps, these two activities are carried out repeatedly. In the meantime, the number of cost centres keeps increasing. The question recurring throughout the design process concerns how much of the assets will be required in relation to the budget, i.e., the client's money that is supposed to be spent on building components made from building materials. The quantities are specified in terms of building components. These items represent the cost per unit; in turn, these costs are made up of quantities and unit costs of the means of production.

The most familiar activity is the preparation of an estimate. Unfortunately, cost control is often restricted to this. The estimate is merely a financial representation of the design. After decisions have been taken, they are quantified and expressed in monetary terms. This is known as 'pricing'. The main purpose of making an estimate is to test whether the design is feasible within the (client's) budget.

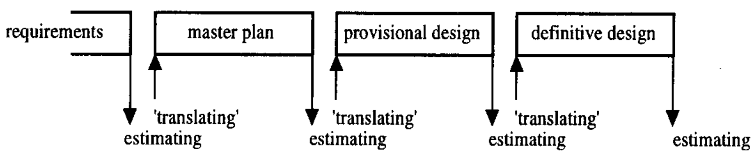


Figure 3. The place of estimation and 'translation' in the design process

'Translation' occurs prior to each step in the design process. It can be regarded as one of the planning activities. The requirements set for space components are translated into characteristics of building components. For instance, an air temperature of 20^0 C in a room determines the necessary R value of walls and roof, as well as the power kW of a heating system. In regard to cost, the budgets, expressed in Dutch guilders, are 'translated' into quantities of building components. The purpose of 'translation' is to relate the technical and financial requirements of the client to the units of the designer, i.e., the building components.

Estimation and 'translation' may be considered as processes with input data, output data, control data, and means.

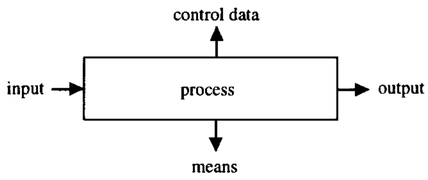


Figure 4. The process of estimation and 'translation'

The input and output data pertain to the project that is being designed. The input data can always be taken from the drawings or descriptions of the building in question. The output is the estimate or 'translation' for that building. In order to carry out the process, criteria, data, methods, knowledge, etc. are necessary. Together, these constitute the control or management data. They are independent of the project being undertaken; they must be applicable to any project. Finally, the means are the people and the machines that carry out the process; hence, both the costing expert, with his calculator, and the computer.

One and the same simple equation plays an important part in such processes. According to this equation, the quantity of the cost centres is multiplied by the cost per unit and the results are added together.

$$\sum_{\text{cost centres}} \text{quantity x costs per unit}$$

The remainder of this article elaborates on how this equation should be used in practice. The input, output and management data are treated separately for the estimation and 'translation' activities.

3. Estimation

The input data for this activity consist of quantities. These can be derived from written documents, such as a programme of requirements, or drawings, such as a floor plan. The data related to the design can be read or measured. Some further calculation is necessary, but generally it is not difficult to determine the quantities, i.e., the number of cost units. The result of the process, the output data, is best represented by the term 'building sum'. This is the amount which will probably be spent. The building sum may refer to a separate cost centre as well as to the total for all cost centres. The building sum can be calculated on the basis of the control or management data. That data consists of the cost per unit, on which basis the quality of a cost centre has been determined.

This procedure represents the process of estimating in its most elementary form. The estimation of the definitive design is generally carried out in this way. By that stage, the design has progressed so far that estimates can be made at the most detailed level; that is, the level of the building file (see Appendix 1). In determining the price, allowance is only made for factors affecting the cost per unit of the means of production. Factors such as series and routine effect, quantity discount, regional differences in time rates and cost of materials, and reference date can be determined on the basis of characteristic figures. These may include routine lines, discount percentages, correlation coefficients, and index figures, for instance.

