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## Defects in Housing, Musikbyen

*Danish Building Defects Fund (BSF) CREDIT Case DK08*

Olsen, Ib Steen; Bertelsen, Niels Haldor; Frandsen, Anne Kathrine; Haugbølle, Kim

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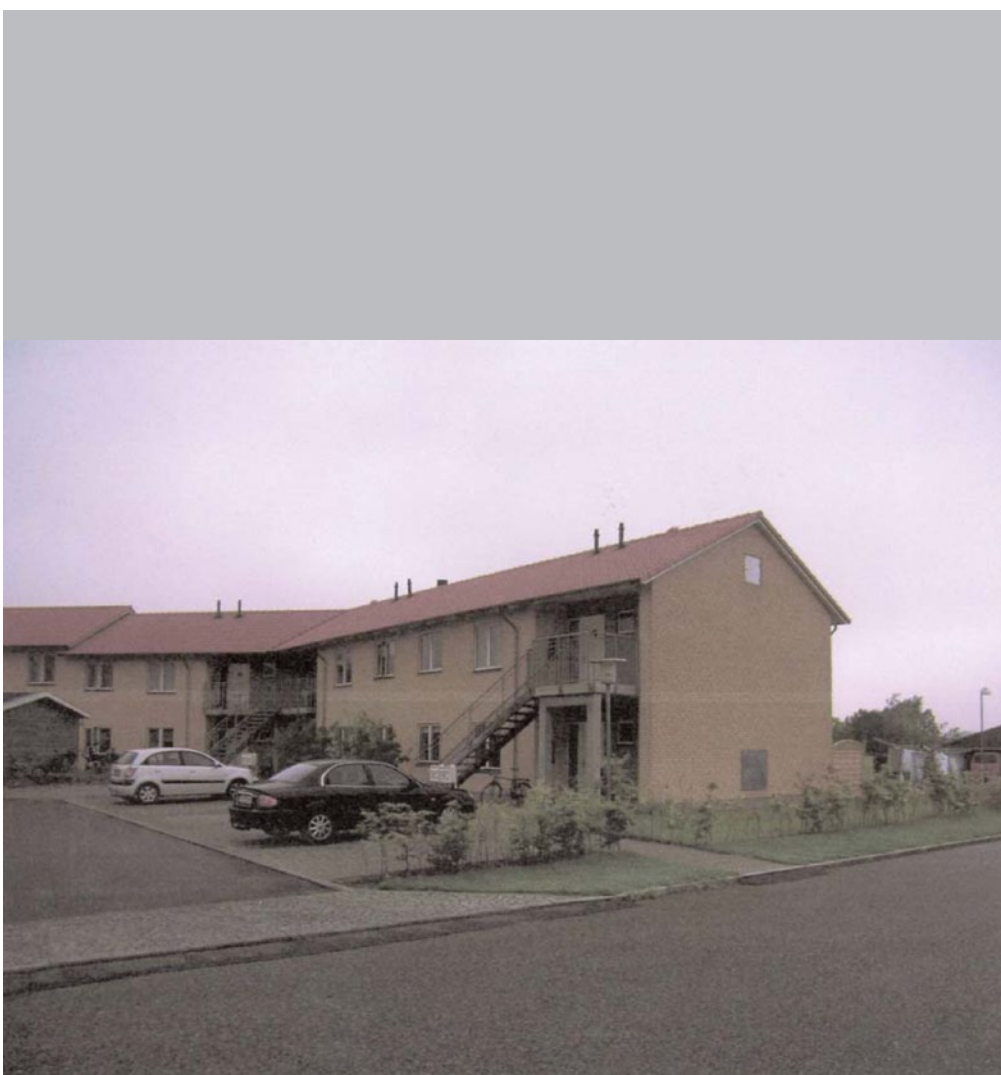
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Danish Building Defects Fund (BSF)

CREDIT Case DK08





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CREDIT Case DK08

Ib Steen Olsen  
Niels Haldor Bertelsen  
Anne Kathrine Frandsen  
Kim Haugbølle



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Danish Building Research Institute, Aalborg University  
Dr. Neergaards Vej 15, DK-2970 Hørsholm  
E-mail [sbi@sbi.dk](mailto:sbi@sbi.dk)  
[www.sbi.dk](http://www.sbi.dk)

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# Preface

This report describes the results of a case study undertaken as part of the Nordic/Baltic project *CREDIT: Construction and Real Estate – Developing Indicators for Transparency*. The case study is part of the work in work package 4-6 with respect to project assessment tools, application in firms and national benchmarking systems.

CREDIT includes the most prominent research institutes within benchmarking and performance indicators in construction and real estate, namely SBI/AAU (Denmark), VTT (Finland), Lund University (Sweden) and SINTEF (Norway). Further, three associated partners have joined CREDIT. The three associated partners are the Icelandic Center for Innovation (Iceland), Tallinn University of Technology (Estonia) and Vilnius Gediminas Technical University (Lithuania).

