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HODA 2.0 : a benchmark for rating buildings with regard to health, comfort and energy use

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ABSTRACT

Information on the 69 office buildings and 97 residential ones investigated within the HOPE project is stored in the HODA database. This includes building characteristics collected by the building management according to a checklist, and responses of occupants to questionnaires asking their perceived comfort (thermal visual, acoustical and IAQ) and health (SBS and allergies). This database allows benchmarking any building with regard to building characteristics such as energy use, ventilation system, occupant density, perceived comfort, sick building syndrome, etc. The HODA database is presented including the way to compare other buildings with the buildings investigated in the HOPE project in order to characterise how healthy and energy-efficient they are.

KEYWORDS: healthy buildings, database, energy

INTRODUCTION

The project Hope, Health Optimisation Protocol for Energy-efficient Buildings, has investigated 69 office buildings and 97 residential ones using different questionnaires, for occupants and a checklist [1]. To provide automatic evaluation of building characteristic, algorithms have been developed within the project and have been encoded into the HOPE Database (HODA 2.0). All the data collected have been introduced in the database. Hoda was developed using the languages Delphi and the data collected are memorised in an Ms Access database file. Hoda, the questionnaires checklists, the personal questionnaires and the guidelines can be downloaded free of charge from the project website developed by E4Tech: http://hope.epfl.ch . The downloadable version of Hoda allows to introduce a building and to compare the results/outcomes of this building with the statistics from the HOPE buildings sample. This includes the risk analysis rules developed within the project.

METHOD

The first screen of Hoda is composed of different parts, the list of the building and a list of button that allow the user to see the data introduced for each building, to create a new building and to export the results to Ms Excel.

To introduce a new building is necessary to use before two kinds of screening methods **Error! Reference source not found.**]:

(a) interviews with building management, from which, among others, information on building energy performance is collected

(b) questionnaire surveys of occupants, providing information on how they feel and perceive their internal environment.
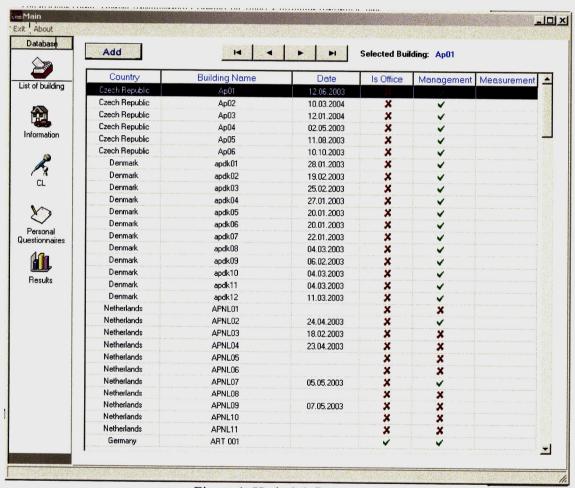
Country	Building Name	Date	Is Office	Management	Measurement
Czech Republic	Ap01	12.06.2003	✗	✓	
Czech Republic	Ap02	10.03.2004	✗	✓	
Czech Republic	Ap03	12.01.2004	✗	✓	
Czech Republic	Ap04	02.05.2003	✗	✓	
Czech Republic	Ap05	11.08.2003	✗	✓	
Czech Republic	Ap06	10.10.2003	✗	✓	
Denmark	apdk01	28.01.2003	✗	✓	
Denmark	apdk02	19.02.2003	✗	✓	
Denmark	apdk03	25.02.2003	✗	✓	
Denmark	apdk04	27.01.2003	✗	✓	
Denmark	apdk05	20.01.2003	✗	✓	
Denmark	apdk06	20.01.2003	✗	✓	
Denmark	apdk07	22.01.2003	✗	✓	
Denmark	apdk08	04.03.2003	✗	✓	
Denmark	apdk09	06.02.2003	✗	✓	
Denmark	apdk10	04.03.2003	✗	✓	
Denmark	apdk11	04.03.2003	✗	✓	
Denmark	apdk12	11.03.2003	✗	✓	
Netherlands	APNL01		✗	✗	
Netherlands	APNL02	24.04.2003	✗	✓	
Netherlands	APNL03	18.02.2003	✗	✗	
Netherlands	APNL04	23.04.2003	✗	✗	
Netherlands	APNL05		✗	✗	
Netherlands	APNL06		✗	✗	
Netherlands	APNL07	05.05.2003	✗	✓	
Netherlands	APNL08		✗	✗	
Netherlands	APNL09	07.05.2003	✗	✗	
Netherlands	APNL10		✗	✗	
Netherlands	APNL11		✗	✗	
Germany	ART 001		✓	✓	

Figure 1: Hoda 2.0 first screen

The different questionnaires can be downloaded from the project website **Error! Reference source not found.**] but for the interviews is possible to use directly in the software the special screen as show in Figure 2.

