Summary

In this paper we set up a framework for lifetime oriented maintenance planning as an outcome and input for strategic housing stock management. The maintenance planning holds maintenance activities and costs in the longer term. We consider the maintenance planning as a tool to calculate and implement maintenance strategies. Therefore we designed a model to derive maintenance strategies from housing complex strategies. Maintenance strategies depend on the desired or expected lifetime of buildings and desired performances of building components. In this way the likelihood of loss of capital is reduced and property owners can carry out maintenance and improvement in a sustainable manner. By adopting a condition-dependent approach to maintenance, property owners can exercise control over the actual and desired maintenance performance levels and costs over its lifetime. A precondition is that the maintenance management system is capable of being used as a policy instrument. Advanced maintenance management systems enable users to calculate maintenance performance levels and lifetime costs based on the condition of building components after executing maintenance work.

1. Introduction

Almost all Dutch housing associations carry out planned maintenance on the basis of a long-term maintenance planning. The maintenance planning has been computerised. A growing number of housing associations register the maintenance condition of building components with marks on a six-point scale. The use of marks makes the maintenance condition transferable between the operational level of the managerial body and the management. Maintenance activities are no longer determined on-site. At the office, data about necessary activities is being recorded. In general terms, the housing associations recognise three performance levels in planned maintenance: a basic level, a lower level if a technical intervention in the near future is foreseen, and a higher level, that is based on the position of the housing complex on the housing market. Nevertheless, a clear coupling between the strategic housing stock management and the technical management with respect to planned maintenance including minor improvements, is still lacking in most cases. Housing complex and maintenance strategies are not clear at all levels within the organisation. That means a good chance of wasted money. Often forecasting costs of various maintenance strategies and priority setting of maintenance work are impracticable.

Based upon fieldwork amongst Dutch housing associations we designed a model relationship between the strategic housing stock management and the technical management by housing associations. This has been achieved by using (housing) complex strategies, maintenance strategies and maintenance performance levels [1, 2]. We defined technical management as all technical and associated administrative activities that are directed at preserving the existing performance level and alterations of the performance level. To execute technical activities it is desirable to draw a distinction between collective building parts, services and surrounds and building parts of individual dwellings. Alterations of performance levels take place through technical interventions.
The volume, layout, amenities, and material specifications of buildings and dwellings can change. Technical maintenance is directed at preserving the performance level. But, the maintenance performance level can differ. At the tactical and the operational level of the organisation four processes can be identified: (1) alterations per housing complex (major improvements), (2) relet maintenance and alterations per dwelling (minor improvements), (3) responsive and emergency maintenance, and (4) planned maintenance.

The strategic and technical housing stock management should be based on objective, reliable information about the performance of housing complexes, buildings, dwellings and building components. Data are required on the technical condition of the building components, amenities or qualities of buildings and individual dwellings (e.g. lifts, heating installations, kitchens), the environmental qualities (e.g. use of materials, energy-use, water-use), adaptability for changes in housing and environmental quality and realised costs for maintenance and improvements. In this paper we describe how the model has been set up and draw attention to maintenance performances and lifetime costs.

2. Strategic technical management

2.1 Complex and maintenance strategies

The alternatives for housing associations’ exploitation of housing complexes can be summarised in two main groups: continuing exploitation or ending the exploitation period within a short time period, for instance by demolition or sale. If a housing complex will be exploited over a long time in the future, the definite strategy depends on whether preserve or alter the technical performance and whether allocate the housing complex for the existing client group or a new client group. A housing association strives for a quality level of a complex appropriate to its present position on the housing market or its desirable position in the future. At the same time, this market position determines the margins for dwellings to deviate from that level. A property manager can meet the wishes of individual clients by improving the individual building parts per dwelling.

![Diagram of process linking complex strategies and maintenance strategies](image-url)

**Fig. 1** Process linking complex strategies and maintenance strategies
A housing association ought to align maintenance with one of the complex strategies. The maintenance strategy depends either on an anticipated intervention or on the product line. We call this successively intervention-oriented and market-oriented maintenance. Figure 1 gives a schematic outline of succeeding complex strategies, maintenance strategies and activities.

For lifetime oriented maintenance planning it is very important to have certainty about the expected exploitation period or functional service life, of the housing complex. If the maintenance strategy is intervention-oriented a lower maintenance level than the standard level will be sufficient. A housing association could just respond maintenance complaints of tenants and run down planned maintenance work. Even after the sale of dwellings to individual house-owners the housing association could be keeping involved maintaining collective building parts and exterior of the dwellings. In the near future housing associations will probably play a dominant role in technical maintenance of whole housing estates with several owners. The central government in the Netherlands encourages the sale of dwellings by housing associations, if the quality in the future is guaranteed [3]. After executing technical interventions all building complexes are labelled as consolidate. Market-oriented maintenance strategies can be worked out for maintenance performance and housing qualities. Table 1 gives an outline of maintenance strategies and maintenance performance levels.

