



Influence of structural design on the sustainability assessment of building constructions

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Lecture topics

- Motives and background
- Objective of the project
- Model development
- Practical application
- Comparison
- Critical evaluation of the model
- Conclusions

Motives and background

At the present real estate assessment is only based on economic values →

the calculation of actual market values is the attempt to forecast market behaviour

Frequently used real estate assessment models are:

- Vergleichswertverfahren (comparative value method)
- Sachwertverfahren (gross-rental method)
- Ertragswertverfahren (asset value method)

Motives and background

Certification systems

LEED

- environmental aspects
- social aspects
- aspects of the construction process
- aspects about the building site

BREEAM

- environmental aspects
- social aspects
- aspects of the construction process
- aspects about the building site
- functional and technical aspects

DGNB/ÖGNI

- environmental aspects
- economical aspects
- sociocultural and functional aspects
- technical aspects
- aspects of the construction process

Aim of the project

- to elaborate the effect of construction and construction materials on future performance of buildings to develop the base for new additional evaluation methods
- to identify classified primary parameters that influence building performance
- to develop an evaluation method that assesses constructions due to service life, separability, recyclability, maintenance, change of use etc
- to point out the interface between building performance over the life cycle and future real estate assessment methods

Expected results

- development of an evaluation model that describes and evaluates building constructions due to sustainable aspects
- instruction for practical application of the model
- to demonstrate the need of supplementation of the underlying certification system
- evaluation of the assessment model exemplarily demonstrated on selected buildings of the TU Graz
- identification of opportunities for improvement and implementation of the model

Model development

Analysis of the 49 evaluation criteria

unreleased evaluation criteria were not observed



Yes/No - Analysis

regarding the relevance for the construction
Why is it construction relevant? What is relevant?



Attempt to find a definition for
„construction relevance“



Gathering additional assessment
requirements

Evaluation criteria

Kriterium 40

Die Reinigungs- und Instandhaltungsfreundlichkeit eines Baukörpers haben einen wesentlichen Einfluss auf die Kosten.
Ziel: gezielte Reinigung und Instandhaltung

Tragkonstruktion

DGNB	Sind die wartungsrelevanten Teile der Primärkonstruktion für Instandhaltungsmaßnahmen zugänglich:
	ja, freiliegend ja, nach Demontage nein
eigene Überlegungen	Ist ein Auseinandernehmen und Wiederherstellen der Konstruktion möglich? Demontierbarkeit für Instandhaltung (≠ Demontage für Rückbau); DGNB ersetzt durch neue Punkte:
zu ergänzende Punkte	<p>Zugänglichkeit</p> <p><input type="checkbox"/> ja 3 Pkt.</p> <p><input type="checkbox"/> ja, nach Demontage 2 Pkt.</p> <p><input type="checkbox"/> nein 1 Pkt.</p> <p>Demontage</p> <p><input type="checkbox"/> ja, zerstörungsfrei 3 Pkt.</p> <p><input type="checkbox"/> ja, mit kleinen Schäden 2 Pkt.</p> <p><input type="checkbox"/> nein 1 Pkt.</p> <p>Wiederherstellung</p> <p><input type="checkbox"/> ja 3 Pkt.</p> <p><input type="checkbox"/> ja, mit Ausbesserungen 2 Pkt.</p> <p><input type="checkbox"/> nein, nur mit neuer Konstruktion 1 Pkt.</p>