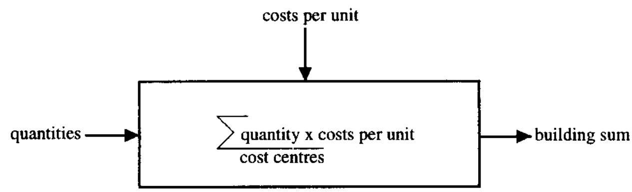


Figure 5. Estimation in its most elementary form

That does not apply to the estimates which have to be made earlier in the design process. There, the cost information is frequently obtained from so-called cost analyses (see Appendix 2). The form factor, which affects the cost per unit of building components, is of great importance. Thus, before the cost per unit can be entered into the equation, the form factor has to be checked. If discrepancies are found, it must be adjusted accordingly in the cost per unit. The following example will clarify the role of the form factor.

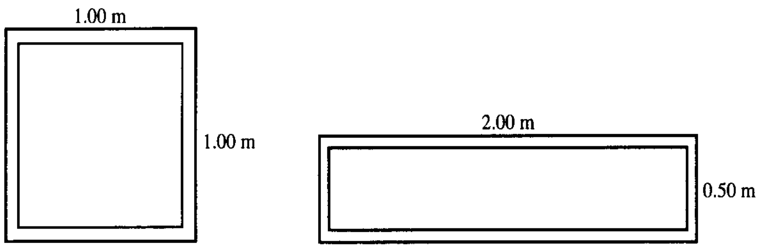


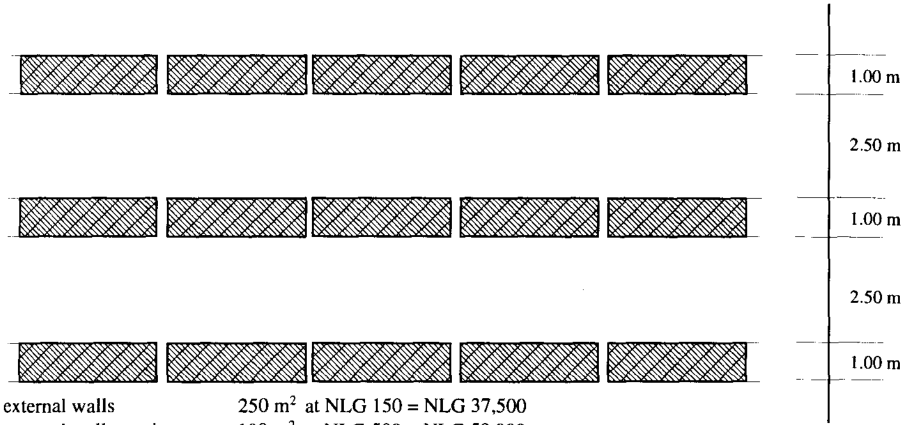
Figure 6. Two windows of the same surface area and different form factors

The cost per unit of a building component is expressed in the unit most convenient for that element. The cost of the square window in Figure 6, measuring 1 x 1 metre, was analyzed. It was found to be NLG 550 per square metre, specified as follows: 1 m^2 of glass at NLG 150 per m^2 = NLG 150; and 4 m of frame at NLG 100 per metre = NLG 400. Should this amount be used in an estimate for another project in which windows also occur with a surface area of 1 m^2 but are rectangular in shape (2 x 0.50 m)? The answer is no. The form factor, in this example the ratio *periphery* (m^1) / *surface area* $(m^2)$is 4.00 for the window analyzed and 5.00 for the new window to be estimated. This shows a difference of + 1.00. That outcome requires correction of the cost per unit, which was said to be + 1.00 x NLG 100 = + NLG 100. A sum of NLG 650 must therefore be included in the estimate as the cost per unit.

For an accurate estimate, it is necessary to take the form factors into account. This estimation process is shown schematically in Figure 7.

