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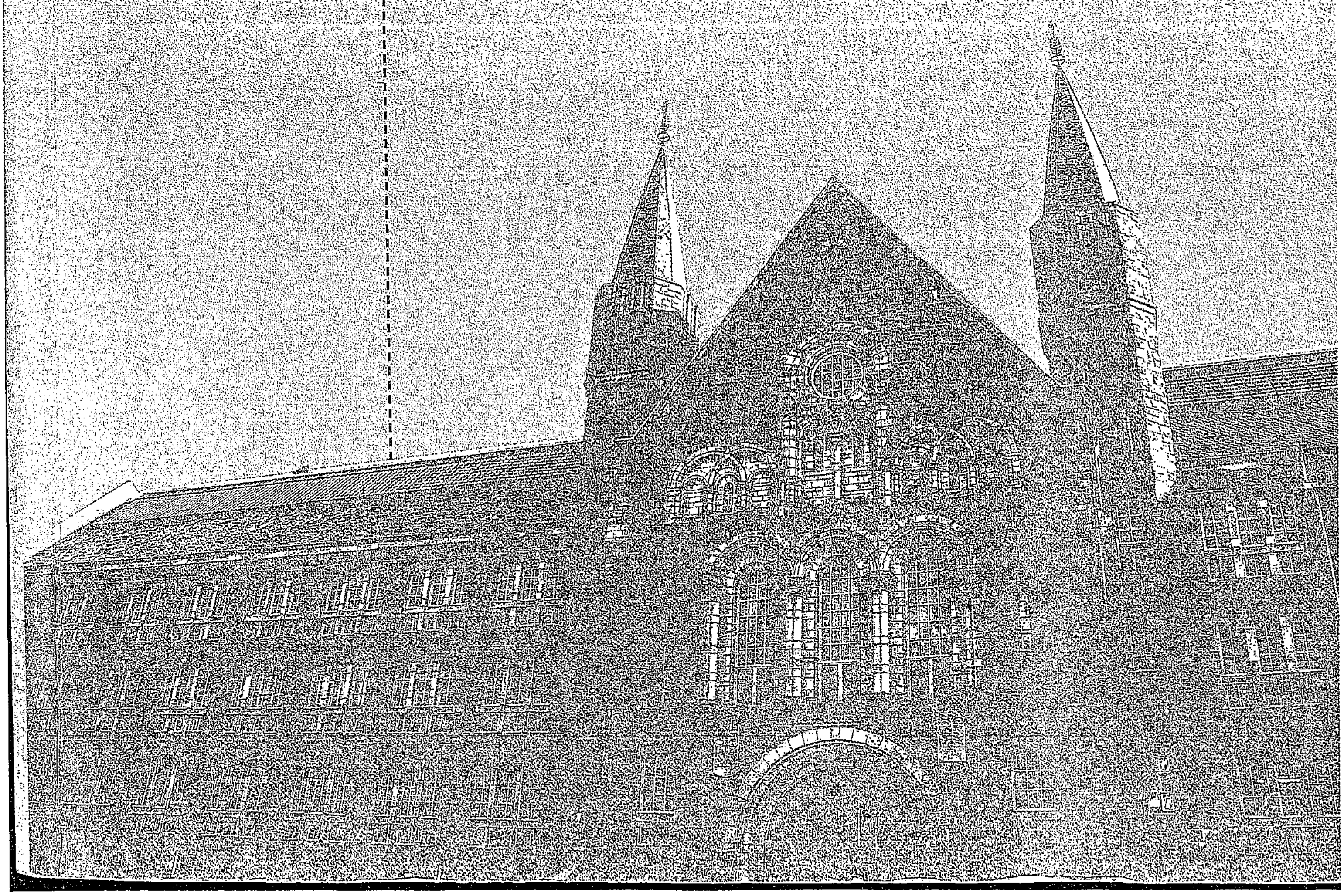

DEVELOPMENT OF AN EFFECTIVENESS-EVALUATING-FACTOR OF LIFELONG PERFORMED VALUE MAINTAINING AND INCREASING MEASURES

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ABSTRACT

The paper describes the methodology to evaluate the effectiveness of lifelong performed value maintaining and increasing measures (VMM) by determining the actual condition of the building and classification in different building categories. These categories include different designs in terms of building expenses and complexity, components choice, the level of standardization and the consequential maintenance expenditure. The research bases on an all encompassing investigation of real data. It is part of a research project called BEWIS situated at the Universität Karlsruhe (TH). This project focuses on a survey of a variety of facilities, for which complete life cycle data is compiled in order to point to optimal maintenance, upkeep and modernisation measures (also described before as VMM). Second step is the evaluation of the actual building substance on the basis of a method developed within the scope of an EU-research program. Next step is the development of the so called SWEE-factor. This factor describes the efficiency of VMM-measures that take place over the course of the entire life-cycle, as well as being able to describe the impact of repair backlogs on the overall efficiency of maintenance efforts. Further result of this evaluation is the answer of the following research question, “How to reach the ideal SWEE-factor”?

