COST MODELING AS A MANAGEMENT TOOL FOR REFURBISHMENT PROJECTS

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ABSTRACT

In the Dutch housing stock, many residential buildings constructed between 1945 and 1975 either need major refurbishment or have to be replaced by new construction [1]. In the context of the sustainability of the housing stock, refurbishment seems to be the more promising one of these two approaches [2].

An important success factor in refurbishment projects is the possibility to match (existing or easy to accomplish) quality dimensions of a building with the requirements of one or more target groups of (future) tenants. Based on experiences in recently executed projects in several Dutch cities, the paper will show how cost modeling can help to find the right match in such a project.

Key words: Housing, Management, Development, Modeling.
Introduction

After the Second World War, in the Netherlands (and elsewhere in Europe), a large amount of dwellings were built in new urban extensions. Approximately, one third of these dwellings consist of apartments of modest dimensions and quality. At the time of construction these apartments were designated for mostly young families, but in the course of years the population of the neighborhoods has changed. Driven by family development (children growing older and leaving their parental homes) and economic improvement the initial tenants’ group has been replaced by newcomers: people with low income, often coming from foreign countries. Partly due to the relatively large scale of the neighborhoods in question the evolved uneven composition of the population is now becoming a problem [3].

Which kind of solutions do we have to aim at? In recent years, the capacity of our building industry in terms of numbers of new housing development did not exceed the amount of just 1% of the stock [1]. Therefore major redevelopment by demolition and new construction to solve these urban (sustainability) problems on a significant scale would need a considerable expansion of this industry. This is practically beyond economic feasibility and both the ecological and social sustainability of such an approach could be questioned.

To improve the sustainability of our living environment, renovation appears to offer at least the same possibilities as new construction. Renovation is expected to result in dwellings with less energy efficiency, but new construction usually causes so much more environmental burden as related to the applied construction materials that it often cannot compete with renovation as far as sustainability is concerned [2]. Since by far not all housing problems can be solved with renovation alone, strategic measures in the existing urban areas, which are cost effective, in ecological as well as social and economic sense, should probably exist of combinations of renovation and new construction.

In redevelopment projects that are related to this approach, a complex decision making process has to be facilitated by an adequate building cost estimation model. The cost information offered by such a model should serve both the general policy decisions and the design decisions, which are involved in the project. In section 2 the principles of such a model are presented. Section 3 offers an example of practical experience in the case Nijenheim at Zeist (a town in the centre of the Netherlands). In section 4 some conclusions are drawn.
Design and development process

Flexible design process in a formal development process

While the design process allows an architect quite well to go up and down the composition hierarchy of a building (or complex) in order to evaluate several design alternatives on different levels, the sequence of formal development process stages is much more static. When in practice a certain phase is completed by an official client’s approval, only very severe arguments can make the process return to that phase, otherwise, economic interests of the involved parties would be damaged too much. This static character of the development process sequence, as compared to the sequences in the design process, urges architects and other professionals in building development projects to be quick and lean in going ‘up and down the design ladder’ to evaluate possibilities of interesting design alternatives on different scale levels. Especially in the early stages, architects may want to evaluate several alternatives (for features on lower scale levels) on a very quick basis, because budget for extended research is usually not available. Estimating tools should be able to follow this quickly going ‘up and down’. In other words they need to offer ‘ready and easy’ cost information that can be used to evaluate design alternatives on different scale levels simultaneously, connecting the information on the discerned levels in a way that excludes double counting or omission.

Requirements for an estimating model

Many architects prefer to relate, as to building cost data, to their own experiences from previous design commissions concerning similar buildings. They do so mainly, because in the early process stages no better alternative is usually available. Using these self-made cost data for the early process stages has several drawbacks. The (greater part of) project documents in architectural firms are not structured in such a way that the contained cost data can be modeled according to the (main) dimensions of preliminary design. In general, the cost information from these reference projects is poorly connected to the information in later development stages.

