# COSTS AND BENEFITS OF FLEXIBILITY

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## ABSTRACT

Developing buildings increasingly causes problems for administrators. The great diversity in demand is the main factor, and this demand is changing all the time. This combination of diversity and change causes many problems in planning, developing, creating and administering buildings. Property managers are confronted with more and more vacancies because their buildings are not adequately tailored to meet demand. Partly owing to the fact that so many parties are involved in creating a building, budgeting for additional capital expenditure to ensure future flexibility is still an exception. As a rule, the party bearing the initial cost is not the one that reaps the possible future benefits of alterations. The final life-cycle costs incurred in considering alternative solutions are more important than simply investing extra money in providing for flexibility. Altering buildings can become very expensive when no flexible systems have been used.

Answering the following question played a crucial role in developing the Flexcos method: If extra investments for flexibility are made now, what costs will be spared in the future (savings)? The Flexcos method is a useful aid in making costs and benefits comparisons between different design and construction strategies. The method combines (extra) investment costs, maintenance costs and adaptation costs (rebuilding) with flexible parameters such as the period when the rebuilding takes place and the prognosis (probability) of the rebuilding occurring. In this way, policies can be evaluated over the projected benefits arising from extra investments for flexibility. In addition, various designs can be considered in relation to each other at any given stage in the planning.

## KEYWORDS:

Flexibility; costs and benefits; life cycle; performance

## INTRODUCTION

Flexcos is a method of mapping the costs and benefits of flexibility. This method allows organisations to consider the effects of different construction strategies at an early planning stage. The relative costs of investing in future flexibility and possible future savings can be compared with each other. The motive for developing Flexcos is the rapidly-changing market for office and residential space. Older office space in less desirable locations is particularly at risk of dropping out of the business accommodation market. There is currently great demand for office space and relatively few are empty. However, it is expected that in the near future an increase in the number of new offices and a fall in demand for office space will cause the number of empty offices to rise again. If they remain empty for long, they must be demolished, renovated or used for other purposes. This is very wasteful, as it harms the environment as well as destroying capital. Both the desire for durable buildings and the increasing variety of users' requirements make it more necessary to create flexible buildings.

### Costs and benefits of flexibility

Partly owing to the fact that so many parties are involved in creating a building, budgeting for additional capital expenditure to ensure future flexibility is still an exception. As a rule, the party bearing the initial cost is not the one that reaps the possible future benefits of alterations. The final

life-cycle costs incurred in considering alternative solutions are more important than simply investing extra money in providing for flexibility. Altering buildings can become very expensive when no flexible systems have been used. This is a particularly important factor for property managers and users.

**Extra investments versus future savings**

The most appealing flexibility measures are of course those that involve no extra expenditure. Implementing these measures will meet little opposition. Things are different when additional expenditure is involved. Such expenditure must above all be affordable, yet the expected financial advantages are not always very clear. An important factor in this respect is the likelihood of the flexibility measures being actually used. If this is uncertain, then the future savings are also uncertain. To make a choice between the various alternatives, it is essential to weigh the costs against the benefits. To do this, a method of calculating was developed in association with the Dutch Building Research Foundation (SBR). This takes into account, among other things, maintenance costs, life expectancy, cost of adaptations and possible savings.

**Conclusions**

A design or construction strategy aims to create a coherent system of constructional arrangements that can achieve specific targets. Two strategies can be compared in Flexcos: flexible and non-flexible. Scenarios describe possible future accommodation situations. They describe how accommodation requirements develop over a period between two specific periods. In Flexcos two scenarios can be compared: the accommodation requirements within a certain period remain essentially unchanged, or the requirements really do change. Flexcos records the probability of scenarios taking place as a separate parameter in the calculation model. A building designed with flexibility in mind will be adapted earlier than a building that is less suitable for these changes. When buildings are designed with less flexibility, it is more likely that moving to a different location or building new premises will be considered in preference to adapting the existing building. With Flexcos one can compare the costs and benefits of flexibility.

## DIFFERENT KINDS OF COSTS AND FLEXIBILITY

Before going further into the method of calculation involved in Flexcos, it is a good idea to spend some time considering the different kinds of costs that can be identified in this respect. Figure 1 illustrates the investment costs that flexibility can influence. It has a particularly strong influence on building costs and layout costs, and less influence on some of the associated costs. Investing for future flexibility raises the cost of architectural work, particularly for installation and fixed designs. The preparation and supervision of a project with provisions for extra flexibility normally require more attention and effort compared to traditional projects. Accompanying costs are also higher.