KEYWORDS

Life Cycle efficiency, Life Cycle analysis,

INTRODUCTION

The monetary value of European property assets is enormous. In Germany alone, the gross fixed assets for real estate properties amounts to approximately € 9.05 trillion. While 56.6% of this overall number represents residential buildings, the remaining 43.4% is representative of so-called non-residential buildings (SBA, 2005).

According to Bernd Knobloch’s seminal financial article on real estate assets (Knobloch, 2005), the location of the majority of high value property assets in Europe is in Germany. Such a large number of valuable assets includes an exorbitant cost for operating expenses.

In the context of increasing costs in relation to the life cycle of property assets, the total costs of a building are composed of financing-, operational-, planning-, and construction costs, as well as demolition and disposal costs (Reinhardt, 2005, p. 20). Costs associated with the operating phase represent the highest cost pool, which has ensured they are paid increasing attention. Generally speaking, the degree of involvement an owner has with setting the costs involved with the building (e.g. operational costs), is in proportion with the benefits this type of effort can produce.

Yet, the influence that factors such as the chosen maintenance strategy or the condition of building services have on operational costs are to a large extent unknown (Stoy, 2005, p. 4), while a building's VMM-expenses have a noticeable effect on operational costs.

Due to budgetary constraints, the efficient maintenance of real estate assets is of particular importance for public authorities. Recent public expenditure trends have curtailed upkeep (maintenance) funds in order to save expenses in the "short term". The long-term consequences of these financial cutbacks in regard to building condition begins to appear a few years later and has had a drastic impact on public facilities (KGSt, 1984, p. 10). As a result, the level of modernisation of public facilities is decreasing. In recent years, this trend has been borne out in figures, with the level of modernisation in German facilities declining from 78.9 % in the year 1991 to 62.2 % in 2005 (SBA, 2005). The level of facility modernisation is generated by the relationship of net fixed assets to gross fixed assets, whereas the net fixed assets represent the current value and the gross fixed assets represent the replacement value of certain building facility parts. When considering the complete life cycle of real estate assets, such "short term" decisions may be counterproductive. In order to keep costs and benefits in balance, an efficient building upkeep/maintenance plan, which encompasses a "big picture" view of the complete life cycle of the building, has shown itself to be of primary importance when making cost containment decisions.

Nonetheless, it must be noted that building maintenance/upkeep is subject to a matrix of dependencies, which are to large extent unknown to date. Yet, all research findings about statistical correlations and influencing factors point to the necessity of planning for effective building maintenance/upkeep.

This paper describes the research findings from the BEWIS project, which was carried out by the department of Facility Management at the University of Karlsruhe (TH), Germany. This specific project deals with the analysis of facility management practices in office and administrative buildings, as well as public school facilities. The focus of the research work was on optimised- and life cycle-oriented building upkeep and maintenance. This research identifies the factors that influence the development of real value efficiency-factors (SWEE – factor) and illuminates the best practices in effective building upkeep and maintenance.

STATE OF THE ART

The effective upkeep and maintenance of real estate assets requires an all-encompassing level of know-how concerning the service life of building components, as well as their quality. Furthermore, analyses of life cycle data in connection with determinations of building condition and maintenance backlogs are necessary and highly relevant to such projections. However, there is a lack of knowledge regarding this topic, and as such, the BEWIS research project was conceptualized to close this gap. The actual state of the art in terms of factors impacting operational costs and maintenance issues is detailed in the following section.

Service life of building components and influencing factors

Buildings consist of different building components, which are made of different materials. Thus, every component has specific ageing behaviour. Life-cycle service issues of different components are described by Arved Tomm'(Tomm et al., 1995, pp. 25-81) and 'Paul Meyer' (Meyer et al., pp. 21-57) in related research. Another relevant research project at the ETH Zürich, which is also based on maintenance data, shows that the current lifecycle of residential buildings is helpful in determining optimal maintenance/upkeep cycles that are based upon economic data. Findings from this research are based upon empirical data about a large residential building portfolio in Switzerland (Christen et al., 1999, pp. 25 et sqq.).

Another source on the aspect how to calculate with maintenance cycles is found in ISO 15686-1:2000(E) (ISO, 2000). It describes the “factor method“ for real service life estimation, which is based on the reference service life of building components. In order to pre-estimate the real service life of building components as exactly as possible, the reference service life of the components has to be multiplied with any number of modifying factors. Modifying factors for conditions which have a substantial influence on the service life of building components are given below:

Table 1: modifying factors for estimating the service life of building components (ISO, 2000, p.23)

Agents	Factor	Relevant conditions (examples)	
Agent related to inherent quality characteristics	A	Quality of components	Manufacture, storage, transport, materials, protective coatings (factory-applied)
	B	Design level	Incorporation, sheltering by rest of structure
	C	Quality level of work execution	Site management, level of workmanship, climatic conditions during execution of the work
Environment	D	Indoor environment	Aggressiveness of environment, ventilation, condensation
	E	Outdoor environment	Elevation of the building, micro-environmental conditions, traffic emissions, weathering factors
Operational conditions	F	In-use conditions	Mechanical impact, category of users, wear and tear
	G	Maintenance level	Quality and frequency of maintenance, accessibility for maintenance

Any combination of these variables can affect the service life of the buildings components. The factor method can therefore be expressed as a formula:

ESLC = RSLC × factor A × factor B × factor C × factor D × factor E × factor F × factor G

ESLC: estimated service life
RSLC: reference service life of the component
Important in the use of these factors is the degree of reliance of the estimation data used (ISO, 2000, p.23).