The personal questionnaires can be introduced one by one or, if they are completed in the Adobe Acrobat pdf file, they can be directly imported via the form data pdf files.

A useful user's manual is available at the same website than the software.

Figure 2: example of data introduction screen

RESULTS

Some results can be exported from Hoda to Ms Excel. It is possible to select one or all of buildings shown. The results that can be exported are:

- For offices, the building symptom index (BSI) for perceived health, which is the mean number of acute health symptoms believed to be building-related that are experienced by occupants. This is a well-established metric[2, 3].
  Symptoms included in the questionnaire are:
  BSI: Dry eyes, itching or watering eyes, blocked or stuffy nose, runny nose, dry throat, headache, tiredness or lethargy, dry itching or irritated skin.
  BSI 5: Dry eyes, blocked or stuffy nose, dry throat, headache, tiredness or lethargy.
  Acceptance limits, based on upper and lower 3 deciles, are fixed as follows:

	Acceptable	uncertain	Not acceptable
BSI	<1.59	in-between	>3.57
BSI 5	<1.16	in-between	>2.53

- In the same way for apartments, the building related symptom (BRS) for perceived health is the mean number of acute health symptoms believed to be building-related that are experienced by occupants. Again, this is a well-established metric.
  Symptoms included in the questionnaire are:
  BRS 10: Dry eyes, itchy or watery eyes, blocked or stuffy nose, runny nose, suffering from sneezing, dry throat, lethargy, headaches, dry skin, breathing.
  BRS 5: Dry eyes, blocked or stuffy nose, dry throat, lethargy, headaches.
  Acceptance limits, are fixed as follows:

	Acceptable	uncertain	Not acceptable
BRS 10	<0.61	in-between	>2.44
BRS 5	<0.31	in-between	>1.33

- For the comfort "Personal questionnaire analysis", the answers are given on a 7 point scale, 1 being "satisfactory" and 7 "unsatisfactory". The acceptance limits are fixed as follows:

Acceptable	uncertain	Not acceptable
<3	In-between	>5

- The health and comfort hazards assessed through the checklist have been sorted into three classes, based on the severity of their expected/possible health outcome:
  - Class 1 - Hazards that increase the risk of causing death or an illness with a high probability of being fatal (e.g. lung cancer). This class includes: asbestos, radon, carcinogenic volatile organic compounds (VOCs), Environmental Tobacco Smoke (ETS) and high carbon monoxide concentrations.
  - Class 2 - Hazards that increase the risk of causing systemic illness (principally respiratory illnesses). This class includes: ozone, nitrogen oxide, particulate matter, infectious agents (from the building or from occupants), house dust mites (only for residential buildings), fungi, other allergens, non-carcinogenic VOCs, CO at low concentrations.
  - Class 3 - Hazards that increase the risk of minor diseases or causing discomfort. This class includes: noise, lighting, too hot, too cold.

- The Energy efficiency of the building is evaluated by means of the total annual energy use, the total annual energy use for heating, and the total electricity use. These data are either derived from data about actually used fuels and electricity or by calculation using an appropriate model (e.g. EN ISO 13790 for heating energy).
  "Energy": total annual energy use, calculated using the gross calorific values of fuels
  "Electricity [kWh]": yearly total electricity use
  "Others Energy fuel [kWh]": yearly total other energy fuel or sources
  "Gross floor area [m^2]": gross heated floor area
  "Energy / area [kWh/m^2]": energy use per gross heated floor area
  "Primary energy / area [kWh/m^2]": rough estimate of the primary energy use per gross heated floor area, the electricity use being multiplied by a factor 2.5

Figure 3 shows an example of exported data. Colours correspond to acceptance levels: green ins acceptable, red is not acceptable and yellow is in-between.