The project has been managed by a steering committee consisting of the following persons:

- Kim Haugbølle, SBI/AAU (project owner).
- Niels Haldor Bertelsen, SBI/AAU (project coordinator)
- Pekka Huovila, VTT.
- Päivi Hietanen, Senate Properties
- Ole Jørgen Karud, SINTEF.
- Magnus Hvam, SKANSKA.
- Bengt Hansson, Lund University.
- Kristian Widén, Lund University.

The project group wishes to thank our industrial partners and all the contributors to the case studies. In particular, the project group wishes to thank the four Nordic funding agencies that sponsored the project as part of the ERABUILD collaborative research funding scheme: The Nordic Innovation Centre (NICe), TEKES in Finland, FORMAS in Sweden and the Danish Enterprise and Construction Authority (Erhvervs- og Byggestyrelsen) in Denmark.

Danish Building Research Institute, Aalborg University  
Department of Construction and Health  
August 2010

*Niels-Jørgen Aagaard*  
Research director

# Summary

This case study has been chosen:

- To show how deficiencies and building damages can be registered one year and five years after the construction has been completed and handed over.
- To analyse the extent of the cost of repairing work.
- To explore how experiences from inspections of finished buildings can be utilized in new construction and as benchmarking.

The Danish Building Defects Fund is the primary source of information on the building quality of Danish non profit housing. The Fund is an independent organization, which was established by law in 1986 as part of a quality and liability reform the same year. Further information can be found on [www.byggeskadefonden.dk](http://www.byggeskadefonden.dk)

Since 1986 it has been obligatory for new housing with public financial support to register at the Fund and pay 1 % of the building costs including site costs to the Fund. A part of the payment is used for inspections – one year and five years after handing over. The rest is an insurance concerning defects.

## *Buildings (WP4) summary*

The inspections are executed in accordance with a general classification of the different parts of a building. They are the indicators. When a deficiency or a building damage is observed, the actual part is therefore also marked. The Fund has furthermore established a classification of the seriousness of a deficiency or a building damage with a division into five categories.

The indicators are the starting point to show whether there are or could be problems with indicators at higher levels as indoor environment ( as safety and indoor climate) and product performance (as constructions and installations).

## *Enterprises (WP5) summary*

The indicators are used, as described, when an independent company execute an inspection after hand over. In this way they are not used in the planning or construction of the actual project. But they are used in eventually repair work and in the operation of the building. And due to the dissemination of information and the rules for the obligatory quality assurance they are part of the planning and execution of coming projects.

With one year and five year inspections after hand over it has been possible to establish a rapid and effective feedback of knowledge and experiences concerning building methods, components and materials.

## *National benchmarking (WP6) summary*

The purpose off the Fund is:

- To carry out the one year and five year building inspections
- To give financial support to the repair of building defects
- To communicate findings and experiences about the building process and building to the building sector for the purpose of preventing future build-ings defects and to promote quality and efficiency in building.



The information about the quality of housing projects is available in the Fund's extensive database. The database includes all information collected from systematic five year building inspections, which were established in 1991. After 1998 a one year building inspection was established. The information collected here is also stored in the database, and are accessible for the public on [www.byggeskadefonden.dk](http://www.byggeskadefonden.dk).

The Fund has carried out inspections of approximately 10.000 buildings with approximately 205.000 dwellings in all since 1986. The building inspections register for all parts of the building, which are essential for the lifetime of the building, whether the building part is in accordance with laws, regulations and likely, or if there is defect or damage.

For example all building parts concerning the climate protection are registered, while for instance indoor equipment is not registered, because it has no influence on the lifetime of the building.

Approximately 250 independent firms, consultants (architects and engineers) and other (i.e. contractors) carry out the buildings inspections throughout the country. The same firms are involved in planning, supervision and execution of publicly subsidized housing – but of course they do not carry out inspections of houses, in which they have taken part in the building.

The Fund covers up to 95% of the expenditures for damage repairs, that are claimed at the latest 20 years after hand over has taken place. After acknowledgement of a building damage, the Fund make liability claims to the responsible builder, consultants, contractors and suppliers as far as are possible.

The Fund has developed an extensive statistic about defects in housing, which is disseminated to the industry and clients. The statistic is organized in accordance with different aspects as client (with concrete name), building parts after the classification and seriousness and involved companies (with names).

If necessary the Fund will also publish warnings about specific methods, components or materials. Some examples are problems with stability of buildings, use of specific bricks and cement slates and roofs with light under-roofing.

It is estimated that dissemination of information has reduced repair costs by at least 100 million DDK per year. The number of estates with defects has been reduced from about 30 % to about 4 %.