Within the scope of this research project, the quality of components can only be verified by a rough visual inspection and by analysing the construction costs of the building.

Analyses of life cycle data

In order to generate relevant statistical data, analyses across the complete life cycle of a building are required. However, there is still a lack of analyses based on empirical data for the complete life cycle of buildings. In most cases, when empirical data is available, the data is from recent years. Due to this constraint, only a snap-shot of the life-cycle of buildings results from this data, although statistical outlooks still have relevance in terms of cost predictions.

An example of current research is Minami (Minami, 2003, pp. 131-137) who analysed 1.255 post office buildings in Japan in terms of their operating costs. The research findings from this analysis showed the costs for repair and improvement to the post office buildings in question and gave specifics about the relationship between total repair and improvement costs per square meter and the age of the buildings. The analysis for this research project is based on data provided by the Japanese government in the year 2000. Although this research is focused on the range of data produced in one year, the comprehensive analysis of the data which clusters on different age properties, provides an outlook on all phases of a property life cycle due of the variety of old and new buildings in the data set (Minami, 2003, pp. 131-137).

In German speaking countries, there is also a lack of empirical data about Whole Life Costs of buildings. Riegel (Riegel, 2004) has developed a software-based method for predicting the occupancy expenses of office buildings. The drawback with this method is that it is not yet based on empirical data.

The Office Charge Analysis Report (OSCAR, 2005) provides benchmarks on average service charges, such as maintenance, cleaning, and management overhead, etc. This report is published once a year in Germany and creates benchmarks based on real data from office buildings (OSCAR, 2005).

For the projection of operating expenses in Anglo-Saxon countries, the BMI Occupancy Cost Information Service - BMI Bulletin, is noteworthy. It is also published once a year and provides a very good data base for life cycle predictions (BMI, 2005).

Condition Evaluation Method

There are several methods to evaluate building condition and maintenance back-logs. The conventional real value method, which is based upon the German “WertV” (value designation regulations), identifies the value of the building, including site and location. It is not used for the evaluation of the building’s condition (WertV, 1997).

The inspection method for residential buildings according to Krug (Krug, 1985), the *méthode d'évaluation rapide* MER (Merminod et al., 1984), the “Impulsprogramm Bau-Grobdiagnose (rough diagnostics)” (IPBau, 1995) as well as the Epiqr (energy performance - indoor environmental quality - retrofit/refurbishment) method (epiqr, xxxx) have only been developed for residential buildings. They have not yet been applied to other types of real estate buildings without substantial effort.

The DUEGA diagnosis method (Gredig et al., 1997) was developed in Switzerland. It overturned this building type restriction and it bases its costing projections on Swiss standards and regulations. The next method worthy of mention is the “STRATUS Gebäude” evaluation method, which is limited due to its ability to only assess 13 building elements, which only results in a rough evaluation of building conditions (STRATUS, 2002) .

The condition evaluation program EPIQR+, is based on the European research project INVESTIMMO (INVESTIMMO, 2002) and the EPIQR method. It has been adapted for public administration buildings and school facilities. Besides the evaluation of the condition of 100 building elements (a = good condition; b= slight wear and tear; c = extensive wear and tear; d = end of service life), EPIQR+ enables the determination of the maintenance backlogs on these buildings.

Optimisation of operational costs

The main objective of the EUREKA project, “Building Maintenance Considered under Ecological And Economical Aspects”, was to “add the ecological and economical aspects to the existing building maintenance process in order to save the environment and optimise the operational costs” (EUREKA, 2001). Project objectives are confined to the maintenance of buildings. Other measures to increasing or maintain the value of the building are not included in this research project data.

RESEARCH

The BEWIS research project focuses on a survey of 20 – 30 publicly-owned facilities (including 11 public school buildings), for which complete life cycle data has been compiled. The project was conceptualized to point out optimal building value maintaining and increasing measures (VMM). Complete life cycle data means that for each building, all the archived accounts during the building life were compiled in a database. This database was set up especially to record this data. Currently, the database includes 29,000 datasets. The surveyed life-cycle data includes information about any measures that were carried out to increase or maintain the value of the building during its lifetime.

A wide variety of different school facilities are included in the study, so that it is comprehensive in scope. Different building clusters were built. All the facilities have in common that they are publicly-owned. The study includes one hospital, 13 school facilities, and 9 office buildings. Due to the status of the study in this paper, only the results from 11 school buildings can be considered.

To meet the requirements of designating cost influencing factors, as previously described (e.g. ‘State of the art’), the school buildings are clustered according to different kinds of building use. When considering the analysis of the data on these sites, it is necessary to keep these different clusters in mind. The clusters are:

- Basic primary schools [790 – 1.100 m^2]
- Grammar schools [7.900 – 17.800 m^2]
- Vocational schools [11.900 – 22.800 m^2]

All together, the schools investigated encompass 129.955,46 m^2 [gross floor area], with different space and complexity designations for different designs, interior detailing and equipment, as well as different building components. The different criteria designations used in the project for these items are listed below.