<table>
<thead>
<tr>
<th>Maintenance strategy</th>
<th>Expected exploitation period</th>
<th>Maintenance performance level</th>
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</thead>
<tbody>
<tr>
<td>Market-oriented</td>
<td>≤ 15 years</td>
<td>Low or Basic</td>
</tr>
<tr>
<td>Market-oriented</td>
<td>&gt; 15 years</td>
<td>Basic or Plus</td>
</tr>
<tr>
<td>Intervention-oriented</td>
<td>≤ 5-7 years</td>
<td>Very low</td>
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</tbody>
</table>

A housing association chooses a basic quality level for collective building parts (entries, facades, roofs, etc.), building services and surrounds, and a desired basic quality level and a higher quality level for individual building parts of dwellings. The basic quality level differs per product line. To meet the basic quality of a dwelling, minor improvements are executed when the tenants move, so-called relet maintenance. At the same time the new tenants are offered minor improvements restricted to the top quality level of the dwelling. This client-centred approach has consequences for a housing association’ policy with respect to alterations undertaken by tenants themselves when they move. Until 2001 it was compulsory for tenants to leave their home in the same condition as it was concluded in the tenancy agreement. Nowadays changed market circumstances force housing associations to freedom and choice of quality for tenants [3]. So the tenants are allowed to execute minor improvements themselves and leave the house without removing them. A computerised database for the building components of individual dwellings is indispensable for the implementation of client-centred technical management. The data on complexes and individual dwellings can be derived to a large extent in combination with other basic data from the business information system. Table 2 shows the implementation of maintenance performance levels in maintenance processes at the technical and operational level of a housing association.

<table>
<thead>
<tr>
<th>Maintenance performance level</th>
<th>Planned maintenance</th>
<th>Responsive maintenance</th>
<th>Relet maintenance including minor improvements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very low</td>
<td>None</td>
<td>Restricted</td>
<td>Restricted</td>
</tr>
<tr>
<td>Low</td>
<td>Restricted</td>
<td>Standard</td>
<td>Basic quality level</td>
</tr>
<tr>
<td>Basic</td>
<td>Standard</td>
<td>Standard</td>
<td>Basic quality level</td>
</tr>
<tr>
<td>Plus</td>
<td>Additional</td>
<td>Standard</td>
<td>Additional quality</td>
</tr>
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</table>

2.2 Strategic technical management
In our model the process of setting up complex and maintenance strategies takes place completely.
This model leads to the choice of a complex strategy, a maintenance strategy, a maintenance performance level, a basic quality level for the building, and quality levels for the individual dwellings. Budgets for maintenance and improvement are calculated at the same time. A landlord classifies its property in product lines according to a number of product, client, price and exploitation characteristics. One or more housing complexes belong to a product line. Market-oriented maintenance strategies can be developed independent of the final strategy choice for a housing complex. See figure 2.

3. Maintenance performance levels

3.1 Maintenance performance

The implementation of various performance levels in planned maintenance requires the standardisation of conditions, performance loss and defects of maintenance cost components. All building components have to contend with performance loss through ageing, use, and external causes. Performance loss is measured in terms of defects ascertained. The defects are registered during a survey. As a result of several research projects and the use of the method in the Dutch House Condition Survey, the process of condition assessment using standard lists of defects and a six-point condition scale has become popular by property managers, consultants and contractors in the Netherlands [4]. The condition categories are of a chronological order that describe possibly occurring defects without references to remedial work, but just describe occurring defects. A condition-dependent approach to planned maintenance leads to a decoupling of quality assessment from the determination of maintenance activities [5].

In general, acceptable performance loss and the implementation of appropriate maintenance activities depend on legal requirements, technical and functional motives, and environmental aims. The international standard ISO 6241 classifies 14 categories of performance of building components [6]. In reference to this standard, we distinguish between technical performance, fire safety, utilisation safety, social safety, health and the interior environment, functionality and availability, maintainability, aesthetic performance, energy performance, water performance and sustainable use of materials. We apply those performance categories also to maintenance activities. Maintenance activities influence the performance of building components at a particular point in time.
3.2 Maintenance activities

Maintenance activities can be distinguished according to type (repair, replacement, (re)painting and cleaning), part of the building component to which an activity applies, the specification of materials, the quantity of the work, the frequency of short cyclical preventive maintenance actions and the nature of an activity (preventive or corrective). We consider replacement of building components and the installation of new building components as maintenance activities. In fact, through functional material modifications and installing new building components, performance alterations take place. The product characteristics of the building change and the original performance capacity increases.