4. 'Translation'

The newly developed activity of 'translation' converts the budget - i.e., the amount of money made available by the client - into quantities of building components. The same equation can be used as for making an estimate, while the cost per unit can be used for control purposes (Fig. 8). 'Translation' in its most elementary form only applies if the budget can be spent freely. In reality, If the client accepts the element-group estimate, he also agrees with the amount allowed for the external wall structures, NLG 200. This is the budget for the external wall structures. Using the



external walls	250 m² at NLG 150 = NLG 37,500	
external wall openings	100 m² at NLG 500 = NLG 50,000	
total	350 m²	NLG 87,500

costs per m² of frontage: NLG 250

Figure 10. Fragment of a frontage

characteristic quantity figures, it can then be calculated how much of that amount applies to external wall openings and how much to external walls: 0.286 x 800 = 229 m^2 external wall openings; 0.714 x 800 = 571 m^2 external walls. A 'translation' has thus been carried out in accordance with the model in Figure 11. The 800 m^2 of external wall structures has been 'translated' into 229 m^2 of external wall openings and 571 m^2 of external wall.

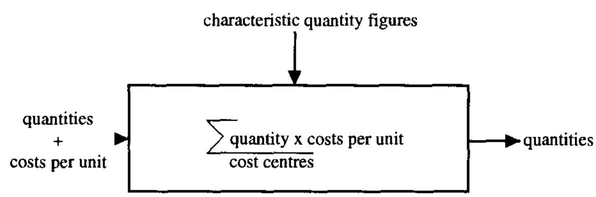


Figure 11. 'Translation' using characteristic quantity figures

The results of 'translation' can be regarded as one of the countless ways to stay within the budget. This is, however, not an arbitrary solution but one which is based on data derived from the analysis of a project. Therefore, this result is a goal to aim for.

5. Characteristic Quantity Figures and Form Factors

The distinction between estimation and 'translation' demonstrates that they are different activities. In the estimating process, the quantities of the cost centres are expressed in monetary terms. In other words, "what is the building sum for the design?" 'Translation' determines the quantities of the cost centres which have to be incorporated in the next step in the design process. The result of estimation - i.e., the building sum - is compared in this process with a previously set budget. After approval, it serves as a new, possibly adjusted, but in any case more detailed budget.

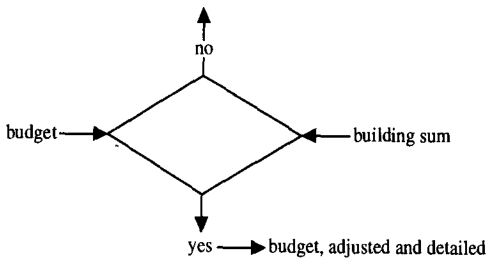


Figure 12. From building sum to budget

In practice, estimation and 'translation' cannot be performed separately. These activities have to be regarded as 'Siamese twins'. Form factors are used in making an estimate in order to check the cost per unit. The characteristic quantity figures are used in 'translation' for a further breakdown of the quantities. Sometimes, if the form factors cannot be verified, estimation yields not just a building sum but also quantities.

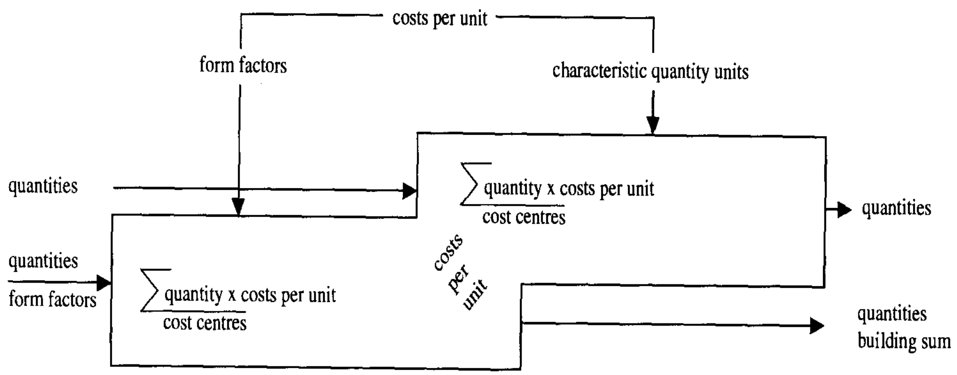


Figure 13. Estimation and translation combined

Jointly, estimation and 'translation' play a significant role in the m^2 estimate, the element-group estimate, and the element estimate. Different characteristic figures and form factors are important for each estimate. The ratios of the gross and net floor space in Figure 14 are significant for the m^2 estimate at the start of the master-plan phase. In preparing the element-group estimate, after the completion of the master plan, the characteristic figures and factors with the element groups in the denominator are important. The characteristic quantity figures with which the outside and inside wall openings can be quantified are also used (Figure 15).