In 2008 the Danish Parliament issued a law concerning private housing in accordance with which it is obligatory for a developer or contractor to sign an insurance concerning possible defects in new dwellings. The law is based on experiences from the Fund, and the Fund is also involved in disseminating knowledge and experiences from this arrangement in order to prevent future buildings defects and to promote quality and efficiency in this type of buildings.

# 1. Introduction

This chapter describes the objectives of the CREDIT project, the background, scope and purpose of the case study of search engines for private homes, and the research design of the study.

## 1.1 Objectives and work packages of CREDIT

Sir Winston Churchill once said, “We shape our buildings, afterwards our buildings shape us” (28<sup>th</sup> Oct 1943). This quotation underlines how strong a building can influence an occupier or a user. Providing complex public facilities for example hospitals, schools, universities and libraries that are able to meet both the internal and external stakeholders’ needs and requirements is not without complications. The aims and demands of different stakeholders within a project can sometimes create conflict with each other’s interest. Understanding the needs and requirements of these stakeholders are essential to remain competitive in today’s market. A client that pays attention to the needs of the end-users will be rewarded with a high-performance property. Simultaneously, this shift seeks to solve many ills associated with inadequate building conditions and resulting in poor building function.

Due to the amount of both public and private money being invested in delivering public and private facilities, strong actions must be adopted. Collaboration with the relevant stakeholders will help building owners in identifying the required performance indicators to create high-performance facilities. The project aims to define a model for the implementation of performance requirements, which ensure the fulfilment of the various types of users’ and stakeholders’ needs and demands. The model shall also allow for the continuous measuring of the effectiveness of the used requirements and the model as such so that it may be improved as more knowledge and experience of it is achieved.

Following the themes of the ERABUILD call closely, the aim of CREDIT is to improve transparency on value creation in real estate and construction.

Thus, the objectives of CREDIT are:

- To capture end user needs and requirements in order to identify and quantify – where possible – value creation in real estate and construction.
- To develop compliance assessment and verification methods.
- To define and develop benchmarking methods and building performance indicators in real estate and construction.
- To set out recommendations for benchmarking internationally key building performance indicators.

Consequently, the deliverables of CREDIT are:

- 1. The establishment of a network of Nordic and Baltic researchers for benchmarking and performance indicators through frequent interactions in workshops across the Nordic and Baltic countries.
- 2. A State-of-the-Art report, that will identify and critically examine a number of existing tools, databases, mandatory reporting, approaches and benchmarking schemes to capture and measure end-user needs, client and public requirements on performance and value creation.

- 3. A strategic management and decision making tool to guide the definition and development of benchmarking methods and building performance indicators in different business cases.
- 4. A comprehensive performance assessment and management tool with associated key performance indicators to capture end-user requirements and to continuously measure and verify the compliance of performance throughout the lifecycle of an actual building project and linked to building information models.
- 5. Recommendations as to how sectoral and/or national indexes for performance indicators can be designed in order to allow for international benchmarking of construction and real estate.
- 6. Dissemination of the lessons learned and tools developed through news articles, press releases, workshops with actors in the real estate and construction cluster etc.

## 1.2 Background, purpose and focus of the case study

This case study has been chosen:

- To show how deficiencies and damages can be registered one year and five years after the construction has been completed and handed over.
- To analyse the extent of the cost of repairing work.
- To explore how experiences from inspections of finished buildings can be utilized in new construction and as benchmarking.

The Fund, who is in charge of the inspections, has developed a classification of every part of a building and has also worked out a method for the evaluation of the seriousness of deficiencies with different levels.

As Danish housing with public financial support normally is of a better quality compared to many other countries and without restrictions for different income groups this housing form here is called non profit housing and not social housing.

## 1.3 Research design and methods applied in the case study

The case describes the inspections of a housing project one year and five years after handing over. The inspections are executed by an independent fund, the Building Defects Fund.

The description is based on meetings with the Fund and written documentation for inspections in a housing estate, Musikbyen, and guidelines from the Fund and the Ministry of Interior and Social Affairs

The case study has been written in collaboration between SBi, Ib Steen Olsen, and the Fund, Ole Bønnelycke.