In addition, a need for more specified cost data will become evident very soon in the process. Design is then probably dealing with alternative building forms. And several combinations of functional and/or spatial entities may be considered. Technical specification of building elements, however, may be still far away. In this stage of preliminary design, information is needed that relates costs to alternative combinations of (functional) project sections and varying dimensions of buildings. Not until the process stages of definite design and specifications, cost information referring to more specified elements (i.e. technical solutions) is required or applicable, since the detailing of the design has not yet proceeded thus far.
Only in these final stages, cost effects of applying different materials and semi-finished products are considered on a more extensive scale.

So, cost analysis should be closely related to the requirements from the design process. That means being specified if required, but global when the decisions involved have a global character; and, moreover, the model should be able to follow the designer ‘up and down the design ladder’, as mentioned before.

**Filling in the missing link**

At this point the existing tools for cost estimating apparently have a missing link. At the top end of the composition hierarchy, a general idea of building costs may be available, based on square meter prices of previously designed projects. At the bottom end, unit-prices of functional building elements may be available from a data base of cost analyses, which links specified elements (i.e. technical solutions) to the costs of materials, labor etc. through element recipes.

![Diagram](image-url)

**Figure 1:** Decomposition of cost information according to functional building elements.
In between, however, the existing estimating tools do not provide information about which combination of technical solutions is characteristic for the actual type of building in the concerned development project. To fill in this missing link, the Reference Projects Model has been composed. It provides the needed data, based on the idea that (within a building market region, e.g. the Netherlands) a building is a unique product, not so much because of the unique technical solutions it consists of, but much more because of the unique combination of (per se) similar technical solutions.

The Reference Projects Model

The idea behind the Reference Projects Model is that an architect deduces the construction costs of a new design from the construction costs of a project he already knows: the reference project. Evidently, projects that contain the architect’s own designed buildings are the reference projects most suitable to him. So, in general, an architect should relate the new project, in which he actually is involved as a designer, to other projects from his own portfolio. Two exceptions can be discerned on this rule: (1) the architect is confronted with a commission referring to a category of buildings he is not acquainted with, and (2) there is not a database with well-structured cost data referring to the architect’s portfolio. In these situations a public database of reference projects could provide ‘second best’ cost data for early development process stages. The Reference Projects Model has been designed as such a database [4]. By using this model, architects (and clients) are able to estimate the costs of housing projects on an appropriate scale level in all stages of the development process.

The Project Sections Model

In the 1980s the Municipality of Rotterdam developed and used the so-called Project Sections Model. In this model construction costs are not designated to building elements, such as walls, doors and ceilings, but to building areas, which are characterized by their functional use, e.g. residential areas (‘dwelling-types’), storage areas and access and circulation areas. If a building project is divided into these types of areas, implementing the construction costs of certain specified building parts in an estimate turns out to be problematic. For instance the foundations, roofs and end elevations of a building belong to this category of building parts. Consequently, together with the functional areas, these specified building parts are discerned as ‘project sections’ in the model [5] [6]. In the 1990s this model was used in several building projects that integrated housing development with the development of shops. In 2002 the model was adapted for improved use in all kinds of complicated building development projects [7].
Combining two models

The Project Sections Model is a pre-eminent tool for management decisions referring to the major alternatives in a project development process: what kinds of dwelling types are to be constructed, how much usable floor area (UFA) per apartment is feasible, which quality levels are wanted, what should be the general approach for the improvement of the thermal insulation (in renovation projects) etc.

In the Project Sections Model, however, cost data are not linked to technical solutions for building elements. Therefore the cost effects of differences in the shape of building elements or in the applied materials cannot be estimated in this model. Consequently, unlike the Reference Projects Model, the Project Sections Model cannot follow the design decisions in the later stages of the development process. In order to solve this imperfection, which has often caused a hobble in the decision making process of development projects, both models have been integrated in a matrix structure.

<table>
<thead>
<tr>
<th>elements</th>
<th>project sections</th>
<th>main entrance</th>
<th>apartment type 1</th>
<th>apartment type 2</th>
<th>boxroom type 1</th>
<th>etcetera</th>
<th>total per element</th>
</tr>
</thead>
<tbody>
<tr>
<td>substructure</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>xx</td>
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<tr>
<td>primary structure</td>
<td>x</td>
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<td>x</td>
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<tr>
<td>roofs (secondary structure/finishing)</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>xx</td>
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<td>facades (secondary structure/finishing)</td>
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<td>x</td>
<td>x</td>
<td>x</td>
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<td>internal walls (secondary structure/finishing)</td>
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<td>etcetera</td>
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<tr>
<td>total per project section</td>
<td>xxx</td>
<td>xxx</td>
<td>xxx</td>
<td>xxx</td>
<td>xxx</td>
<td>xxx</td>
<td>xxxxxx</td>
</tr>
</tbody>
</table>

Figure 2: matrix of elements and project sections.