Finally, the element estimate is associated with a large number of form factors. The elements and varying element groups which form part of the building work are expressed in m^2, pieces (number) or linear metres. For each building component with m^2 as its unit, the ratio *peripher* (m^1) / *surface area* (m^2) is used as the form factor. This factor is important for the following

cost centre	characteristic quantity figure	form factor
gross floor space	net floor space (m^2) / gross floor space (m^2)	location facilities (m^2) / gross floor space (m^2)
	structural surface (m^2) / gross floor space (m^2)	roof 'floors' (m^2) / gross floor space (m^2)
	ground floor (m^2) / gross floor space (m^2)	external- and internal wall structures (m^2) / gross floor space (m^2)
	upper floor space (m^2) / gross floor space (m^2)	transport facilities (no.) / gross floor space (m^2)
		heating- and cooling facilities (kW) / gross floor space (m^2)
		liquid and drainage facilities (no.) / gross floor space (m^2)
		lighting systems (kVA) / gross floor space (m^2)
net floor space	traffic area (m^2) / net floor space (m^2)	
	services area (m^2) / net floor space (m^2)	
	'lost' surface area (m^2) / net floor space (m^2)	
	useful surface area (m^2) / net floor space (m^2)	

Figure14. Characteristic quantity figures and form factors for the m^2 estimate

element or varying element groups: ground facilities (dirt), ground facilities (water), floor beds, external walls, internal walls, ground floors, upper floors, roofs, external wall openings, windows in external wall openings, doors in external wall openings, fixed external wall openings, internal wall openings, windows in internal wall openings, doors in internal wall openings, fixed internal wall openings, roof openings, floor finishes (ground floor), floor finishes (upper floors), ceiling finishes (under floors), ceiling finishes (under roofs), and roof finishes. For building components which are quantified on a piece basis, the ratio *length* m^1 / *quantity (no.)* is the form factor. This applies to pile foundations, main load-bearing structures (columns), stair structures, and transport. The building components with m^1 (linear metres) as their unit have no form factor.

The installation parts in the element estimate are expressed in units such as kW, m^3/h, kVA and pieces. The first three of these are associated with the elements for generating heat, cold, air, and possibly electricity. These are concentrated in one or two appliances. Form factors play scarcely any part in the cost per unit of those appliances. However, the building elements which are stated in units (off), i.e., the distribution parts of these appliances, always consist of two parts: pipes and outlet points.

For the cost per unit, the ratio *piping* (m^1) */ outlet points (off)* is extremely important. This ratio, which has already been described for the building elements expressed in units (off), applies to outlets (rain water), outlets (waste water), outlets (solid waste), water, gases, cold-air distribution, heat distribution, ventilation (distribution), and lighting. 'Translation' plays a considerably smaller role in the element estimate than in the element-group estimate. It does not determine quantities of building components at a lower level than estimated. The results can be described as quantities of building materials.

In principle, 'translation' plays an important role for all building components comprising more than one fixed combination of building materials. In particular, the elements subsumed under the