The case study has been conducted as an action research by researchers and members of the organization seeking to improve their situation (Greenwood and Levin, 1998)

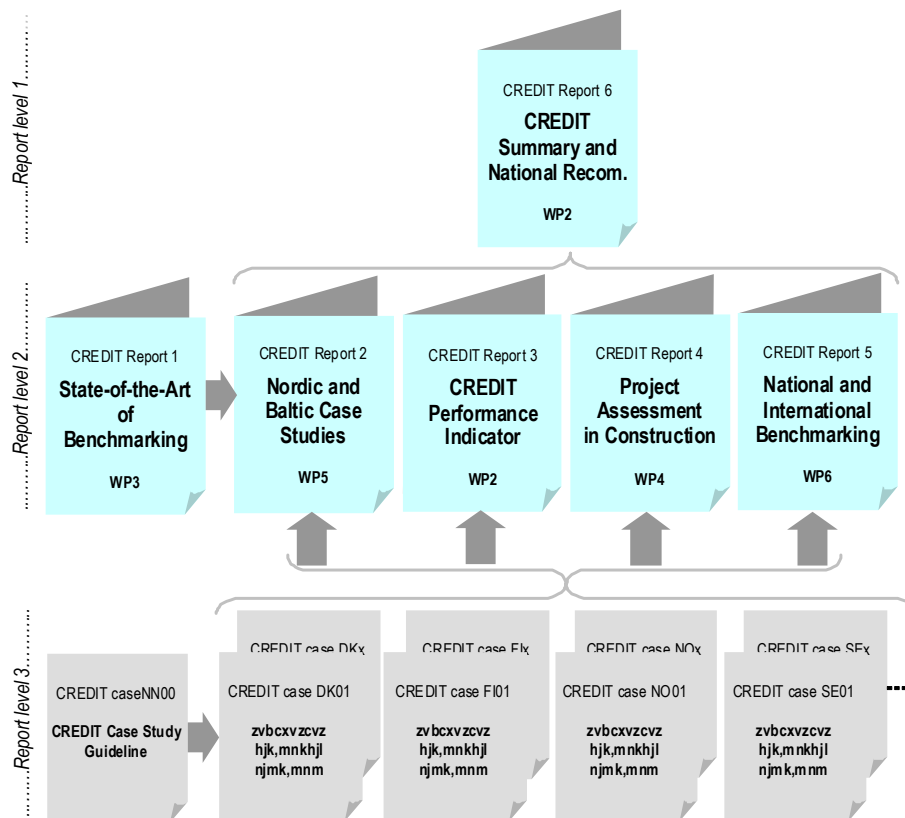
Data have been conducted from multiple sources to enhance reliability and trustworthiness of the results (Robson, 2002).

## 1.4 Reading instruction

Chapter 2 in this report addresses issues relevant to WP4 on assessments at project level. Chapter 3 addresses issues relevant to WP5 on the application of assessments in firms. Chapter 4 addresses issues relevant to WP6 on sectoral, national or international benchmarking systems. Chapter 5 discusses and concludes on the lessons learned with respect to the three levels of projects, firms and systems.

The work of each work package (WP) is documented in various other reports, articles etc. Below, a graphical illustration of the hierarchy and linkages between the individual reports is given.

Figure 1. Graphical illustration of the hierarchy of the CREDIT reports.



## 2. Buildings – assessments in construction or real estate processes

The established indicators are one year after completion evaluated to detect deficiencies or building damages. And five years after the Fund will inspect, whether the deficiencies or building damages registered at the one year inspection have been eliminated and look at possible signs of damages from hidden deficiencies, which were not registered under the one year inspection.

The results concerning the indicators are published and thereby used in coming new housing projects.

### 2.1 The actual building, building parts and processes

The actual case study has focus on a non profit housing project one year and five years after handing over. The project consists of 25 dwellings and was designed and constructed in 2003-2004 with handing over 23 April 2004.

The client was a non profit housing organization Boligselskabet af 1943 in Næstved.

The project was executed by the following companies: White arkitekter A/S as architect, Lyngkilde A/S as consulting engineer and by the following local contractors: carpenter: H. Nielsen & Søn, bricklayer: Murermester Peter Knudsen, foundations: FC Entreprise A/S, plumber: H. P. Christensen & Søn A/S and electrician: Ole's EI-Service.

The one year inspection was executed by Tegnestuen Steudel & Knudsen, architects, and the five year inspection by Friis Andersen, architect. Both firms were not involved in the design or the execution.

The inspections are in general executed by a number of private companies, who are chosen after a prequalification. They have to take part in different meetings arranged by the Fund in order to disseminate experiences from inspections.

### 2.2 The applied assessment methods and tools in the processes

The indicators are used, when an independent company executes an inspection after handing over. In this way they are not used in the planning or construction of the actual project.

The results of the evaluations of the different indicators are meanwhile used in eventually repair work and in the operation of the building. And due to the dissemination of information and the obligatory rules for quality assurance, they are part of the planning and execution of coming projects.

The independent companies are chosen by the Fund. They look after deficiencies and building damages which are registered in accordance with a classification of the different parts of a building and the seriousness.

In practice the inspections are divided into some phases. The starting point is an examination of the documents for the execution and for the quality assurance work. Thereafter the buildings will be visually inspected and if necessary some components or parts of the building will be inspected in more details.

Only a certain number of apartments and building parts will be inspected. This percentage will vary in accordance with individually considerations.