nicht tragende Konstruktion außen

DGNB	sind die Außenglasflächen leicht zugänglich?
	<input type="checkbox"/> ja 4 Pkt. <input type="checkbox"/> teilweise (mind. 90% der Außenglasfläche) 3 Pkt. <input type="checkbox"/> teilweise (weniger als 90% der Außenglasfläche) 2 Pkt. <input type="checkbox"/> nein 1 Pkt.
eigene Überlegungen	Ist eine Fenstertausch möglich? Es liegen keinerlei Überlegungen für Instandhaltung vor! Lediglich die Reinigung wird berücksichtigt. Hier auch nur der Fensterflächenanteil an der Fassade sowie die Lage des Fensters über FOK relevant. DGNB Punkte werden beibehalten, aber ergänzt.
zu ergänzende Punkte	<p>für Reinigung Punkte belassen</p> <p>Instandhaltung: wie leicht/schwer ist der Fenstertausch?</p> <p><input type="checkbox"/> überlappende Konstruktion ja - 1 Pkt. nein - 4 Pkt.</p> <p><input type="checkbox"/> zusätzlicher Blindstock vorhanden ja - 4 Pkt. nein - 1 Pkt.</p> <p><input type="checkbox"/> Fenstertausch von innen möglich ja - 4 Pkt. nein - 1 Pkt.</p> <p>Sonnenschutz für Reinigung zugänglich</p> <p><input type="checkbox"/> ja 4 Pkt.</p> <p><input type="checkbox"/> ja, nach Demontage 2 Pkt.</p> <p><input type="checkbox"/> nein 1 Pkt.</p> <p>Sonnenschutz für Instandhaltung zugänglich</p> <p><input type="checkbox"/> ja 4 Pkt.</p> <p><input type="checkbox"/> ja, nach Demontage 2 Pkt.</p> <p><input type="checkbox"/> nein 1 Pkt.</p> <p>Zugänglichkeit der Photovoltaikanlage</p> <p><input type="checkbox"/> ohne Hilfsmittel möglich 4 Pkt.</p> <p><input type="checkbox"/> mit Hilfsmittel möglich 1 Pkt.</p> <p>Tausch der Photovoltaikanlage</p> <p><input type="checkbox"/> von außen zerstörungsfrei demontierbar ja - 4 Pkt. nein - 1 Pkt.</p>

nicht tragende Konstruktion innen

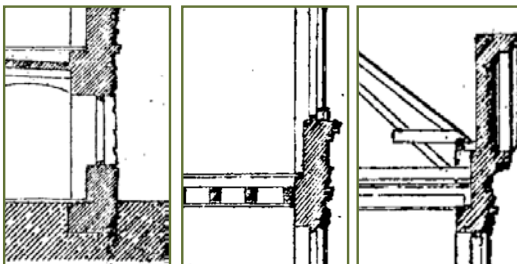
DGNB	Ist der Bodenbelag tolerant gegenüber leichten Verschmutzungen?
	ja (gemustert oder meliert) teilweise nein
eigene Überlegungen	Wie sehr sieht man Schmutz auf dem Fußboden? Wie sehr bleibt er haften (Rauigkeit)? Eigentlich nur rein ästhetische Bewertungspunkte; DGNB-Kriterien werden durch neue Punkte ersetzt:
zu ergänzende Punkte	<p>Reinigung:</p> <p><input type="checkbox"/> Oberflächenbeschaffenheit</p> <p>glatte Oberfläche 3 Pkt.</p> <p>leicht strukturierte Oberfläche 2 Pkt.</p> <p>grob strukturierte Oberfläche 1 Pkt.</p> <p><input type="checkbox"/> Kontaktkompatibilität (chemische Verträglichkeit mit Putzmitteln)</p> <p>problemlos 3 Pkt.</p> <p>empfindlich 2 Pkt.</p> <p>sehr empfindlich 1 Pkt.</p> <p>Instandhaltung: Ist ein Tausch des Fußbodenbelages möglich, ohne darunter liegende Schichte zu zerstören?</p> <p><input type="checkbox"/> ja, zerstörungsfrei 3 Pkt.</p> <p><input type="checkbox"/> ja, mit kleinen Beschädigungen 2 Pkt.</p> <p><input type="checkbox"/> nein 1 Pkt.</p>
DGNB	Ist eine ausreichende Schmutzfangzone vor den Eingängen vorhanden?
	<input type="checkbox"/> ja 3 Pkt. <input type="checkbox"/> teilweise 2 Pkt. <input type="checkbox"/> nein 1 Pkt.
eigene Überlegungen	so belassen; ist eigentlich nur für die Reinigung relevant.
DGNB	Sind die Fußbodenleisten mechanisch befestigt?
	<input type="checkbox"/> ja 3 Pkt. <input type="checkbox"/> nein 1 Pkt.
eigene Überlegungen	belassen; lediglich ja/nein Analyse; keine weitere Relevanz für Instandhaltung -> steht sowohl für Reinigung als auch für Instandhaltung
DGNB	Ist die Raumaufteilung hindernisfrei erfolgt?
	Hindernisfrei ohne Vorsprünge geringe Anzahl von Hindernissen hohe Anzahl von Hindernissen
eigene Überlegungen	zu streichen, denn auf Bauteilebene nicht relevant
generelle Überlegung: Trennung von Reinigung und Instandhaltung	

Practical application

Main Building (AT)



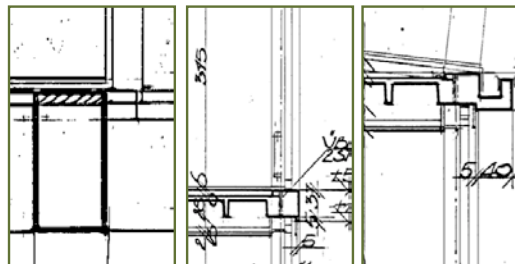
year of construction:
1884-1888
materials: bricks, natural
stone, timber
Building in Wilhelminian style
typical: high ceilings, stukko