To perform efficiently and effectively the performance of a building component after executing maintenance work should be clear. We found that the performance of building components after partial replacements, repairs and cleaning is not clear for most technical managers. After an integral replacement of the component the condition will be as new. In case of partial replacements and repairs the condition gap before and after the activity is insecure. That depends on the solved defects at that particular moment of time. Hermans found that cleaning and repainting of surfaces does not influence the technical performance of substrates [7]. The degradation will just process more gradually. Nevertheless, the aesthetic performance of a surface improves.

3.3 Calculating maintenance performance levels

Just as the collection of survey data the decision-making process for planned maintenance holds subjective elements and often is not transparent. Formulating maintenance performance levels in planned maintenance mean deliberate about maximum performance loss, appropriate maintenance activities and the available financial means. One has to examine the consequences of the proposed maintenance work for the assessed condition and to answer questions like: What is the new performance of the building component compared to the initial performance and which defects have been solved and which defects are still present?

Advanced maintenance management systems enable users to calculate maintenance performance levels at the technical level and priority setting of maintenance work at the operational level. Maintenance performance levels can be based on the condition of building components after executing maintenance work. In this approach assessed defects and condition marks before at one side and acceptable defects and conditions marks after executing maintenance work at the other side, are steering instruments in the planning process. To distinguish between performances of building components, e.g. the technical performance, aesthetic performance and sustainability performances (energy, water, sustainable use of materials) one should have the opportunity to adapt the weights of defects afterwards, in the phase of formulating long-term maintenance plans. We can explain that with an example. As a reference point for building inspectors mechanical damages to window frames are weighted normally as serious defects. However for aesthetic reasons, the property manager can weight the defect as a critical defect. Doing that the condition mark rises and probably will exceed a minimal condition standard. Even if the expected lifetime of the building and/or the substrate of the paintwork is short, performance requirements for paintwork may be high for aesthetic reasons. The substrate: window frames, windows and doors, may show major technical performance loss. But functional performance, for instance opening windows and doors, should be guaranteed.

3.4 Lifetime costs

Property owners are able to weigh maintenance performances and costs during the expected exploitation period (functional service life) of the housing complex using lifetime costs. Applying lifetime costs in maintenance planning means subsequently determining:

- expected exploitation period or functional service life;
- maintenance costs elements (building components);
- actual performance maintenance costs elements (actual condition state);
- maximum performance loss of maintenance costs elements during the functional service life;
• alternative maintenance activities for maintenance cost elements;
• costs of maintenance activities;
• maintenance scenario’s during for the functional service life;
• average annual costs per maintenance scenario.

Outcomes should be checked for sensitivity by extending or shortening the functional service life. Besides, if the original performance capacity of maintenance costs elements increases by replacing those elements during its lifetime, lifetime costs will change.

4. Discussion

Property owners can carry out maintenance and improvement more efficiently and effectively by linking maintenance strategies to complex strategies. Doing so they act in a sustainable manner. However, we think that environmental performances like energy performance and sustainable use of materials ought to play a more prominent part in decision making about complex and maintenance related strategies. Housing associations in the Netherlands acknowledge this, but initiatives in that direction hardly get off the ground. Issues of sustainability have just become important in new housing construction. The execution of technical interventions and planned maintenance in a sustainable manner will lead to additional costs or less costs compared to a standard approach. Property owners can define sustainable management as achieving the lowest integral life time costs. The application of sustainable materials and improvement of the energy performance will mean higher initial costs (investment). But, the exploitation costs of facility managers and the user costs of tenants will go down.

For technical interventions in the housing stock new forms of co-operation between clients and building parties (contractors, subcontractors, consultants, architects, suppliers) are needed. Not just for the building and renovation phase, but also for long-term maintenance of the existing housing stock. Despite different views, involved parties have a common interest in the further development of performance-based co-operation and the appropriate measurement tools. The aim of ongoing research projects is to design process models and process requirements for the performance-based management and realization of maintenance and adaptations in the housing stock. In the long term multi-year performance-based maintenance will probably become linked to new building or renovation by means of integrated contracts. This way, performance-based co-operation can add momentum to concepts of lifetime engineering.

5. References

4 Damen Consultants et al, Brite Euram Project 4213 Condition Assessment and Maintenance Strategies for Building and Building Components, Rotterdam.