STUDENT MODELLING COMPETITION

Fault detection and diagnosis of a mixed-use building

Building Simulation 2027
Briefing Document

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Student Modelling Competition

Building Simulation 2027

Briefing Document

1. Background

As part of the Building Simulation Conference, IBPSA is organizing a student modeling competition. The aim is to facilitate wider participation in the conference and to provide a competitive forum for student members of the building simulation community. It is expected that several tutors of relevant courses in universities around the world will use the brief of this competition as part of their teaching material.

This document contains all the information relating to the competition. Entries will be judged *prior* to the conference, with an award presented at the conference in Vienna, Austria, in August 2027.

2. Tasks

For this year's competition, the exercise aims to use a building simulation model to detect and diagnose the faults that occur during the operation of a mixed-use university building located in Graz, Austria. The primary goal of this competition is to identify faults occurring during the operation of a building.

- The building for analysis is a mixed-use 4-story concrete structure (for more details, see section 3). Faults are limited to the operation of the ground and first floors.
- Entrants are provided with the site conditions, building drawings, wall and glazing configurations, HVAC details, weather data, occupancy, and appliance schedules (refer to the Appendices).
- Entrants are expected to model the building and its technical systems, making realistic assumptions for all unknown inputs.
- Entrants are provided with a time-series dataset indicating *healthy* (non-faulty) operation of the building (dataset 1). This dataset is to be used for model calibration.
- A second time-series dataset (dataset 2) is provided, which represents the *faulty* operation of the building. A number of faults have been intentionally introduced into this dataset. Note: No fault has been implemented in the schedule and profile of lighting and electrical appliances.
- Entrants must use their building simulation model to detect the faults within dataset 2 (both temporally and spatially) and diagnose the source of the fault. In terms of temporal detection, the period in time during which the building is operating abnormally must be reported as accurately as possible, with the start and end times of each fault. In terms of spatial detection of the fault, the room(s) where the fault is taking place must be reported. As for diagnosis, the cause of the fault must be described. In some cases, the exact source of the fault might not be diagnosable. In these cases, entrants should provide a list of plausible events that could have led

to the observed fault. It is important to note that this list should only contain credible causes, as listing irrelevant possibilities will be judged negatively. Furthermore, entrants are expected to simulate the healthy operation of the building over the fault period and, using their simulation output, revise dataset 2 with time-series data to describe the normal, healthy operation of the building. This revised version of the faulty time-series data is referred to as dataset 3, must adhere to the same format as dataset 2, and must be provided along with the final report.

Entrants are expected to use their simulation model and, by comparing it with the faulty dataset, detect and diagnose the faults as accurately as possible. All entrants must describe their modeling approach, along with assumptions made during model development. In addition, the use of AI-based or machine learning methods for fault detection is highly encouraged and would be considered as a bonus criterion in the evaluation process. However, such methods must be applied in addition to a physics-based simulation model developed using validated building simulation tools. In case ML methods are used, a sufficient description of the type of model used, the model development process, along with the use of the model for fault detection, is to be provided.

3. Case study

The building is a mixed-use university building hosting lecture rooms and offices. It is located on the Campus Inffeldgasse of TU Graz in the center of Graz (Austria). It is composed of a basement and 4 floors: a ground floor and three floors with similar plans. The building is a concrete construction. The windows have triple glazing with aluminum frames. The slabs are concrete-based with linoleum covering. For this competition, the modelling and implementation of faults are limited to the ground floor and first floor. Adiabatic boundary conditions may be assumed for the rest of the construction.

For this competition, ideal heating is assumed. The building has a mixed ventilation system in which some rooms are equipped with mechanical ventilation, and some are naturally ventilated. Occupancy profiles, lighting profiles, and the heating capacity of each zone are given in Appendix C. Furthermore, in this study, external shading caused by neighboring buildings is not considered.

4. Provided inputs and constraints

The following information is to be used for developing simulation models of the use case. Constraints regarding schedules and heat gains of electrical appliances, occupancy, and lighting must be followed precisely. Furthermore, the schedule, flow, and supply temperature of mechanical ventilation, the schedule of natural ventilation, heating capacity, and heating set-point of each room, and shading activation threshold must be followed exactly as well. Any deviation from these requirements, unless explicitly mentioned below, will result in disqualification. The intention is to remove uncertainty from many project parameters so that the competitors can concentrate on a specific system on an equal playing field. In addition, the staircase and elevator areas on both floors are excluded from the modelling and fault detection tasks. Adiabatic heat transfer between these zones and the rest of the floor may be assumed.

Site and Building plans

The building is oriented 32.16 degrees west of true north. Drawings of the building levels, sections, and the site plan are provided in Appendix D. These plans must be followed exactly, and rooms may not be rearranged.