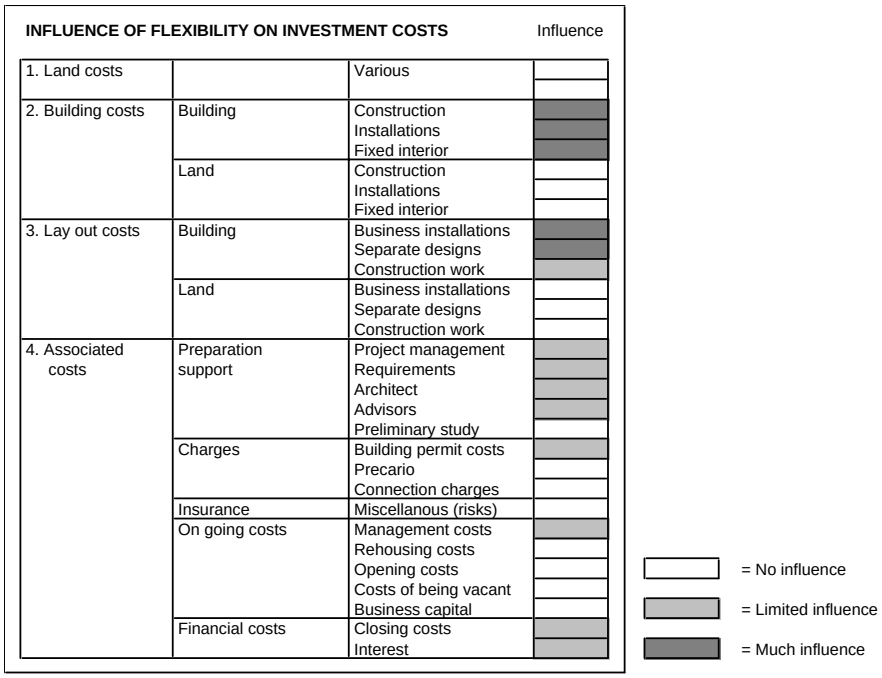


*Figure 1: the relationship between flexibility and investment costs*

Operation costs relate to the ownership and use of the building. They depend on whether the building is owner-occupied (A), maintained in a useable condition (B) or used by a third party (C). Combinations of these three possibilities are also possible.

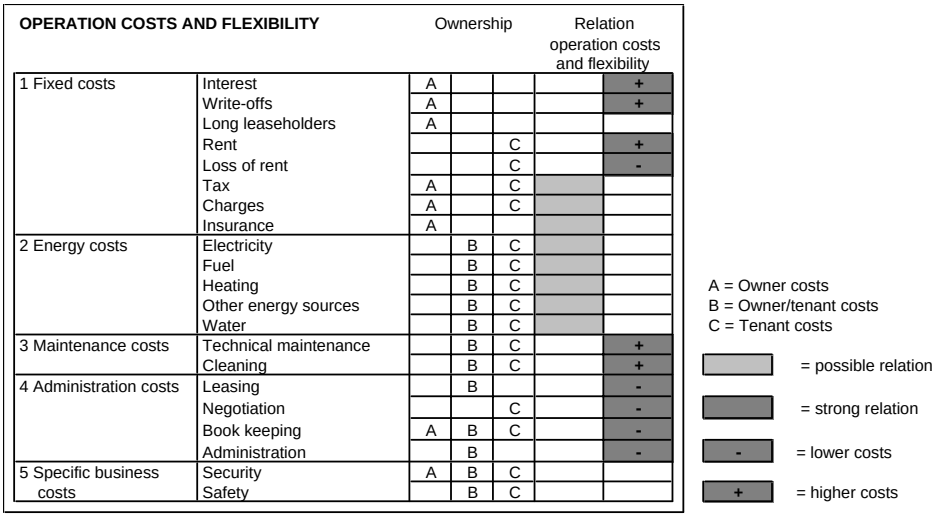


*Figure 2: how ownership and use determine the relationship between costs and flexibility*

Figure 2 illustrates how flexibility and operation costs can be related. Where a strong relationship exists, the figure also indicates whether the influence on operation costs is positive (+) or negative (-). This applies to interest, write-offs, rent and technical maintenance when extra investment is made for architectural flexibility. The operation costs and associated administrative and management costs are markedly lower if the building is easily leased (less rent loss).

## STRATEGIES AND SCENARIOS

A design or construction strategy aims to create a coherent system of constructional arrangements that can achieve specific targets. This solves specific accommodation problems, both now and in the future. Two strategies can be compared in Flexcos: flexible and non-flexible.