Design complexity (including the different use of building components):

- Extensive design (e.g. many components are job-works or prototypes especially designed for this building)
- Normal design
- Basic design

Building equipment degree:

- High level of building automation and equipment
- Normal

Building age groups:

- Group I 20-30 years old
- Group II 30-45 years old
- Group III >45 years old

Due to the current state of the research project these clusters, except the building age group, are not yet considered in this paper.

In Figure 1, it is noticeable that the highest average building costs (production value) are associated with younger buildings. Our assumption is that this fact reflects the economic conditions during the respective decades. Also illustrated is in each case the corresponding design of the building.

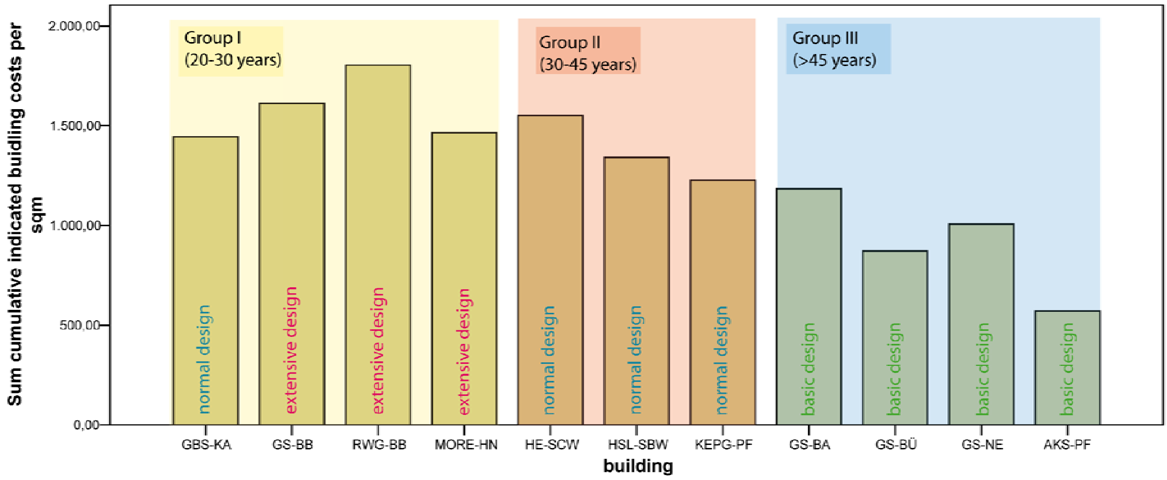

Figure 1: indicated building costs (production value) clustered in building age groups

In order to compare the current value of the building with the production value of the building, and to compare the effectiveness of consecutive interventions during a building's lifecycle, on-site inspections of buildings condition and building components were undertaken. In order to accomplish this, a method was designed which describes the actual condition of the building.

In order to ascertain the best method to determine the buildings condition, different methods were evaluated. Finally, an existent method (EPIQR+) developed in a large European research project was chosen and implemented (ref.: chapter 'State of the art'). The chosen EPIQR+ method helps standardize how to describe actual repair back-logs in €.

It is important that the same valuation method is used for all the buildings being examined under this method. To fulfil this criteria, on-site inspections and specific inputs in the database of EPIQR+ are consistently carried out by the same inspection team using the same definitions and evaluative standards.

During the site inspection, the method differentiated between 4 conditions:

A (good condition), B (slight wear and tear), C (extensive wear and tear), D (end of service life)

After each of the more than 100 differentiated components are evaluated, a so-called scenario is developed. In this scenario, the different current conditions of the building components are assigned measures which must be carried out in order to restore the building to the required condition. No measures which would retrofit the building or which would increase its value more than needed were considered. If these measures are carried out as suggested by the scenario, the building would be restored to "adequate" conditions, but would not exceed the designation of "adequate" in terms of quality of building condition.

Currently, twelve on-site surveys that are part of the BEWIS research project have been completed on public school buildings. Part of the research is the development of a SWEE factor ('SWEE'–Substanz Wert Erhaltungs Effektivität – can best be approximated in English as the effectiveness of maintaining real value), which describes the effectiveness of measures (VMM) that take place over the course of the entire life cycle. It also describes factors that impact repair backlogs, such that the overall efficiency of maintenance efforts in relation to costs expended on construction and the optimisation of actual repair backlogs. In the following chapter some approaches to the development of this method are described.

RESULTS

The following section of this paper discusses some of the exemplary results from the BEWIS research project, which concern the development of the so-called SWEE-Factor. The development of the SWEE-factor is still in progress. The formulas shown here are a first attempt to describe all the impacts that have been observed.