#		Czech Rep	Czech Rep	Denmark	Denmark	Finland	Finland	Germany	Germany	Italy	Italy	Netherland	Netherland	Portugal	Portugal	United King	United King	Switzerland	Switzerland
1	Office Buildings																		
2	Country name:	Czech Rep	Czech Rep	Denmark	Denmark	Finland	Finland	Germany	Germany	Italy	Italy	Netherland	Netherland	Portugal	Portugal	United King	United King	Switzerland	Switzerland
3	Building:	OR04	OR07	ofdk06	ofdk08	OHelsinki3	OVantaa	ENG 002	LZB 009	O3	O1	OFNL01	OFNLO4	OFF5	OFF6	UK II	UK I	CH VII	CH VI
4	Nb. of quest.:	6	25	58	103	99	65	33	31	67	337	52	208	29	105	45	98	63	132
6	BSI:	1.00	2.32	2.02	1.56	3.00	2.13	1.82	0.77	1.59	2.06	0.35	1.26	3.38	3.06	1.24	1.35	1.32	2.43
7	BSI 5:	0.83	1.40	1.34	1.16	2.09	1.45	1.31	0.65	1.25	1.51	0.29	1.05	2.45	2.19	0.82	0.95	1.01	1.75
9	Personal questionnaires analysis																		
10	Air Quality Winter	2.33	3.28	4.44	3.71	4.78	3.39	4.09	3.83	3.56	4.04	3.58	4.22	4.34	3.79	3.73	3.58	2.56	3.75
11	Light Winter	3.00	2.64	3.32	3.54	2.74	2.22	3.36	3.03	3.45	3.24	2.06	3.19	2.97	2.98	3.43	3.28	2.88	2.81
12	Noise Winter	2.40	2.12	2.47	2.78	2.58	2.22	2.40	1.91	3.68	3.43	2.42	3.37	3.62	2.50	3.02	2.96	2.25	2.22
13	Comfort Winter	2.40	2.88	3.05	3.30	4.43	3.30	2.78	3.52	3.50	3.41	2.88	3.78	3.90	2.85	3.57	3.28	2.83	3.15
14	Air Quality Summer	3.00	2.52	3.98	3.42	4.87	3.46	3.84	3.87	3.90	3.86	3.30	4.18	4.59	3.72	3.42	3.28	4.56	5.28
15	Light Summer	2.60	2.24	3.53	2.96	2.56	2.29	3.03	1.94	3.12	3.02	1.88	3.01	2.89	2.10	3.11	2.96	2.56	2.97
16	Noise Summer	1.83	1.92	3.13	2.57	2.92	2.33	2.58	2.13	3.61	3.51	2.21	3.35	3.56	2.61	3.20	2.98	2.94	3.40
17	Comfort Summer	1.67	2.46	3.49	3.03	4.76	3.41	3.23	2.68	3.70	3.32	2.32	3.89	4.10	2.98	3.64	3.11	4.13	4.75
19	Hazards of class 1																		
20	Asbestos	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
21	CO very high	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
22	ETS	0	0	0	2	1	0	2	2	0	2	0	2	2	0	1	0	0	1
23	Radon	0	0	0	1	0	1	1	1	1	2	1	1	1	0	0	0	0	1
24	VOCs(Carcinogenic)	2	2	0	1	1	0	1	1	1	2	1							
26	Hazards of class 2																		
27	CO low	1	1	0	0	0	0	1	0	0	1	0	1	1	0	1	1	1	1
28	Infection from building	1	1	0	1	0	1	1	1	0	0	1	1	0	1	1	1	1	1
29	Infection from occupants	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
30	NOx	1	1	0	0	0	0	1	1	0	1	0	2	0	1	1	1	1	1
31	Ozone	1	1	1	1	0	1	0	0	0	1	0	1	1	1	1	1	1	1
32	Vocs non carcinogenic	1	1	2	1	1	1	1	1	1	1	1	1	0	0	0	0	1	0
33	Fungi	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1	1	1
35	Particulate matter	2						0		1		1	2	2	1	1	2		1
37	Hazards of class 3																		
38	Lighting	2	2	1	1	1	1	1	2	1	2	2	1	2	1	0	1	1	1
39	Noise	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
40	Too cold	2	1	2	1	2	2	1	2	2	0	0	2	2	2	1	2	2	2
43	Energy																		
44	Electricity [kWh]	31620	8600000	0	1524482	1126000	832000	2755231	873713	582240	11939033	107543	307000	237000	1727375	0	0	563300	1270395
45	Others Energy fuel [kWh]	354417	5325111	0	828800	2400000	1100000	3081002	3268000	260106	6293850	0	357000	158811	0	0	0	1243000	2424832
46	Gross floor area [m2]	0	21000	0	9828	22500	7000	22878	26457.01	3000	63500	1850	7660	1125	5740	1570	1570	5700	14726
47	Energy / area [kWh/m2]	0	663.1	0	239.4	156.7	276	255.1	156.5	280.8	287.1	58.1	86.7	210.7	328.6	0	0	316.9	250.9
48	Primary energy / area [kWh/m2]	0	1277.4	0	472.1	231.8	454.3	435.7	206.1	571.9	569.2	145.3	146.8	526.7	780	0	0	465.1	380.3