## 2.3 Cost and performance indicators applied in the assessments

The inspections are executed in accordance with a general classification of the different parts of a building. They are the indicators. When a deficiency or a building damage is observed it is therefore also marked at the concrete part. The Fund has furthermore established a classification for the seriousness of a deficiency or a building damage.

The general classification covers - except from for example indoor equipment - construction parts from the whole building, which are essential for lifetime of the building - especially the climate protection - and comprises

- the foundation and the cellar,
- the structural elements (bearing and stabilizing parts of the building),
- the outer walls,
- the roof,
- the bathroom,
- drainage and sanitary facilities,
- concrete in complicated environment (as concrete in outer balconies) and other building parts (for example outer staircases)
- other building parts.

The mentioned parts of the building are each divided in minor parts – from three to nine. So the total number of indicators sums up to about 70.

In a concrete project only a part of the indicators will be relevant. For each indicator it will be noticed whether there is defect or not. It will also be remarked if it is not possible to make an inspection. In that case the Fund will make a further inspection.

A *deficiency* means that the building materials, structures or building elements are in absence of properties, which should have been present. A *building damage* means a deficiency, which leads to breakage, leakage, deformations, impairment or deterioration in the building. Both deficiencies and damages must be caused by the design or the execution of the house in order to be recognized by the fund as covered by the fund.

The inspection firm will use this division of the building in the inspection and make notes in accordance with the indicators. And later the notes will be channelled into the data bank.

In the actual case the one year inspection resulted in deficiencies concerning structural elements and their resistance against horizontal forces, the construction of walls in the bathrooms and insulation of some pipes. Every

deficiency is described in connection with a building part/component or indicator as mentioned above.

In the five year inspection there is a special attention concerning repairing of the observed deficiencies from the one year inspection.

All communication between the Fund and the inspection firms are digitalized, as well as the internal procedures in the Fund including data transmission to the public accessible homepage, [www.byggeskadefonden.dk](http://www.byggeskadefonden.dk)

The indicators are the starting point to show whether there are or will be problems with indicators at higher levels in CREDIT classification as indoor environment (as safety and indoor climate) and product performance (as constructions and installations).

## 2.4 Relation to different enterprises and national benchmarking

The indicators are used, when an independent company executes an inspection after hand over.

In this way they are not used in the planning or construction of the actual project. But they are used in eventually repair work and in the operation of the building. And due to the dissemination of information and the obligatory rules for quality assurance they are part of the planning and execution of coming projects.

## 2.5 Visions for future improvements

The client, Boligselskabet, is satisfied with the way the inspections are executed and uses the results in the operation of the estate.

The Fund has some considerations concerning the future work, see chapter 4 and 5. The main vision is to strengthen the implementation of the experiences by a stronger use of them in connection with the planning and design of new estates.

### 3. Enterprises – assessments and indicators internally applied

The chapter describes how the client and companies cooperate at the inspections and how the results are documented and channelled to involved participants.

The Fund and clients planning new estates expect that the companies will learn of the experiences and take them into account in coming projects. The quality assurance system which is obligatory to use contribute to this.

#### 3.1 The actual enterprise, company and firm

The client was a non profit housing organization, Boligselskabet af 1943, Næstved.

The housing association and the municipality, which is the authority, who administrate the public support, are informed of the results of the one year inspection and the five year inspection executed by independent firms. In cases with deficiencies or building damages the housing association is expected to hold the firms responsible.

If the housing association does not succeed in making an agreement with the responsible firms, they can report essential defects and damages to the Fund, who will acknowledge paying the repair costs, if the defects or damages fulfil the conditions in the law. In this case the Fund will contact the firms concerning their possible liability.

#### 3.2 Assessment methods and tools applied in the enterprise

The actual project is a housing estate with 25 dwellings. Building is organized in a traditional way with consultants for architectural and engineering work and 5 specialist contractors.

The assessments, here the one year inspection and the five year inspection, are used of the client and the involved companies. The inspections are executed after hand over and register the condition of the building and eventually defects and damages.

The assessments are executed by independent firms. The involved companies in the execution of the estate have to deliver documentation for design work and for their work with the quality assurance of the building.

The client will use the results to evaluate whether it is necessary to make some repair work and whether to go to the Fund for funding. The companies get information for coming projects and for their quality system



### 3.3 Costs and performance indicators applied in the enterprise

The Fund has established a classification of the different parts and a classification of the seriousness of deficiencies and building damages. The indicators aim at an evaluation concerning whether the building is planned and constructed as agreed and in accordance with the laws, regulations etc. and without defects and damages.

The used indicators include - except for example indoor equipment - construction parts from the whole building, which are essential for lifetime of the building – especially the climate protection.

The client uses the results for planning of the operation as for example maintenance.