cost centre	characteristic quantity figure	form factor
location facilities	ground facilities; soil (m^2) / location facilities (m^2)	periphery at normal level (m^1) / location facilities (m^2)
	ground facilities; water (m^2) / location facilities (m^2)	pile foundations (no.) / location facilities (m^2)
ground floors	floor beds (m^2) / ground floors (m^2)	foundation beams (m^1) / ground floors (m^2)
	floors (m^2) / ground floors (m^2)	column bases (no.) / ground floors (m^2)
	floor finishes; ground floor (m^2) / ground floors (m^2)	
upper floors	floor finishes; upper floors (m^2) / upper floors (m^2)	beams under floors (m^1) / upper floors (m^2)
	ceiling finishes; under floors (m^2) / upper floors (m^2)	columns under floors (st) / upper floors (m^2)
roof 'floors'	roofs (m^2) / roof 'floors' (m^2)	beams under roofs (m^1) / roof 'floors' (m^2)
	roof openings (m^2) / roof 'floors' (m^2)	columns under roofs (st) / roof 'floors' (m^2)
	ceiling finishes; under roofs (m^2) / roof 'floors' (m^2)	
	roof finishes (m^2) / roof 'floors' (m^2)	
external wall structures	external walls (m^2) / external wall structures (m^2)	conn. external wall structures (m^1) / external wall structures (m^2)
	external wall openings (m^2) / external wall structures (m^2)	
internal wall structures	internal walls (m^2) / internal wall structures (m^2)	conn. internal wall structures (m^1) / internal wall structures (m^2)
	internal wall openings (m^2) / internal wall structures (m^2)	
transport facilities	stair structures (no.) / transport facilities (no.)	transport facilities (fl) / transport facilities (no.)
	transport (no.) / transport facilities (no.)	
heating and cooling facilities	heat systems (kW) / heating and cooling facilities (kW)	heat distribution (no.) / heat generation (kW)
	cooling systems (kW) / heating and cooling facilities (kW)	cold-air distribution (no.) / cold generation (kW)
		ventilation (m^3/h) / heating and cooling facilities (kW)
		ventilation; distribution (no.) / ventilation; generation (m^3/h)
liquid and drainage facilities	liquid facilities (no.) / liquid and drainage facilities (no.)	
	drainage facilities (no.) / liquid and drainage facilities (no.)	
lighting systems	lighting power (kVA) / lighting systems (kVA)	lighting (no.) / central electr. supplies (kVA)
	power current (kVA) / lighting systems (kVA)	
external wall openings	windows in external wall openings (m^2) / external wall openings (m^2)	
	doors in external wall openings (m^2) / external wall openings (m^2)	
	fixed external wall openings (m^2) / external wall openings (m^2)	
internal wall openings	windows in internal wall openings (m^2) / internal wall openings (m^2)	
	doors in internal wall openings (m^2) / internal wall openings (m^2)	
	fixed internal wall openings (m^2) / internal wall openings (m^2)	

Figure 15. Characteristic quantity figures and form factors for element-group estimation

heading of finishing are 'translated' into the share that each of thebuilding materials(e.g.,linoleum tiles and project carpet) has in the total (the floor finishing). The varying element groups for the outside and inside wall openings may consist of different building products (e.g., side-hung windows and casement-stay windows or fire-resistant and normal doors). In that case, they require a 'translation'.

With building components, it is still possible to give a concrete description of the characteristic quantity figures. This is no longer possible when we pass from building elements to building components. The number of building elements is limited, and they are more or less accurately classified. The number of building materials, on the other hand, is practically unlimited. Even the low number of building components which are still 'translated' in this phase will lead to an unacceptably long list of characteristic quantity figures. Standard characteristic values cannot be developed for the element estimate.

Estimation and 'translation' together build a bridge between the subsequent steps in the design process. The budget is regularly tested and given greater detail. At the same time, information is obtained in the form of a possible solution for the following step. In this process, characteristic quantity figures and form factors are important management data. As the estimates / 'translations' become more detailed, the number of characteristic values and factors increases. Up to and including the element estimate, the standard ratios do not depend on the individual project. The values associated with these ratios can be determined from analyses of projects that are considered 'right'. Non-standardized characteristic quantity figures can still play a role in the 'translation' element. These figures can only be obtained from one single comparable project and are therefore somewhat less reliable. At that point, however, we are at the end of the process. There - as indicated in Figure 2 - the influence on the total cost is slight. The use of less precise values will then certainly not lead to failure of the cost-control exercise.

References

Bathurst, P.E. and Butler, D.A. (1980) *Building Cost Control Techniques and Economics*, Heinemann, London.

BNA (1988) SR 1988, Amsterdam.

Haar, E. ter (1991) *Gebouwkostenkennis - Een Analyse van Instrumenten voor de Vroege Planfasen,* Delftse Universitaire Pers, Delft.

Naar een Ordening op de Bouwmarkt (1982) Government Publishing Office, The Hague.