Two different approaches are discussed here. The first attempt modified the so-called Peter formula (Peter, 1984, p. 144). Peter developed a formula for the estimation of predicted maintenance expenses for the life period of 80 years. His basic outcome is that for the ordinary life cycle of 80 years, 1,5 times more should be invested in building maintenance than in original building costs.

$$ME = \frac{BC_I \times 1,5}{80 \times GFA}$$

ME	Maintenance expenses
BC	Building costs
GFA	Gross floor area
I	Time of construction

For the research project in question (BEWIS), Peter's formula was modified to have a characteristic value for a better comparability (in Figure named as $SWEE_2$). It takes *fixed costs,* such as 'building costs' (BC) of the construction and *variable costs,* like the 'value of maintaining and increasing measures' (VMM), into account. The fixed costs are the basis for the following variable portion of the calculation/formula found below. There is a dependency (ref.: **Table 1**) between the building costs and the resulting variable costs that has not yet been analysed in this project. The step of adding the reciprocal to this formula generated a better basis for comparison. The most efficient building will exhibit the highest SWEE-factor. The difference of this formula vs. the $SWEE_1$ factor is found in the pre-definition of the service life as 80 years.

$$SWEE_1 = \left(\frac{\underbrace{\left(\frac{RBL_T + \sum_{j=1}^{m} VMM_j}{age_T}\right)}_{\text{variable costs}}}{GFA_T} + \underbrace{\frac{\sum_{i=1}^{n} BC_I}{GFA_T}}_{\text{fixed costs}} \right)^{-1} * 10^2$$

$$SWEE_2 = \left(\frac{\underbrace{\sum_{i=1}^{n} BC_I}_{\text{fixed costs}} + \underbrace{\left(\frac{RBL_T + \sum_{j=1}^{m} VMM}{age_T}\right)}_{\text{variable costs}} \times 80}{GFA_T} \right)^{-1} * 10^3$$

SWEE	*= real value maintaining efficiency*
BC	*= building costs*
RBL	*= repair back-log*
VMM	*= value maintaining and increasing measures*
m	*= number of VMM*
n	*= number of construction works*
T	*= base year (2004)*
I	*= year of costruction*
GFA	*= gross floor area*

Figure 2: two formulas to express the real value maintaining efficiency over the building lifetime

In Figure 3, the factors ($SWEE_1$ and $SWEE_2$) are filled with real data from some of the buildings analysed for the BEWIS project. For each of the 11 analysed buildings, the two SWEE-factors are illustrated (grey stands for $SWEE_1$ and dark-grey for $SWEE_2$). The buildings are clustered in groups driven by property age (refer to section entitled Research). The encircled number above each bar shows the overall rank of each building per SWEE-factor. The number below in the rectangle shows the ranking in each building cluster. For the overall ranking, three fictitious buildings were added. 'TEST 1' is a building with relatively high building costs (BC), high repair backlogs (RBL), and high upkeep expenses (VMM) over the building lifetime. The 'TEST 2' building shows an pretended effectively maintained building (low BC, low RBL, and also low upkeep expenses – VMM). The 'TEST 3' building shows a building with low BC, low RBL, and high VMM expenses.