### 3.4 Relation to building cases and national benchmarking

The companies in the project Musikbyen use to some extent information gathered in other benchmarking systems in Denmark and general guidelines. Meanwhile it is obligatory for the enterprises to know and to use in their quality assurance system the experiences obtained by the Fund.

### 3.5 Visions and innovation for future improvements

There are several partners with interest in the inspections. The main partners are the Fund, the client and the involved companies. But also politicians with responsibility for the quality of the estates, the building industry and the local authorities are interested in the results.

It is the opinion of the Fund that the experiences concerning the used methods with inspections and dissemination of information should be spread to other clients and sectors within the building industry. It has been done in 2008 to private housing with a specific law.

It is the general opinion that the indicators give the client as well as the companies' possibility to learn more about the effectiveness and quality of the executed work and to use the results in new projects. They can for example be used as points of attention in quality assurance systems.

The indicators can stimulate thinking about all the phases in the building process – from the idea and the first discussions to details in the project and further to work on the building site.

Furthermore the results can be used in connection with education and post education at the level of the individual companies and in workshops and conferences for several companies.

By using digital reports and a public homepage the Fund contribute to the digital building process.

## 4. National benchmarking – indicators, assessment and organisation

On the basis of one year and five year inspections the Fund has developed an extensive statistic about defects in housing which is disseminated to the industry and clients. The statistic is organized in accordance with the classification of indicators and companies involved in the actual project.

In this way it is also possible for clients and other interested persons and companies to see the results of a concrete project concerning defects related to different parts of the building, the client and the companies involved in the project.

The Fund also publishes warnings about specific methods, components or materials.

### 4.1 The actual benchmarking organization and its purpose

The Danish Building Defects Fund is the primary source of information on the building quality of Danish subsidized housing. The Fund is an independent institution, which was established by law in 1986 as part of a quality and liability reform the same year. Further information can be found on [www.byggeskadefonden.dk](http://www.byggeskadefonden.dk).

The purpose of the Fund is:

- To carry out the year-one and year-five building inspections
- To give financial support to the repair of building defects
- To communicate findings and experiences about the building process and building to the sector for the purpose of preventing future buildings defects and to promote quality and efficiency in building.

Since 1986 it has been obligatory for all housing projects with public support to register at the Fund and pay 1 % of the building costs including site to the Fund. Private housing projects can not register.

The Fund covers up to 95% of the expenditures for damage repairs that are claimed at the latest 20 years after hand over have taken place. After acknowledgement of a building damage, the Fund make liability claims to the responsible builder, consultants, contractors and suppliers as far as possible.

The deficiencies can be due to the design process as well as the work on the building site and the used components. Deficiencies will in few cases lead to a damage which gives breakage, leakage, deformation or deterioration and thereby reduces the use of the building. The Fund will pay the expenses for repairing damages.

All housing projects with public subsidies have to register at the Fund and the Fund executes two inspections.

The results from the two inspections, one year and five years after hand over, are published on a homepage and used in publications.

## 4.2 Assessment applied in the benchmarking organization

Approximately 250 independent firms, consultants (architects and engineers) and other (i.e. contractors) carry out one year and five year inspections through out the country.

On the basis of the registration the Fund will work out a report with conclusions and recommendations for the actual housing association, the client.

## 4.3 Cost and performance indicators applied in benchmarking

The inspections are executed in accordance with a general classification of the different parts of a building, which are used for types of public subsidised housing. They are the indicators. See 2.3 Cost and performance indicators applied in the processes.

The building inspection company register for all the parts of the building, which are essential for the lifetime of the building, whether the actual building part is in accordance with laws, regulations and likely, or if there is defect or damage.

Typically all building parts concerning the climate protection are registered, while for instance indoor equipment are not registered, because it has no influence on the lifetime of the building.

A *deficiency* means that the building materials, structures or building elements are in absence of properties, which should have been present. A *building damage* means a deficiency, which leads to breakage, leakage, deformations, impairment or deterioration in the building. Both deficiencies and damages must be caused by the building of the house.

Defects and damages must in details be described and photographed in the digital report that the independent firm carries out as a result of the inspection.

The Fund has furthermore established a classification for the seriousness of a deficiency or a building damage.

## 4.4 Relation to enterprises, building projects and real estate

The indicators are used, as described, when an independent company execute an inspection after hand over. In this way they are not used in the planning or construction of the actual project. But they are used in eventually repair work and in the operation of the actual building. And due to the dissemination of information and the rules for quality assurance they are part of the planning and execution of coming new projects.

The results from all one year inspections of about 3.000 projects with about 75.000 apartments have been published at the homepage of the Fund

The information is registered by the inspection companies in digital reports. The inspection company will also evaluate possible defects in accordance with a system for the seriousness of the damages and the deficiencies.