Construction

Construction details of all internal and external walls, floors, ceilings, doors, glazing, and thermal bridges are provided in Appendix A.

Heating System features

Ideal heating systems are assumed in this competition. The maximum deliverable heat for each zone is presented in Appendix B. A constant heating set-point of 20 °C has been applied to all rooms. The mechanical rooms on both floors are equipped with ideal cooling devices with a constant set-point of 26 °C.

Ventilation

The building has a mixed ventilation system. Corridors, restrooms, mechanical rooms, seminar rooms, and the common room on each floor are mechanically ventilated with a constant air flow that is active during the office hours on working days (07:00 to 18:00). Each of these zones has its own supply and return vents. A constant temperature of 17 °C is to be assumed for the supply air of these ventilation systems. The office zones are considered to be naturally ventilated. It is assumed that office occupants open the windows to 25% three times a day during working days: [08:00-08:15], [12:00-12:30], [16:00-16:15]. Further information on ventilation is presented in Appendix B.

Infiltration

The infiltration rate of the building is assumed at 1.72 ACH (air change per hour) at 50 Pa. As for the internal air exchange between the zones, the internal doors are considered to be closed. Hence, the air exchange between the rooms is minimized.

Shading

All windows are equipped with shading devices, with the shading on each façade controlled according to the incident solar radiation on that façade. When the incident solar radiation exceeds 100 W/m^2, shading is activated, and when it goes below this threshold, shading is deactivated. Shading has a short-wave transmittance coefficient of 0.286. Shading caused by the neighboring buildings is not considered.

Occupancy profile

A ratio of 0.65 to 0.35 is considered for sensible to latent heat gain due to occupancy. An activity level of 1.2 met is assumed for all the occupants, which leads to a total heat gain (sensible and latent) of 126 W per occupant. See Appendix C for further details.

Lighting and appliances
See Appendix C.

Climate Data
Weather data for Graz, Austria, is provided on the conference website. This weather file is provided in the format of an Excel file describing hourly climate data of Graz.

Dataset 1
This dataset is provided on the conference website and is to be used to calibrate the developed simulation models. The calibration step is intended to ensure that the simulation models reproduce the general trends and dynamic behavior of the temperature and heating demand. It is understood that even well-constructed models will not match the measurements provided in dataset 1 perfectly. Hence, the calibrated models are not expected to achieve the highest accuracy, but rather reasonably capture the rises, falls, and overall patterns observed in this dataset. Hence, no reports on the accuracy and performance of the calibration process are expected from the entrants.

Dataset 2
This time-series dataset is also provided on the conference website. It represents the faulty operation of the building, including a number of deliberately implemented faults. Entrants must use their building simulation model to detect the faults within this dataset (both temporally and spatially) and diagnose their sources.

5. Evaluation Criteria

- The key factors influencing the judges' decision will be *rigorous* and *intelligent* use of building simulation for fault detection and diagnosis (30%).
- Additionally, different scores will be applied to the report, considering the following achievements:
  - Building behaviour simulation (15%)
    - Modelling methods, including rational definition of inputs for simulation
    - Efficacy of graphs and calculated outputs
  - Fault detection and diagnosis (30%)
    - Methods and criteria used to detect the faults
    - Precision of the spatial and temporal detection of the faults
    - Validity of the source diagnosis for each fault
  - Generation of the healthy time-series dataset (15%)
    - Efficacy of the method and assumptions made to rectify each fault
    - Quality of the corrected dataset with respect to the possible fault diagnosis
  - Presentation and quality of the report, figures, and referencing (10%)
    - Quality of the academic language and structure of the report
    - Effectiveness of figures and data visualizations for illustrating used methods

Entrants are encouraged to use AI-based or machine-learning methods to support and enhance the fault detection and diagnosis process. However, such methods must be applied in addition to a physics-based simulation model developed using validated building simulation tools. AI approaches should therefore complement (not replace) the simulation models, for example by assisting in pattern recognition, anomaly detection, or interpretation of simulation–measurement discrepancies. The core modelling and analysis focus must remain grounded in established building simulation practices.

Competition submissions can be either individual or group submissions, but **multidisciplinary teams of students are more advisable.** Following judgment by an expert panel, two finalists will be identified. In case of group entries, a group leader should be nominated as the corresponding person.

Note. The decision of the judges is final, and there will be no further discussion.