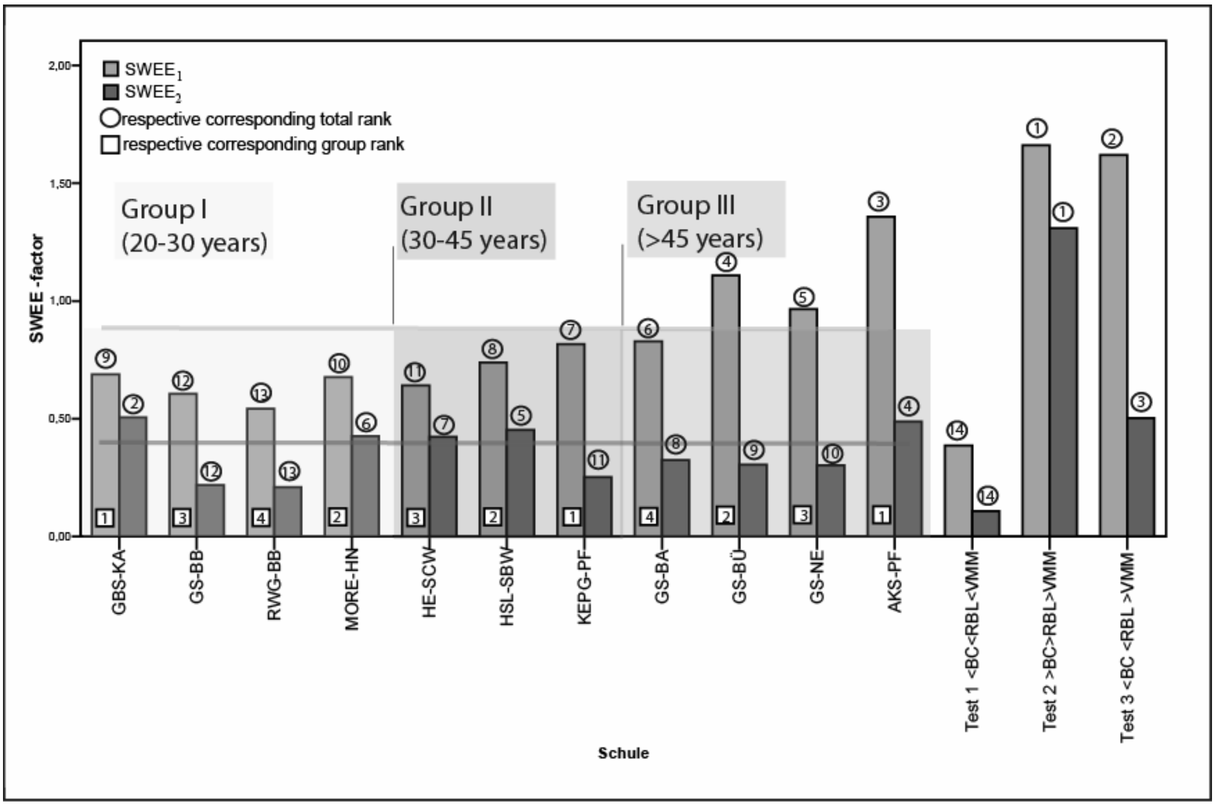

Figure 3: comparison of developed SWEE-factors by calculating with real data

The direct comparison of two buildings that are similar in size (GFA) and which have the same building use (vocational schools) demonstrates this conclusion. 'GBS-KA' is a young building of 20 years. The actual condition described by the repair back-log (RBL) is very good. 'AKS-PF' is an old building of 54 years with very low construction costs (BC) in the beginning and with a building age that corresponds with its repair back-log (RBL). Throughout the building history, only ordinary VMM-measures were carried out.

At the age of 27-34 years, there were increasing expenses for maintenance with a following normalisation. At the very end of the building life-cycle, around the age of 50-54 years, some inescapable measures were necessary. Regarding the ranks of both schools for each SWEE-factor, different conclusions are recorded.

For the GBS-KA school, which is in good condition, a normal rate of upkeep/maintenance expenses would maintain this condition over the next 30 years and would show this school to be effective in its upkeep/maintenance planning and measures. But at the moment, this is not what is predicted for this property.

The problem created by using the characteristic value resulting from Peter's formula ($SWEE_2$), is that the assumption of a normal building lifetime of 80 years requires a linear yearly cost investment trend in reference to the cumulative value for maintenance/upkeep. This set of measures based upon this 80 year designation ignores the fact that costs are not following a linear trend. Unfortunately, another trend has shown itself better suited to the creation of realistic projections. Cumulative illustrated lifecycle costs only follow a linear trend for different life cycle phases, not in relation to the overall set of life cycle phases. For this reason, the GBS-KA school is ranked according to $SWEE_2$ in second place and according to $SWEE_1$ in 9th place. The AKS-PF school is quite effective regarding its age and its corresponding repair back-log. So, the $SWEE_1$ factor seems to be the better way to describe the effectiveness of realised VMM measures.

The following figures plot the lifelong expenses for modernisation and for maintenance and repair in a cumulative delineation for the GBS-KA, as well as for the AKS-PF school.

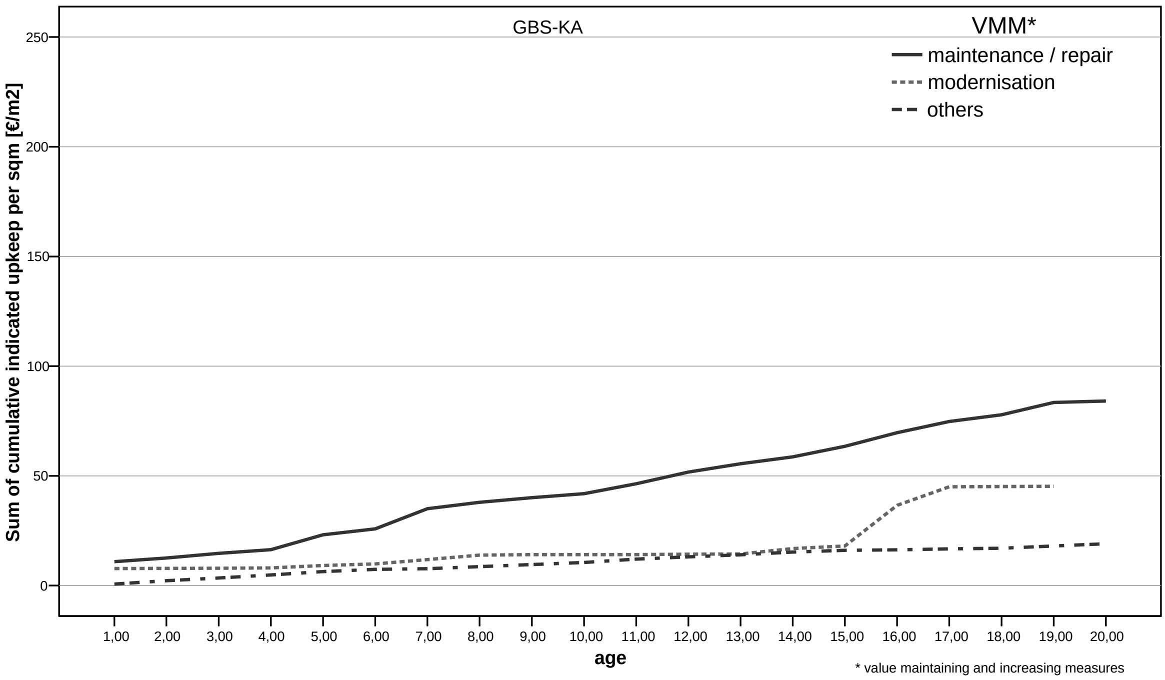

Figure 4: cumulative added VMM expenses plotted against the age (school GBS-KA)