Thereafter it informs the client with conclusions and recommendations concerning liability, possible demand to companies about repair work and about the future operation of the building. And in this way the companies are informed about the executed work.

In addition to the mentioned activities the Fund takes initiative to considerable exchange of the results via courses, meetings, speeches, articles and in several collaborations with the organizations in the building industry.

## 4.5 Visions and innovation for future improvements

The Fund has recently decided to investigate, whether it is possible to change the law and the regulations for the Fund, so that in the future there will be no five year inspections.

The change is under consideration due to new rules for liability and because the five year inspections the latest years only registered very few new defect. The costs to carry out the inspections are very high compared with the costs to repair the few defects that are registered under year-five inspections.

Instead of that there will be an independent examination of the project before the design work is finished and tenders are invited and the work on the building site is started.

The examinations are supposed to be carried out by private firms like the one year and five year inspections have been carried out so far and so that the experiences can be used in future projects of planning, supervision and execution of non-profit housing.

The examinations of the projects will be executed in accordance with a general classification of the different parts of a building – probably the same classification as the year one inspections. When a deficiency is observed, it is therefore also marked.

In this way it will be possible to target messages to the clients and industry and make warnings about defects and damages towards constructions and materials which often show defects in the examinations of projects.

The costs of examinations of projects are supposed to be approximately the same as for five-year inspections so far.

If this new arrangement is established, it will only have impact for projects, where the decision on public subsidising is taken after the law about the new arrangement is passed in the parliament.

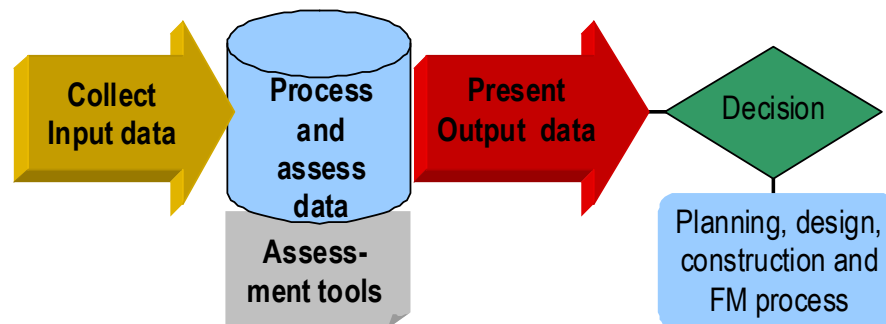
## 5. Discussions and conclusions

The experiences from one year and five year inspections give the Fund, the client and the companies some valuable lessons about good and bad practice in the actual building project.

The Fund's dissemination of the lessons gives at the same time the whole industry not only knowledge about defects but also the possibility to learn and develop methods, components and materials.

Furthermore the results are used to considerations about remediation and liability in the actual project.

Figure 2. CREDIT information model in relation to decisions in the planning, design, construction and facility management processes.



### 5.1 Buildings – lessons learned and recommendations

The general classification of indicators covers construction parts from the whole building, which are essential for lifetime of the building - especially the climate protection - and comprises:

- the foundation and the cellar,
- the structural elements (bearing and stabilizing parts of the building),
- the outer walls,
- the roof,
- the bathroom,
- drainage and sanitary facilities,
- concrete in complicated environment (as concrete in outer balconies) and other building parts (for example outer staircases).

The mentioned parts of the building are each divided in minor parts – from three to nine. So the total number of indicators sums up to about 70.

They have been chosen in accordance with experiences from analysis of defects and earlier inspections. They represent topics where there is a risk for defect.

The Fund has furthermore established a classification for the seriousness of a deficiency or a building damage with a division into five categories.

The indicators are the starting point to show whether there are or will be problems with indicators at higher levels in CREDITS classification as safety, indoor climate and product performance (as constructions and installations).

In some cases detected deficiencies and damages have appeared to be sign of structural or other more general problems. An example is that deficiencies in roofs have been caused by problems with the stability of the building.

It is recommended to choose indicators which can signal possible defects, are well defined and easy to implement in benchmarking and dissemination of experiences as done in the BSF system.

## 5.2 Enterprises - lessons learned and recommendations

The employed assessment methods give the Fund, the client and the companies an effective evaluation of the executed work. And by making inspections one year and five year after handing over it is possible to get information concerning the usefulness of methods, components and materials in practice which is very valuable not only for the individual client but for the whole industry.

In this way the assessments of the indicators give the client as well as the companies' possibility to learn more about the effectiveness and quality of the executed work. Furthermore they give client and companies in a new project possibility to use the results in the design process and the execution.

The indicators can stimulate thinking - in new projects - about all the phases in the building process – from the idea and the first discussions to details in the project and further to work on the building site.

It is recommended to establish methods for the practical use of experiences.