### Strategies

Strategy A (flexible) incorporates various flexibility measures for maximum future partitionability. By applying specific architectural solutions and techniques during both the design and development phases, it takes into account future adaptations and repartitioning when the building is in use.
The interplay of design and architectural arrangements in strategy B (non-flexible) takes little or no account of future partitionability. The architectural solutions and techniques that apply also make no provision for future adaptations. For example, there are no fontanelle constructions in the walls, and no flexible installations or movable inner walls.

### Accommodation scenarios

In this context, scenarios describe possible future accommodation situations. They describe how accommodation requirements develop over a period between two specific periods, T1 and T2. T1 is when a project begins. T2 is a variable point in the future, at which the accommodation requirements change. This study uses examples that take two different scenarios as a starting point. The example given involves two partitions.
Scenario 1: beginning and end situation with two partitions. When a project first starts up (T1), two partitions are created. The accommodation requirements between T1 and T2 remain essentially unchanged. Two partitions are still needed during T2.
Scenario 2: repartitioning from two to four partitions. The accommodation requirements between T1 and T2 change so that four partitions are needed instead of two. Therefore the building has to be divided.

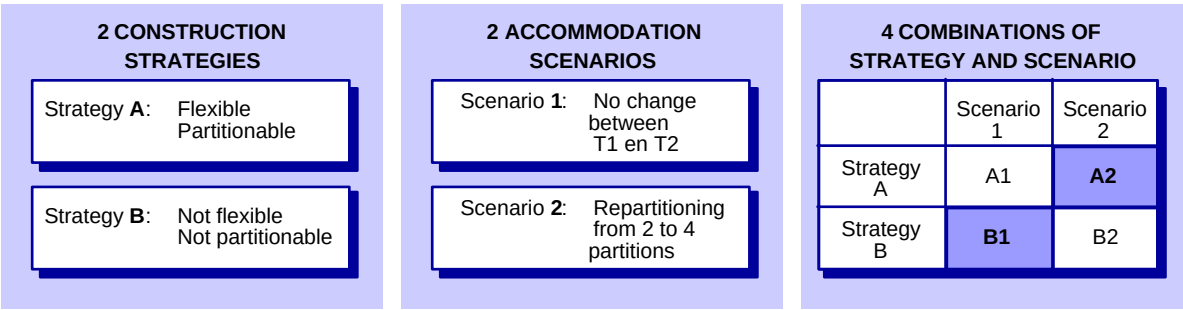


*Figure 3: two possible construction strategies, two possible accommodation scenarios and four possible combinations of strategy and scenario*

### Combining strategies and scenarios

Figure 3 gives an overview of how two construction strategies and two accommodation scenarios might combine. Clearly, some combinations are more favourable than others. Combination A1 is unfavourable because it is a flexible strategy yet there is no requirement for repartitioning from two to four partitions. The investment in future flexibility is thus superfluous. Combination B2 is also unfavourable. Here, repartitioning takes place in the near future, but the construction strategy is not flexible. Combination A2 is very favourable, with a flexible construction strategy paired with future adaptations in scenario 2. B1 is also favourable, since although the construction strategy is not flexible, there are no future adaptations. A calculation can be made of the cost implications of different combinations of scenario and strategy for various intervals T1 and T2. This interval is therefore one of the Flexcos parameters.

**Chances or prognoses**

Prognoses use present developments as the basis for future expectations. They are usually printed as probability percentages (%). It is very important to know how likely it is that any given scenario (future accommodation situation) actually takes place. These probabilities of scenarios taking place are used as the basis for choosing a particular construction strategy. Flexcos records the probability of scenarios taking place as a separate parameter in the calculation model. The calculation makes provisional use of five different prognoses (0, 25, 50, 75 and 100%).

Figure 4 shows an example of the probability that two different scenarios will occur over a 20-year period. The chance of scenario 1 taking place (no future change) falls sharply over time: from 100 % in the first year to 0 % after 20 years. The opposite applies to scenario 2 (future change: rebuilding from two to four partitions). During the first five years, scenario 1 (no rebuilding) has the greatest chance of occurring.