NEN 2630 (1979) Oppervlakten en Inhouden van Gebouwen, Delft.

NEN 2631 (1979) Investeringskosten van Gebouwen, Delft.

NEN 2632 (1980) Exploitatiekosten van Gebouwen, Delft.

Poortman, E.R. (1990) *Budgetbewaking in de Bouw*, Samsom, Alphen a/d Rijn.

Raftery, J. (1987) "The State of Cost/Price Modelling in the UK Construction Industry: A Multicriteria Approach", in P.S. Brandon (ed.), *Building Cost Modelling and Computers: The Transactions of the Building Cost Research Conference*, E.&F.N. Spon, London, pp. 49-71.

Schaefer, W.F. and Erkelens, P.A. (1988) Structurering en Verwerking van Tijdgegevens voor de Uitvoering van Bouwwerken, Bouwstenen 9, Faculty of Building and Architecture, Eindhoven University of Technology, Eindhoven.

Skitmore, M. (1992) "Developments in Contract Price Forecasting and Bidding Techniques", in P.S. Brandon (ed.), *Quantity Surveying Techniques: New Directions*, Blackwell Scientific Publications, Oxford, pp. 75-120.

UGCB et al. (1985) Elementenmethode 1985, UGCB, Ede.

Uniform Prijsregelend Reglement (1988) Association of Cooperating Price-Control Organisations in the Building Industry.

Appendix 1

Specification of building costs (NLG), ref. date April 1, 1989

(32) Inside-wall openings

Code	Designation	Unit	Quantity	Man-hours per unit	Man-hours total	Costs per unit	Costs total
(32)011	**Inside-wall openings, inside doors, veneered doors, oak, stub, up to 25 off**						
	LABOUR						
	Hanging inside door, stub	piece	1	0.850	0.850	32.21	32.21
	Fitting closers+metalwork	piece	1	0.250	0.250	9.48	9.48
	Subtotal	piece	1		1.100		41.69
	MATERIAL						
	Hinge, st.st., 76x76mm	piece	1			5.04	5.04
	Latch, brass, front plate	piece	3			13.03	13.03
	......	piece	1			4.47	4.47
	....	piece	1			8.49	8.49
	......	piece	1			133.65	133.65
	....	piece	1			5.65	5.65
	Subtotal	piece	1				180.41
	SUBCONTRACTORS						
	Top coat sealed door	piece	1			31.30	31.30
	Subtotal	piece	1				31.30
	TOTAL						253.40
	COSTS PER UNIT	piece				253.40	