That is, the Project Sections Model is used in combination with elemental bills of quantities for the discerned project sections, in which the concerned quantities are derived from reference projects. By composing the cost arrays of all project sections exactly in the same format, building costs can be aggregated in project sections as well as in (clusters of) elements. This way, in the early process stages (Project Definition) decisions can be underpinned with cost information that is aggregated in project sections, while the same cost information is available in the next process stages (Preliminary Design and further), but then aggregated as building costs of various elements.

The case of Nijenheim

The combination of the Project Sections Model and the Reference Projects Model, as described above, is used in a number of redevelopment projects in several cities in the Netherlands: Amsterdam, Rotterdam, Delft, Zwolle, Amersfoort, Apeldoorn and Hertogenbosch.
The greater part of the projects refers to the redevelopment of apartment blocks built in the 1960s. However, in one of the projects a nineteenth century convent is to be transformed in a residence with either facilities for sheltered accommodation or luxurious apartments. In all projects, decision-making in the Project Definition stage concerns selection of various dwelling types. In some of the projects, decisions concerning additional new construction are involved. In all projects, construction cost levels play an important role in relation to the acquired housing quality of the discerned design options. Therefore, it is absolutely important that the cost levels in the later process stages stay in line with the construction costs estimated in the early stages.

The used model will be shown in the case of Nijenheim at Zeist. The redevelopment project of Nijenheim refers to a 1960s apartment block with 70 gallery-access apartments on a basement with mainly closed brickwork elevations containing storage and general purpose rooms.

Though the existing apartments are relatively large (70 to over 100 m² UFA), the municipality of Zeist counts such an abundance of similar flats, that they are considered to become obsolete in the near future if they are not renovated. To make the apartments more attractive, first of all the situation at ground level should be improved: a more open entrance and a friendlier appearance of the storage areas are required. To meet these requirements the architects of VSA (see acknowledgements) made some propositions that are indicated in the schemes in figure 4. The proposed interventions contain a redesign of the main entrance and the box rooms and the making of underpasses through the plinth of the building.
In the existing situation, the block contains apartments in 7 types. For these apartments the simplest option that is proposed consists of the improvement of their thermal skin, the renewal of kitchens, bathrooms and lavatories and the replacement of the technical systems. A second set of options consists of renovation plans aimed at making the apartments suitable as accommodation for elderly.

Last but not least, several types of apartments have been designed, which can either be applied as extension on the roof tops or at the end walls of the building. The figures 5 and 6 give some examples.

On the one hand, the vast set of design options for the various parts of the building offers a well documented insight in the possibilities of the project. On the other hand, it is very difficult to make a well-considered choice to conclude the Project Definition, because of the almost endless number of possible combinations of the presented options. To facilitate the decision-making process in this stage a building cost array as shown in figure 7 is used.
The model has been composed in an (electronic) spreadsheet. On the level of the policy concerning the general approach of the project, the various plan options have been structured in 6 blocks of cohesive choices, which can be effectuated by means of easy to determine numbers, related to the relevant quantities of the project sections.