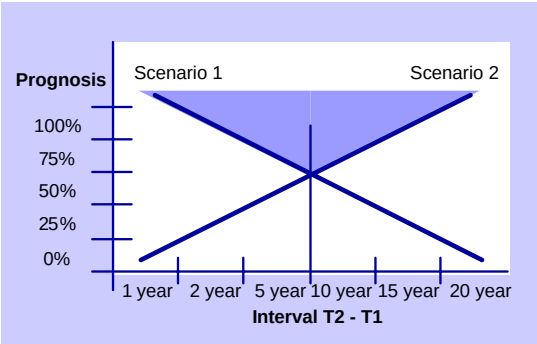


*Figure 4: graphical presentation of prognosis scenarios 1 and 2*

After this, scenario 2 (rebuilding from two to four partitions) is more likely. These probabilities, and knowledge of the cost implications of strategy/scenario combinations, can form the basis of judging which construction strategy is most advantageous. However, another question still remains:

*What is the chance that, over a given time, the accommodation situation will actually have to change?*

A precise answer cannot be given here. It should be based on knowledge of factors concerned with how accommodation needs develop, and on how these have changed in recent years. The solution should also be based on expected trends in the near future. In this way, an estimate can be made, in accordance with policy, of the likelihood that certain changes in accommodation needs will take place.

## COSTS AND BENEFITS OF FLEXIBILITY

Answering the following question played a crucial role in developing the Flexcos method: If extra investments for flexibility are made now, what costs will be spared in the future (savings)? The following concepts are important for a deeper analysis: maintenance costs, adaptation costs, revision of maintenance costs, the evaluation of (future) costs and expected savings. These concepts will now be briefly explained.

**Maintenance costs**

During the lifetime of a building, it is necessary to maintain certain parts in accordance with the appropriate regulations. This kind of maintenance is not considered, since it is not the intention to make a prognosis of maintenance costs. However, the cost of (identical) *replacements* that are technically necessary are taken into account over a given period. The cost of these replacements are

included in various basic calculations. For an example of such a calculation, refer to the 'maintenance costs' column (iA) in Figure 5.

**Adaptation costs**
Changes that appear in the itemised calculations for modifying a building are evaluated in the 'adaptation costs' column (aA) in Figure 5. These costs (shown in guilders) depend on the period when the changes take place. Each calculation is therefore made over various intervals: 5, 10, 15, 20, 25 and 30 years.

**Discounted cash flow method**
To allow comparison of investment costs with adaptation costs that may incur in a later period, the costs are expressed with the discounted cash flow method so they can be easily measured against each other (Dcf formula).

**Revision of maintenance costs**
Modifying a building may result in savings in the planned replacement maintenance costs. This depends on when the modification and cost planning take place. Because of this, Figure 5 has a column titled 'Maintenance costs revision' (cA). Here, the modification that takes place in T2 affects the maintenance costs. This can result in savings because the modification means certain maintenance is postponed. However, it can also add to costs, because after the modification the maintenance applies to a larger number of partitions. It is possible to identify three different possibilities: the modification takes place before the planned maintenance period, both the modification and the maintenance planning occur together or the modification happens after the planned maintenance period. In this respect, the calculation can be revised as follows:

$$\mathbf{Dcf = Dcf1 + Dcf2}$$

*Dcf1 = discounted cash flow of the first period before the modification; Dcf2 = discounted cash flow of the second period after the modification.*

**Prognoses and projected savings**
To determine whether the savings produced by a repartitioning according to strategy A (flexible) compared to strategy B (non-flexible) actually compensate for the extra investment required in strategy A, it is necessary to calculate the projected savings. This is carried out as follows:

$$\mathbf{O = K \times Dcf - Bi}$$

*O = savings; K = probability (as a percentage) that a scenario takes place; Dcf = discounted cash flow of the savings; Bi = the (extra) investment for future flexibility.*

The formula consists of three parts that can affect the savings. The savings increase as the probability of use rises, the value of the savings rises or the extra investment for future flexibility becomes lower.

**Savings**
The value of the savings grows as the rebuilding time approaches. The possible savings can be determined by comparing two different construction strategies for a given scenario. The *savings* (Dcf) are determined by comparing the modification costs including the maintenance costs revision in strategy A (flexible) with similar costs in strategy B (non-flexible). The extra investment in flexibility (Bi) for strategy A (flexible) is determined by comparing the investment in strategy A with the investment in strategy B (non-flexible). This is calculated as follows:

$$\mathbf{O = K \times \{(aB + cB) - (aA + cA)\} - \{(bA + iA) - (bB + iB)\}}$$

*O = benefits of strategy A (flexible) compared to strategy B (non-flexible); K = probability (as a percentage) that a future scenario (accommodation situation) takes place; aA = adaptation costs for strategy A (in guilders); aB = adaptation costs for strategy B (in guilders); bA = construction costs for strategy A; bB = construction costs for strategy B; cA = revision of maintenance costs for strategy A; cB = revision of maintenance costs for strategy B; iA = maintenance costs for strategy A; iB = maintenance costs for strategy B.*

## EXAMPLES

A calculation can now be made for each combination of scenario and strategy over various intervals. The savings of these combinations can then be compared with each other. This is carried out in 3 steps.