COSTS (NLG)				reference date	May 1985	
code designation	quantity per unit		costs per unit	costs total	costs per m^2	%
(11) ground facilities	867	m^2	17.01	14,749	5.43	0.6
(13) floor beds	675	m^2	53.93	36,405	13.39	1.4
(16) foundation	290	m^1	176.98	51,323	18.88	2.0
(17) pile foundations	150	st	157.18	23,577	8.67	0.9
(1-) GROUND SUBSTRUCTURE				**126,054**	**46.38**	**5.0**
(21) external walls	1351	m^2	188.73	254,979	93.81	10.1
(22) internal walls	2243	m^2	161.29	361,767	133.10	14.3
(23) floors; ground floor	165	m^2	52.61	8,680	3.19	0.3
(23) floors; upper floor	1788	m^2	117.61	210,282	77.37	8.3
(24) stairs, ramps	3	st	14025.67	42,077	15.48	1.7
(27) roofs	844	m^2	121.81	102,808	37.82	4.1
(28) main-load bearing structure	388	st	170.88	66,300	24.39	2.6
(2-) STRUCTURE				**1,046,893**	**385.17**	**41.5**
(31) external wall openings	502	m^2	603.52	302,965	111.47	12.0
(32) internal wall openings	246	m^2	444.94	109,456	40.27	4.3
(33) floor openings		m^2				
(34) balustrade and banister	76	m^1	167.76	12,750	4.69	0.5
(37) roof openings		m^2				
(38)						
(3-) COMPLETION				**425,171**	**156.43**	**16.9**
(41) external wall finishes		m^2				
(42) internal wall finishes		m^2				
(43) floor finishes	2426	m^2	47.71	115,741	42.58	4.6
(44) stair finishes		m^2				
(45) ceiling finishes	2421	m^2	45.74	110,746	40.75	4.4
(47) roof finishes	844	m^2	59.01	49,801	18.32	2.0
(48)						
(4-) FINISHES				**276,288**	**101.65**	**11.0**
(51) service centre	210	kW	109.81	23,060	8.48	0.9
(52) drainage	44	off	554.14	24,382	8.97	1.0
(53) liquids supply services	30	off	207.77	6,233	2.29	0.2
(54) gas supply services	30	m^1	117.17	3,515	1.29	0.1
(55) space cooling services		kW				
(56) space heating services	138	off	490.28	67,658	24.89	2.7
(57) air cond. services	16820	m^3/h	13.95	234,565	86.30	9.3
(58) control	1		23709.00	23,709	8.72	0.9
(5-) SERVICES (MAINLY PIPED AND DUCTED)				**383,122**	**140.96**	**15.2**
(61) electrical centre	38	kVA	2263.68	86,020	31.65	3.4
(62) power distribution services	15	kVA	264.07	3,961	1.46	0.2
(63) lighting services	392	off	218.12	85,503	31.46	3.4
(64) communication services	1		32600.00	32,600	11.99	1.3
(65) security services	1		15442.00	15,442	5.68	0.6
(66) transport services	1	off	41867.00	41,867	15.40	1.7
(6-) SERVICES (MAINLY ELECTRICAL)				**265,393**	**97.64**	**10.5**
(71) display, circulation fittings		off				
(72) rest, work, play fittings		off				
(73) culinary fittings		off				
(74) sanitary, hygiene fittings		off				
(75) cleaning, maintenance fittings		off				
(76) storage, screening fittings		off				
(7-) FITTINGS						
(-0) DIRECT PROJECT FACILITIES				**2,522,921**	**928.23**	**100.0**
(0-) INDIRECT PROJECT FACILITIES	**25**	**%**		**630,730**	**232.06**	**25.0**
(--) COSTS OF THE BUILDING	**2718**	**m^2**		**3,153,651**	**1160.28**	**125.0**

Appendix 2

COST ANALYSIS	Project: Office building in Eindhoven	CI/SfB-building code 32
	Useful surface area: 1625 m^2	Office building
	This analysis was compiled by : ir. E.R Poortman	Reference date: May 1985

BUILDING PARTNERS

Client/management:
Maasveste BV, Eindhoven

Architects:
L.I.J. de Bever and L.J.H.F. de Bever Architecten, Eindhoven

Advisors:
- installations: Raadgevend Technisch Buro Van Heugten BV, Nijmegen
- structures: Ingenieursburo Schiebroek-Struik BV, Eindhoven

Contractor:
Nelissen van Egteren Bouwgroep BV, Venray

Installer:
Eikemans-Nobra BV, Eindhoven

DESCRIPTION OF PROJECT

The office building was planned for a site with a total area of approx. 2000 square metres situated on the ring road in Eindhoven, near the Evoluon. The location was the reason for a "bent shape" with an entrance, vertical transport and general facilities in the bend and two wings with user rooms, each ending in built-in emergency staircases. The wings are 11.40 m deep and consist of a 1.80 m wide passage situated in the middle, with 4.80 m deep rooms on either side. On the second floor one wing is fitted for instruction purposes, with a passage on the frontage and rooms 9.60 m deep. In the longitudinal direction the building is divided into 3.60-m bays, a dimension with is also repeated in the disc-shaped column on the frontage. Within the building, for the sake of ready divisibility, only (round) columns at center distances of 7.20 m have been built. The building consists of three floors and a roof superstructure.

CONTRACT PARTICULARS

Duration of operations:	180 working days
Form of tendering:	single price offer
Risk arrangement:	not applicable
Start of operations:	20th May 1985
Completion date:	April 1986

DRAWINGS

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QUANTITIES

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DESCRIPTION OF ELEMENTS

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