### Renovation of apartments Nijenheim at Zeist - based on design sketches by VSA d.d. February 2006

#### I. General: foundation / substructure

- **Foundation** (included in III, IV and VIII)
  - Site: redesign of parking, pedestrian area etc.
  - 1 proj, 4,570 m² site, 18 apartments, 79,875

#### II. General: roof finishing and end elevations

- Roof: refurbishing rooftop unit, edges
  - 1 proj, - m² roof, 18 apartments, -
- Roof: idem + replacement of roof covering and insulation
  - 1 proj, 1,030 m² roof, 96 apartments, 98,745
- End elevations: external wall insulation
  - 1 proj, 790 m² wall insulation, 82 apartments, 64,524

#### III. General: access to dwellings

- Adjustment of main entrance and common areas at ground level
  - 1 units, 276 m² GFA, 328 apartments, 90,519
- Main stairwell improvement
  - 1 units, 471 m² GFA, 201 apartments, 94,759
- Raising stairwell 3 storeys (demolition of rooftop unit included)
  - 1 units, 176 m² GFA, 445 apartments, 78,301
- Improvement of elevators
  - 2 units, - m² GFA, 17,221 apartments, -
- Elevators replaced by new ones with 9 stops each
  - 2 units, - m² GFA, 78,521 apartments, 157,042
- Elevators replaced by new ones with 11 stops each
  - - units, - m² GFA, 87,153 apartments, -
- Replacement / extension of emergency stairs
  - 14 units, 14 m² GFA, 5,561 apartments, 77,849
- Access galleries: raising galleries and adjustment of railings
  - 1 proj, 507 m² gallery, 354 apartments, 197,278

#### VI. Apartments (major repair)

- Type Ab 87 m² UFA major repair
  - - apts, - apartments, 51,141
- Type Bb 81 m² UFA major repair
  - - apts, - apartments, 47,550
- Type Db 100 m² UFA major repair
  - - apts, - apartments, 56,999
- Type Eb 69 m² UFA major repair
  - - apts, - apartments, 40,156
- Type Gb 125 m² UFA major repair
  - 8 apts, 8 apartments, 73,523

#### VIa. Apartments (changed lay out)

- Type An 92 m² UFA changed lay out
  - - apts, - apartments, 59,059
- Type Bn 86 m² UFA changed lay out
  - 48 apts, 48 apartments, 66,477
- Type Dn 105 m² UFA changed lay out
  - - apts, - apartments, 66,272
- Type Gn 126 m² UFA changed lay out
  - 6 apts, 6 apartments, 72,523

#### VII. Balconies

- New balconies (included in VIa and VIb)
  - 4 (50) 1 project, -

#### VIII. Boxrooms and underpasses

- Boxrooms block 1
  - 1 block, 356 m² GFA, 490 apartments, 174,608
- Boxrooms block 2
  - 1 block, 428 m² GFA, 666 apartments, 285,207
- Underpasses block 2
  - 1 block, 2 underpasses, 27,457 apartments, 54,914

#### X. Total of direct construction costs

- 5,667,961

#### XI. Overhead construction firm

- General construction (site) costs
  - 8% 8% 5,667,961 453,437
- Overheads
  - 6% 6% 6,121,397 367,284
- (Calculated) profit margin
  - 4% 4% 6,488,681 259,547

#### XII. Total of construction costs (VAT excluded)

- 6,748,229

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**Management input costs**

- 5,667,961
- 6,121,397
- 6,488,681

**Management input costs**

- 108,842
- 1,026
- 980
- 755
- 273

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Figure 7: Building costs array for Nijenheim, sorted by project sections.

The approach as presented has turned out to be an effective means for the project management board to evaluate several promising plan options. Since the 'unit-prices' of all discerned project sections have been based upon estimates according to the
Reference Projects Model, all cost estimates resulting from the presented Project Sections Model are directly presentable as elemental bills of quantities. At the time this paper is written, in the Nijenheim project, the development process is still in such an early stage that this facility has not really been used. In one of the Amsterdam projects and in Delft, however, the development processes have proceeded to further stages, in which the connection of both estimates was actually used. In Amsterdam this facility considerably smoothed the transition from preliminary design to definite design as far as construction cost questions were involved.

Conclusion

In several complicated (Dutch) redevelopment projects concerning residential buildings from the 1960s, cost modeling based on a combination of the Reference Projects Model and the Project Sections Model turns out to be an effective way to support decision-making in the Project Definition stage. Due to the connection of both models the estimated costs, which form the basis for the Project Definition, can be evaluated throughout the whole project development process. As far as we can see now, this helps smoothing this process considerably. However, since the number of projects in which the model has been applied is still rather small, it cannot be excluded that some adaptation may still be needed to improve the applicability of the model in later process stages.

References