### Step 1: calculating the total costs after an adaptation

The total costs for a specific period after an adaptation are calculated by the addition of the construction or investment costs, the discounted cash flow of maintenance costs over the period including any cost revisions that apply, and the adaptation or rebuilding costs. Figure 5 gives an example of the addition of the total costs of a fontanelle construction in a supporting wall when rebuilding takes place from two partitions into four partitions after a period of 10 years.

**BUILDING ELEMENT COSTS FOR A FONTANEL CONSTRUCTION**

Strategy A: Flexible (partitionable) Scenario 2: Modifying from 2 -> 4 partitions Period 10 years

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | iA | | | aA | | | bA | iA | cA | aA | |
| Code | Descript. | Numb. | Unit | Constr.-costs/ unit | Maintenance costs /unit | Freq. | Dcf | Modification costs /unit | Period | Dcf | Total Constr. costs | Total Maint. costs | Revision Maint. costs | Total Modific. totaal | TOTAL COSTS |
| 22.4 | Fontanel | 25 | m2 | 43,00 | 140,00 | 30 | 45,00 | 32,00 | 10 | 22,00 | 1057,00 | 1097,00 | -62,00 | 535,00 | 2626,00 |

*Figure 5: example of itemised calculation of total costs for a fontanelle construction*

### Step 2: comparison of costs and savings for several strategy/scenario combinations

Figure 6 gives an example of the costs and savings for strategy A (flexible) compared to strategy B (non-flexible), for the extra investment in a detachable fontanelle construction. This is evaluated for various periods (from 5 to 30 years) during which the adaptation from two partitions to four partitions could happen (scenario 2).

**COSTS AND SAVINGS**
**Strategy A (flexible) compared to strategy B (non-flexible)**

| Period | Strategy scenario combination | Basic investment costs | Modification costs | Extra investment A versus B | Savings Dcf A versus B |
|---|---|---|---|---|---|
| 0 years | A1 (2->2 parts.) | 209.800 | - | 2.400 | - |
| 5 years | A2 (2->4 parts.) | - | 44.100 | - | 37.800 |
| 10 years | A2 (2->4 parts.) | - | 30.300 | | 30.200 |
| 15 years | A2 (2->4 parts.) | - | 31.800 | | 26.100 |
| 20 years | A2 (2->4 parts.) | - | 24.800 | | 21.400 |
| 25 years | A2 (2->4 parts.) | - | 13.000 | | 20.100 |
| 30 years | A2 (2->4 parts.) | - | 15.500 | | 16.700 |

*Figure 6: example of costs and savings for strategy A (flexible) compared to strategy B (non-flexible)*

It can be seen that the basic investment costs for providing flexibility using two partitions with a partitionable support amount to f 209,800,-. The extra investment costs compared to strategy B (non-flexible) are f 2,400,-. The adaptation or rebuilding costs of going from two partitions to four partitions after five years are f 44,100,- for strategy B. The savings generated in strategy A compared to strategy B are thus f 37,800,-. Figure 7 illustrates this information graphically. The longer the period before the rebuilding occurs, the lower the value of the savings. However, these calculations

and comparisons do not take into account the probability (%) that the extra investments for flexibility provisions will actually be used. In other words, the likelihood that scenario 2 (going from two partitions to four partitions) goes ahead. The following step takes this into account.

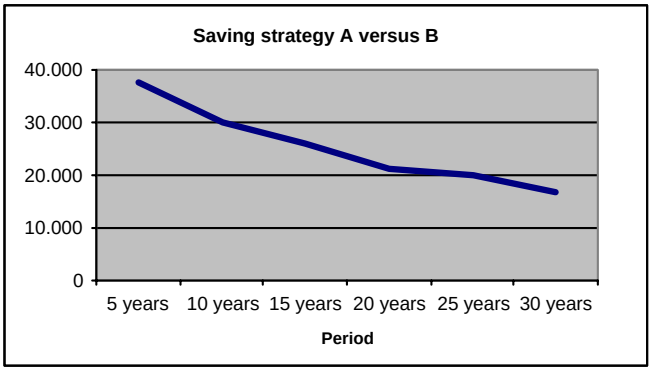


*Figure 7: savings of strategy A (flexible) compared to strategy B (non-flexible)*

**Step 3: determining the projected savings**

To discover whether the savings in strategy A due to repartitioning compensate for the extra investment required, it is necessary to determine the projected savings. This takes into account the likelihood that a repartitioning will take place.