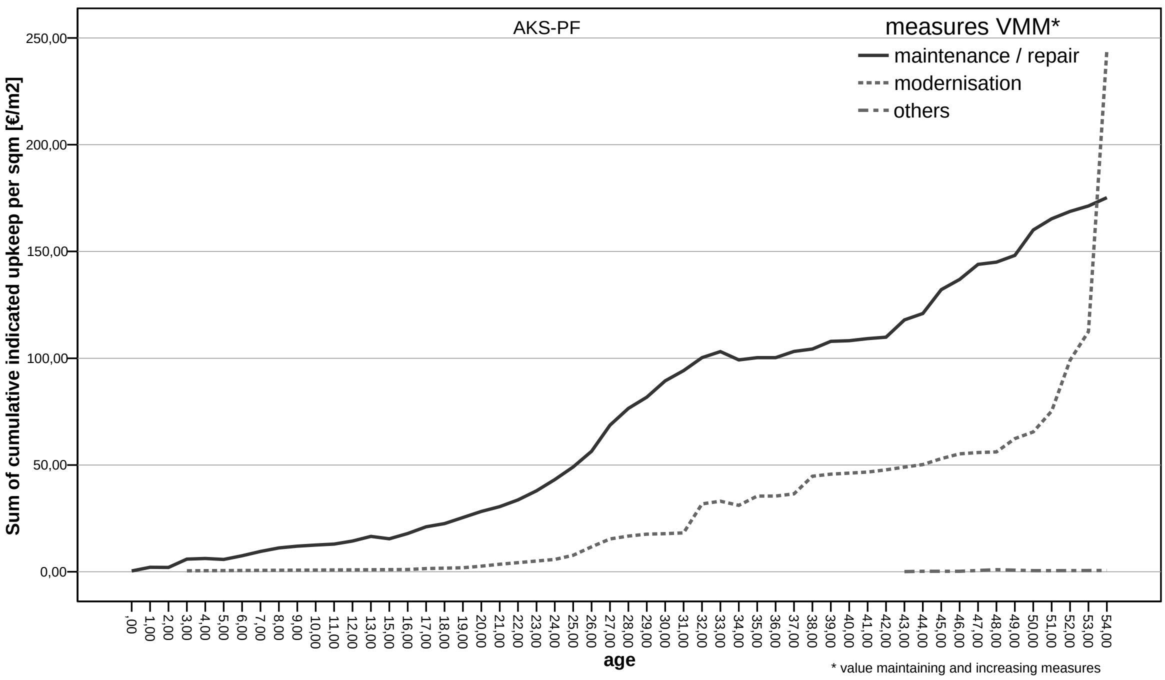

Figure 5: cumulative added VMM expenses plotted against the age (school AKS-PF)

The figures show two schools with the same type of use but of different ages. The GBS-KA school is a modern facility, not expensive concerning its' VMM (value maintaining and increasing measures) in comparison with other schools of the same age category. On the other hand the AKS-PF school concerning its' building costs is a very cheap school and until the age of 30 years also very cheap in VMM expenses, even cheaper than the GBS-KA school. Regarding its' history, after 50 years it was absolutely impossible to defer anymore the badly needed modernisations. And even (with knowledge of the school on site) after these modernisation measures there rests a huge repair back-log. The figures show the difficulties for the development of a SWEE factor.
The development of this ideal SWEE factor formula is still in process. The formulas shown here are first attempts at describing all the impacts of different factors. It is still necessary to describe the interrelations of the described factors in table 1 and the variables used in the SWEE formula.

OUTLOOK

So, the answer to the question "How can an ideal SWEE factor be reached?", has not yet been exhaustively answered. But, the knowledge detailed from the surveyed buildings shown in Figure 4 and 5 should be noted as one great step towards this answer. Using unstandardised building components in some cases, the resulting VMM expenses for the analysed buildings, even though they are prototypes - can be enormous. Some of the schools have very extensive designs, but consequentially demonstrate high maintenance costs.
The next step of the research is to find correlations and coherences between design, way and intensity of use, age on the one hand and on the other hand the effort (in sense of time and intensity) of VMM-measures. Furthermore, the consideration of the repair backlog will help to find the most appropriate SWEE-formula and the answer to the question of the ideal SWEE factor.

Life cycle costing in the planning phase of building projects can generate a lot of savings if done correctly. The continuation of this research project hopes to continue to produce results that get closer and closer to projecting an ideal SWEE factor for real estate assets.