Hydraulic Engineering Lab



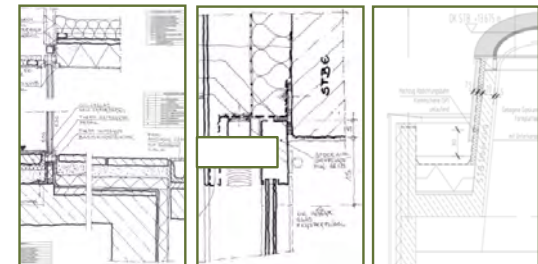
year of construction: 1960
materials: many different
materials, prefabricated
concrete elements
typical: skeleton structure, flat
roof, sandwich construction



Frank Stronach Institute



year of construction: 2006
materials: reinforced concrete,
steel, dry walls, many different
materials, new technologies
typical: open coverage type,
glass facades



Practical application

Input Evaluation Sheet										Project	Project Nr.	Name of the Detail	Detail Nr.	Date
										Main Building AT		connection wall-ceiling-window	AWD 01	08.11.2011

K 40

Ease of Cleaning and Maintenance of the Structure

Evaluation of each device layer with rating score																				Score for constr. gr.	Diagramm for partial results gross	
Device layer	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Detail		
Bearing structure																					0	
accessability		2	2	2	2	2	2	2			2										16	
dismantling		3	3	3	2	3		3			2										19	
reconstruction		3	3	3	2	3		3			2										19	
External non-bearing structure																					0	
accessability external fields of glass																			4		4	
overlapping window constructions																			4		4	
availability additional subframe																			1		1	
possibility of external exchange of window																			4		4	
cleaning solar protection																			4		4	
maintenance solar protection																			4		4	
accessability photovoltaic installation																					0	
possibility of exchange PV installation																					0	
Interior non-bearing structure																					0	
cleaning surface condition		2																			2	
cleaning: contact compatability		2																			2	
maintenance: possibility exchange floor		3																			3	
possibility to contain gutter																					0	
skirting board mechanically fixed		3																			3	
score for device layers	7	8	8	8	6	8	2	8	0	0	6	0	0	0	0	0	0	0	0	21		Diagramm for total score gross
Actual total score (gross)																					85	

K 42

Ease of Deconstruction, Recycling and Dismantling

Evaluation of each device layer with rating score																				Score for constr. gr.	Diagramm for partial results gross	
Device layer	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Detail		
Non-structural (de)construction parts																					0	
effort of dismantling		3								3	3		3								12	
effort of separation		5								5	3		3								16	
recyclability		5								4	4		4								17	
Non-bearing carcass structure																					0	
effort of dismantling																					0	
effort of separation																					0	
recyclability																					0	
Bearing carcass structure																					0	
effort of dismantling			3	4	4	4	3		3			2									23	
effort of separation			5	5	5	5	5		5			5									35	
recyclability			4	5	5	4	4		4			4									30	
																					0	
																					0	
																					0	
																					0	
score for device layers	13	12	14	14	13	12	0	12	12	10	11	10	0	0	0	0	0	0	0	0		Diagramm for total score gross
Actual total score (gross)																					133	

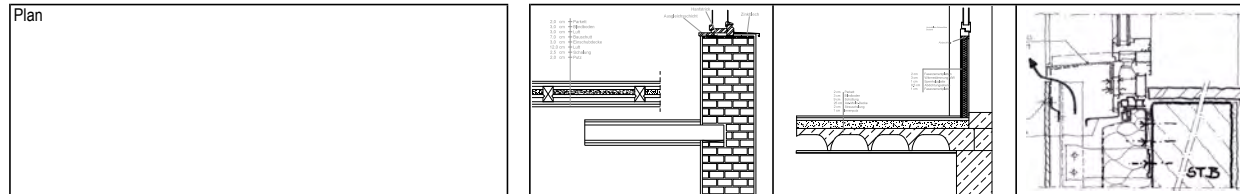
Comparision of the details

It automatically leads to an assessment of the practical suitability of the model. Areas of practice are:

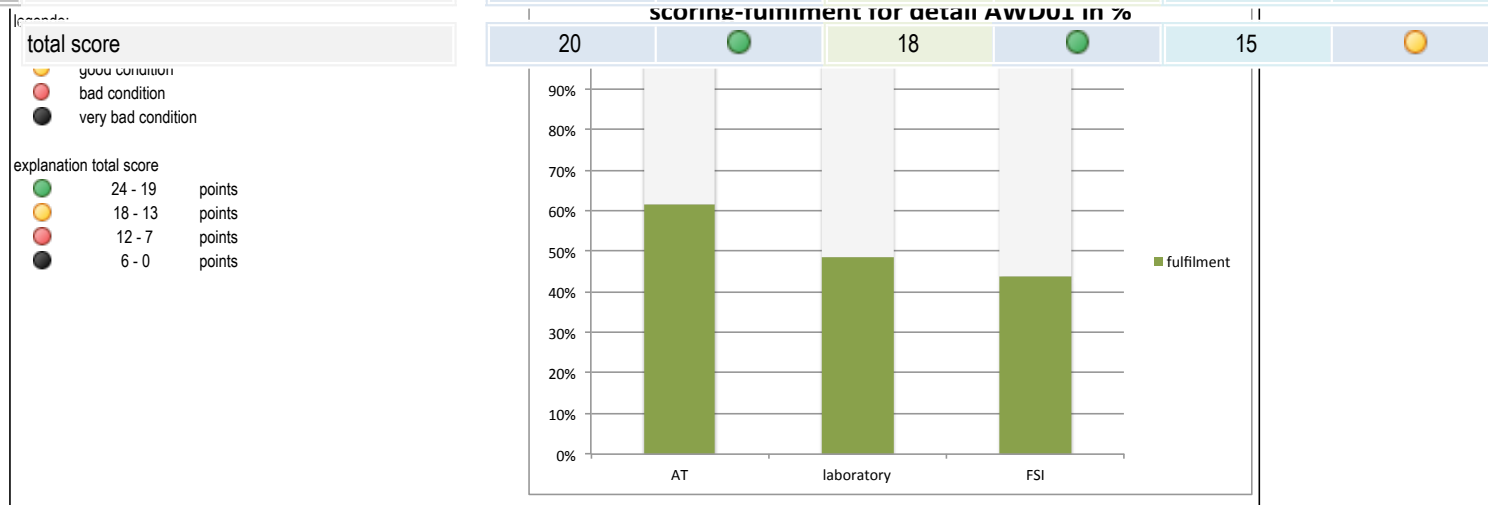
- Useful addition to certification systems
- Comparison of alternatives for planners: to immediatly estimate the life cycle of the details in the planning or design stage the model should be able to serve as a planning process instrument
- Comparison of alternatives for system manufacturers: also valid for producers of building products and system manufacturers. Model as decision support for comparison of alternatives

Comparison of the details

Project: AT - laboratory - FSI | Detail: AWD01 | Datum: 8.7.2012



simplified criteria	entire construction - bearing structure and non-structural construction parts		possible score	average score	AT	average score	laboratory	average score	FSI
		accessability	1 - 3	2	●	2	●	2	●
		dismantling	1 - 5	4	●	2	●	2	●
		effort of separation	1 - 5	5	●	5	●	3	●
		recyclability	2 - 5	4	●	4	●	4	●
		dismantling of joints	1 - 3	2	●	3	●	2	●
		material variety	1 - 3	3	●	2	●	2	●
		durability							
		robustness							



Comparison of the costs

Project	reviser	date
Main Building (AT)	J. Maydl	05.07.12

building product	substance group	target price [€/t]	ALSaG [€/t]	m ³	density [kg/m ³]	weight [t]	price [€]
natural stone	mineral	25,00		2.332,0	2.800,0	6.529,6	163.240,00
filling material	mineral	12,60		1.669,0	1.400,0	2.336,6	29.441,16
brick	mineral	15,00		18.017,0	1.800,0	32.430,6	486.459,00
screed/concrete	mineral	18,00		398,0	2.200,0	875,6	15.760,80
plaster	mineral	14,40	9,20	1.154,0	1.600,0	1.846,4	43.575,04
glas/frame	organic/metallic	142,00	87,00	10,0	2.500,0	25,0	5.725,00
timber	organic/metallic	110,00		2.055,0	450,0	924,8	101.722,50
plastics	plastics	160,00	87,00	42,0	1.200,0	50,4	12.448,80