**PROJECTED BENEFITS**
Strategy A (flexible) versus strategy B (non-flexible)
in scenario 2 repartition from 2->4 partitions

| Prognosis | Period | | | | | |
|---|---|---|---|---|---|---|
| | 5 years | 10 years | 15 years | 20 years | 25 years | 30 years |
| 0% | **-2.400** | **-2.400** | **-2.400** | **-2.400** | **-2.400** | **-2.400** |
| 25% | 800 | 0 | 200 | **-400** | **-100** | **-200** |
| 50% | 3.900 | 2.300 | 2.700 | 1.600 | 2.300 | 1.900 |
| 75% | 7.100 | 4.700 | 5.200 | 3.600 | 4.600 | 4.000 |
| 100% | 10.200 | 7.000 | 7.800 | 5.600 | 6.900 | 6.200 |

*Figure 8: projected savings of strategy A (flexible) compared to strategy B (non-flexible)*

Figure 8 illustrates the projected savings of strategy A (flexible) compared to strategy B (non-flexible) for scenario 2 (modification from two partitions to four partitions) for various periods. The area in which the projected savings are negative is highlighted. The projected savings are calculated using the previously described formula: O = K x Dcf – Bi. Figure 9 shows the same information graphically.

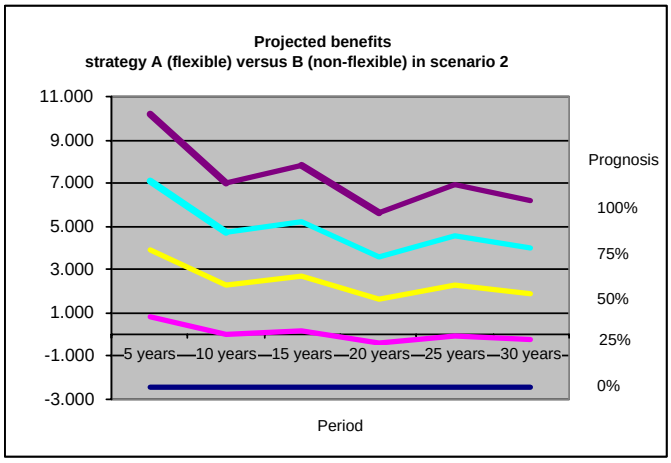


*Figure 9: projected savings of strategy A (flexible) compared to strategy B (non-flexible)*

From Figure 9 it can be concluded:

- The savings fall as the adaptation period moves further into the future
- If there is no chance (0 %) that scenario 2 will occur (adaptation from two partitions to four partitions), the projected savings are always negative. In this case, no use is made of the extra investments in future flexibility.
- If there is a 25 % chance of scenario 2 taking place, the projected savings are only positive if the adaptation happens within 15 years.
- The maximum projected savings, found by comparing the two strategies for this scenario, occur when the adaptation, which occurs with 100 % probability, takes place after five years, and is fl 10,200.

## CONCLUSIONS

This briefly described calculation method Flexcos is a useful aid in making costs and benefits comparisons between different design and construction strategies. The method combines (extra) investment costs, maintenance costs and adaptation costs (rebuilding) with flexible parameters such as the period when the rebuilding takes place and the prognosis (probability) of the rebuilding occurring. In this way, policies can be evaluated over the projected benefits arising from extra investments for flexibility. In addition, various designs can be considered in relation to each other at any given stage in the planning. The largest unknown factor in this method is estimating whether provisions made for future flexibility will actually be used in any given period. It is therefore recommended that attention is paid to follow-up studies. Case studies of past projects, in which extra measures were provided for future flexibility, could offer added insights.

## REFERENCES

Geraedts R.P., Van der Voordt T., “Good buildings drive out bad buildings”, TU Delft, 1999.

Geraedts R.P., Vermaas H., Wees L.J. van, “Partitionable Supports and Costs – Verkavelbare Dragers en Kosten”, SBR 189, Rotterdam 1989.

Dekker K.H., KD/Consultants, Formula Partitionable Supports and Costs, Voorburg, 1989.