REFERENCES

Statistisches Bundesamt Deutschland, SBA (2005) *Volkswirtschaftliche Gesamtrechnungen des Bundes* available at DESTATIS: http://www.destatis.de/

Knobloch, B. (2005) *Immobilienmarkt muss sich reformieren. Banken sind mit in der Verantwortung - Neue, innovative Instrumente in Deutschland etablieren*, Börsen-Zeitung Ausgabe Nr. 40

Reinhardt, S., Bahr, C., et al (2005): *FM - Gerechte Planung und Realisierung,* Leitfaden der IFMA Deutschland e.V., München, p. 20

Stoy, S., (2005) *Benchmarks und Einflussfaktoren der Baunutzungskosten*; Dissertation an der Eidgenössischen Technischen Hochschule Zürich Nr. 15765; Hochschulverlag, Zürich, p. 4

Kommunale Gemeinschaftsstelle für Verwaltungsvereinfachung KGSt (1984), *Hochbauunterhaltung: Richtwerte und Gestaltungsvorschläge zur Mittelbemessung, Maßnahmenplanung und Mittelbereitstellung.* Bericht Nr. 9, Köln (Germany), p. 10

Tomm, A. Rentmeister, O. Finke, H., (1995), *Geplante Instandhaltung Ein Verfahren zur systematischen Instandhaltung von Gebäuden*, Aachen, LBB, (Germany), pp. 25-81

Meyer, P., Büchler, M., Christen, K., Waibel, A. (1995) *Alterungsverhalten von Bauteilen und Unterhaltskosten im Wohnungsbau*; IP Bau, Bundesamt für Konjunkturfragen Bern, 1995 (Switzerland), pp. 21-57

Christen, K., Meyer-Meierling, P. (1999) O*ptimierung von Instandsetzungszyklen und deren Finanzierung bei Wohnbauten*; Forschungsbericht, ETH Zürich, Hochschulverlag AG, Zürich (Switzerland), pp. 25 et sqq.

ISO/DIS 15686-1, (2000) *Buildings and constructed assets – Service life planning- Part1: General principles*, ISO copyright office, Geneva, (CH), p. 23

Minami, K., (2003) *Repair and Improvement Work of Post Office Buildings and reduction of Overall Investment Costs by Lengthening the Life of the Buildings*, Journal of Asian Architecture and Building Engineering (JAABE), Vol. 2 , No. 1,AIJ, Tokyo (Japan), pp. 131-137

Riegel, G. (2004) *Ein softwaregestütztes Berechnungsverfahren zur Prognose und Beurteilung der Nutzungskosten von Bürogebäuden*, Dissertation, 1. Auflage Darmstadt, Eigenverlag, Heft 8, Darmstadt (Germany)

OSCAR (2005) *Office Service Charge Analysis Report*, Jones Lang Lasalle GmbH, available at Jones Lang Lasalle www.joneslanglasalle.de/research

BMI Building Maintenance Information: *Review of Occupancy Costs* (2005); London (UK)

WertV (1997) Verordnung über Grundsätze für die Ermittlung der Verkehrswerte von Grundstücken (Wertermittlungsverordnung-WertV) vom 6.12.1988 (BGB1. I 1986, 2209), zuletzt geändert durch Art. 3 des Gesetzes vom 18.8.1997 (BGB1. I 1997, 2081)

Krug, K-E. (1985), *Wirtschaftliche Instandhaltung von Wohngebäuden durch methodische Inspektion und Instandsetzungsplanung*, Braunschweig (Germany)

Merminod, P., Vicari, J. (1984) *Handbuch MER: Methode zu Ermittlung der Kosten der Wohnungserneuerung*; Bundesamt für Wohnungswesen, Bern (Switzerland)

IPBau Impulsprogramm Bau- Erhaltung und Erneuerung (1995); *Grobdiagnose – Zustandserfassung und Kostenschätzung von Gebäuden*, 2. Auflage; Bundesamt für Konjunkturfragen; Bern, (Switzerland)

Epiqr (xxxx) Fraunhofer Institut für Bauphysik; *Handbuch epiqr*

Gredig, J., Rüst, B., Wright, M. (1997) *Diagnosemethode für die Unterhalts- und Erneuerungsplanung verschiedener Gebäudearten*: Schlussbericht Forschungsprojekt; Zentralschweizerisches Technikum Luzern, Ingenieurschule HTL; Pfäffikon (Switzerland)

STRATUS (2002), *Benutzerdokumentation*, STRATUS Gebäude 3.00 CH; Basler und Hofmann Ingenieure und Planer AG; Zürich, (Switzerland)

Investimmo, European Commission, Growth Programme (2002) available at CSTB http://investimmo.cstb.fr/

EUREKA -Project Σ! 2081 EUROENVIRON-MAINTENVIR (2001) (The ENFNMS Building Maintenance Working Group) *Building Maintenance considered under ecological and economical aspects* IFIN, Brussels, (Belgium)

Peters, H. (1984) *Instandhaltung und Instandsetzung beim Wohnungseigentum* Wiesbaden, Berlin: Bauverlag, p. 184

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The CIBW70 2006 Trondheim International Symposium has been the 13th CIB W70 Symposium, with the main theme "Changing User Demands on Buildings - Needs for lifecycle planning and management".

The symposium has gathered researchers from 20 countries, and they have brought forward the body of knowledge and expertise on Facilities Management and Maintenance in an international perspective. All papers have gone through a full review and editing processes, and the proceedings presents 69 papers organized under 6 themes: Building conservation and refurbishment, Sustainability in FM and design, FM in operation and service management, Changing user demands on adaptability and flexibility, Workplace management/Usability of workplaces and FM in health care.

The Norwegian University of Science and Technology (NTNU) has organized the symposium, in cooperation with CIBW70 and Nordic network for Facilities Management - NordicFM.

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