## 5.3 National benchmarking - lessons learned and recommendations

On the basis of the inspections it has been possible for the Fund to develop an extensive statistic about defects in housing which is disseminated to the industry and clients. The statistic is organized in accordance with different aspects as clients (with concrete name), building parts after the classification and seriousness and involved companies (with concrete names).

If necessary the Fund also publishes warnings about specific methods, components or materials. Some examples are problems with stability of buildings, use of specific bricks and cement slates and roofs with light under-roofing.

It is estimated that dissemination of information has reduced repair costs by at least 100 millions DDK per year. The number of estates with defects has been reduced from about 30 % to about 4 %.

It can also be mentioned that the Danish Parliament in 2008 issued a law concerning private housing. In accordance with this law it is obligatory for a developer or contractor to sign an insurance concerning possible defects in new private dwellings. The law is based on experiences from the Fund.

The Fund has recently decided to investigate, whether it is possible to change the law for the Fund and the regulations of the Fund, so that in the future the five year inspections will be cancelled.

The change is under consideration due to new rules for liability and because the five year inspections in the latest years only have registered very few new defect. The costs to carry out the inspections are very high compared with the costs to repair the few defects that are registered after five year inspections.

Instead of that there will be an independent examination of the actual project before the design work is finished and tenders are invited.

The examinations are supposed to be carried out by private firms like the one year and five year inspections have been carried out so far and so that the experiences can be used in future projects of planning, supervision and execution of non profit housing

BSF has been established for a specific group of clients and the clients have to pay to the Fund in accordance with a demand from the state. For an international exchange of experiences it has appeared to be important with similar methods and organizations with identical definitions of buildings defects.

It is recommended to organize benchmarking in accordance with a well defined target group and establish incentives for this group to participate. Furthermore it is important to have a well defined system for data with procedures for input and output. Last but not least it is essential with a framework for active participation from interested clients and companies in the use of the results.

Table 1. Questionnaire to evaluate CREDIT Indicator Classification.

<b>CREDIT Indicator Classification</b>		<b>To which degree are the following indicators preferred?</b>					
Company:		Please use the following scale when answering:					
Role:		2 Always - strategic and very important					
Project:		1 Sometimes, depends upon the project					
Date:                      Sign:		0 Not at all, unimportant					
		Public demands	Internal project demands	Measures during building process	Measures when finished project	During facility management	Comments and other indicators recommended
<b>Cost and performance indicators</b>							
<b>1. Cost, price and life cycle economy (LCE)</b>							
11 Capital, investment, construction, commissioning cost							
12 Building services related to operation and maintenance							
13 Business services related the activities in the building							
<b>2. Location, site, plot, region and country</b>							
21 Location and address							
22 Plot opportunities							
23 Spatial solution and property aesthetics							
24 Surrounding services							
25 Social values							
<b>3. Building performance and indoor environment</b>							
31 Category of building, quantity, size and area							
32 Safety and security of burglary							
33 Usability and adjustability							
34 Thermal comfort							
35 Air quality and health							
36 Visual climate							
37 Acoustic climate							
38 Aesthetics of building and indoor spaces							
39 Feelings and sensations							
<b>4. Building part and product performance</b>							
41 Category of building parts, quantity, size and area							
42 Safety							
43 Durability							
44 Thermal quality							
45 Impact on air quality							
46 Lighting quality							
47 Acoustic quality							
48 Aesthetic quality as form, surface, colour and details							
49 Feelings and sensations							
<b>5. Facility performance in operation and use</b>							
51 Category of tenancy and operation and area of space							
52 Applicability of the facility							
53 Operation							
54 Services							
55 Social performance							
<b>6. Process performance in design and construction</b>							
61 Category of process, supplier and organisation							
62 Resource control and project management							
63 Health and safety and work environment							
64 Quality management							
65 User involvement and cooperation							
<b>7. Environmental impact</b>							
71 Resource use							
72 Emissions							
73 Biodiversity							



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This report describes the results of a case study of Defects in housing, Danish Building Defects Fund. The study was undertaken as part of the Nordic and Baltic project CREDIT: Construction and Real Estate – Developing Indicators for Transparency.

The analysis is aiming at three levels: the project or building, the firm and the national benchmarking system.

It has been obligatory in Denmark since 1986 for new housing with public financial support to register at the independent Danish Building Defects Fund and pay 1 % of the building costs. A part of the payment is used for inspections which are organized one year and five years after handing over. The rest is an insurance concerning defects.

Since 1986 the number of estates with defects has been reduced from about 30 % to about 4 %.

The case describes the inspections of the estate Musikbyen with 25 dwellings organized one year and five years after handing over.

The information about the quality of housing projects is available in the Fund's extensive database on [www.byggeskadefonden.dk](http://www.byggeskadefonden.dk)

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