disposal costs incl. ALSAG contribution 858.372,30

total cubic gross volume [m ³]	121.243,0
disposal costs €/m ³	7,08

Hydraulic engineering laboratory

building product	substance group	target price [€/t]	ALSaG [€/t]	m ³	density [kg/m ³]	weight [t]	price [€]
artificial stone	mineral	25,00		17,0	2.200,0	37,4	935,00
filling material	mineral	12,60		232,0	1.800,0	417,6	5.261,76
screed/concrete	mineral	18,00		861,0	2.200,0	1.894,2	34.095,60
plaster	mineral	14,40	9,20	51,0	1.700,0	86,7	2.046,12
drywall	mineral	95,00	9,20	24,0	900,0	21,6	2.250,72
brick	mineral	15,00		194,0	1.800,0	349,2	5.238,00
mineral wool	mineral	108,00	9,20	38,0	70,0	2,7	311,75
Durisol	mineral	15,00	9,20	98,0	1.400,0	137,2	3.320,24
eternit panels	mineral	95,00	9,20	6,0	1.700,0	10,2	1.062,84
glas/frame	organic/metallic	142,00	87,00	50,0	2.500,0	125,0	28.625,0
timber	organic/metallic	110,00	9,20	335,0	450,0	150,8	17.969,4
bitumen	organic/metallic	90,00	9,20	6,0	1.050,0	6,3	625,0
plastics	plastics	160,00	87,00	11,0	1.200,0	13,2	3.260,4

disposal costs incl. ALSAG contribution 105.001,79

total cubic gross volume [m ³]	7.231,0
disposal costs €/m ³	14,52

Frank Stronach Institut

building product	substance group	target price [€/t]	ALSaG [€/t]	m ³	density [kg/m ³]	weight [t]	price [€]
screed/concrete	mineral	18,00		1.581,0	2.200,0	3.478,2	62.607,60
insulation	mineral/organic	108,00	9,20	395,0	70,0	27,7	3.240,58
artificial stone	mineral	25,00		12,0	1.800,0	21,6	540,00
filling material	mineral	12,60		137,0	1.800,0	246,6	3.107,16
plaster	mineral	14,40	9,20	22,0	1.700,0	37,4	882,64
drywall	mineral	95,00	9,20	194,0	900,0	174,6	18.193,32
ceramic	mineral	44,00	9,20	1,0	2.300,0	2,3	122,36
gravel	mineral	10,50		74,0	2.000,0	148,0	1.554,00
substrate	organic	12,60	9,20	3,6	2.000,0	7,1	154,8
geotextile	organic	44,00	20,60	6,0	1.100,0	6,6	426,4
bitumen	organic	90,00	87,00	10,0	1.050,0	10,5	1.858,5
timber	organic	110,00	9,20	10,0	450,0	4,5	536,4
glas/frame	organic/metallic	7,00	87,00	142,0	2.500,0	355,0	33.370,0
plastics	plastics	160,0	87,0	10,0	1.200,0	12,0	2.964,0
aluminium	metallic	-800,0		13,0	2.700,0	35,1	-28.080,0

disposal costs incl. ALSAG contribution 129.557,70

total cubic gross volume [m ³]	13.770,0
disposal costs €/m ³	9,41

disposal costs incl. ALSAG contribution incl. alu-refunding 101.477,70

total cubic gross volume [m ³]	13.770,0
disposal costs €/m ³	7,37

Strengths of the evaluation model

- detailed assessment
- quick rating
- no fixed maximum points available
- weighting customisable
- division into gross (without weighting) and net points (with weighting)
- decision support for planners
- decision support for system manufacturers
- integration basically possible into DGNB / ÖGNI system

Weakness of the evaluation model

- manual input of the criteria and the weighting of points required
- points are not implemented in the program → list for scoring should be closed at hand
- at first sight it appears complicated because of the manual input
- high number of sheets when printed
- inadequate definition of the term "supporting structure" for criterion K 40

Further development

- definition of the point scale
- detailed guidance for awarding points for each criterion
- addition to possibly other criteria necessary
- possible addition of criterion K40 by the point "fitout" (with the same indicators such as rating point "supporting structure")
- implementation of the proposed criterion K41b "Durability and robustness" in the program
- implementation in the certification system of DGNB / ÖGNI

Prospect

- *evaluation model*: It is now important to develop tools for planners to implement sustainability in the constructional details
- *Lifespan*: it is important to consider the different lifetime of the component layers and coordinate them with future planning and maintenance
- *Demolition*: in the future dismantling friendly designs will allow to dismantle building components recycling oriented and to separate them varietal
- *Real estate*: the new view image of a life-cycle cost-based analysis must be implemented in assessment procedures

A photograph of a brick wall with a semi-circular arch made of stone or concrete. Two vertical metal rebar rods are visible on the right side of the arch. The bricks are reddish-brown and show signs of wear and discoloration.

Thank you for your attention!