6. Deliverable Report

One report of maximum 20 pages (excluding annex) containing the following sections:

1) Title page, including author(s) 'names, affiliation(s), and, in case of team applications, contact details of the corresponding author
2) Executive summary (1 page or less)
3) Table of contents
4) Nomenclature
5) Introduction
6) Building Energy Simulation
  a) Modelling assumptions
  b) Modelling techniques
7) Fault detection and diagnosis
  a) Description of the fault detection process
  b) Detected faults (temporal and spatial) as well as diagnosis of their source(s)
  c) (optional) machine learning techniques used for fault detection
8) Healthy operation of the building
  a) Description of the assumptions and revisions considered to generate the healthy operation of the building
  b) Healthy time-series data (dataset 3), replacing the faulty dataset (dataset 2)
  Ensure all graphs provided are legible and concise to support overall results. Additional graphics can be included in the Appendices.
9) Conclusions
10) References (if required)
11) Disclosure statement on AI use or non-use
  a) How has the AI tool been used
  b) Name of the used AI tool
12) Appendices (if required)

7. Key Dates

March 15th, 2027*:	Notification of intent: all students who intend to submit have to notify the modelling competition team via email: competition.bs2027@tugraz.at

April 30th, 2027*: Deadline for completed entries.
These should be sent via email in WORD or PDF to:
competition.bs2027@tugraz.at

June 1st, 2027: Winners informed

August 29th –
September 1st 2027: BS2027 Conference in Vienna, Austria

**Please note that participants are welcome to submit both their intent to submit and the final report ahead of the respective deadlines; however, the intent to submit must be received before the final report. The intent can be submitted from 01.06.2026 and no later than 15.03.2027.*

8. Enrollment and notification of finalists

All entrants must be enrolled as students (PhD, MSc, BSc, or equivalent) at the time of submission (i.e., April 28th 2027). Entrants must upload the following documents as proof of their student status:

- A bonafide letter on the university/institute letterhead from the supervisor or faculty-in-charge
- Student ID provided by the university/institute

Entrants who fail to submit these documents will be disqualified. Please note that in the case of group entries, each member must submit these documents.

The two finalists will be notified by June 1st, 2027, and will receive free registration to BS2027 plus up to € 2000 in reimbursed travel expenses. The two finalists will be expected to attend the Building Simulation 2027 conference and prepare a short presentation and produce a poster for display at BS2027. Poster requirements and travel/registration information for the finalists will be provided at that time. Based on the conference presentation and poster, an overall winner will be selected and announced at the conference.

9. Queries

If you require any further information, please contact us at the following e-mail:

competition.bs2027@tugraz.at

Please try to make your question as concise as possible. All questions and responses will be posted to the Student Competition section on the BS2027 website, so please look here first to check that your query has not already been answered.

10. Submitting to other conferences

Groups and individuals intending to submit a report and results to a different conference must acknowledge the IBPSA BS27 modeling competition in such a paper.

Appendices

Appendix A: Envelope components

External Walls

Assembly direction: outside → inside

No.	Layer	Material / Description	Thickness [m]	Thermal conductivity λ [W/m·K]	Density [kg/m^3]	Specific heat capacity [j/kg K]
1	Exterior cladding	Aluminum façade	0.0040	160	2800	880
2	cavity	Still air layer	0.0360	0.2	1.2	1008
3	Thermal insulation	Mineral wool (FDPL)	0.1600	0.035	50	1030
4	Load-bearing wall	Reinforced concrete wall	0.2500	2.3	2300	1000
5	Interior finish	Plaster layer	0.0050	0.67	1500	1000

Internal Floor

Assembly direction: top → bottom

No.	Layer	Material / Description	Thickness [m]	Thermal conductivity λ [W/m·K]	Density [kg/m^3]	Specific heat capacity [j/kg K]
1	Floor finish	Floor covering (linoleum)	0.003	0.17	1200	1400
2	Screed	screed	0.07	1.33	2000	1080
3	Thermal insulation	EPS T650	0.03	0.044	11	1450

4	Thermal insulation	EPS-W 25	0.04	0.036	23	1450
5	Filling / levelling layer	Chippings (split), compacted	0.045	0.700	1800	1000
6	Load-bearing slab	Reinforced concrete slab	0.22	2.300	2300	1000
7	Ceiling finish	Plaster layer	0.005	0.67	1500	1000

Internal walls (IW-01)

No.	Layer	Material / Description	Thickness [m]	Thermal conductivity λ [W/m·K]	Density [kg/m^3]	Specific heat capacity [j/kg K]
1	Wall lining	Gypsum plasterboard	0.038	0.210	700	1000
2	Insulation	Mineral wool WF MW-W	0.1000	0.040	60	1030
3	Wall lining	Gypsum plasterboard	0.038	0.210	700	1000

Internal walls (IW-05)

No.	Layer	Material / Description	Thickness [m]	Thermal conductivity λ [W/m·K]	Density [kg/m^3]	Specific heat capacity [j/kg K]
1	Interior finish	Plaster layer	0.0050	0.67	1500	1000
2	Load-bearing wall	Reinforced concrete wall	0.2500	2.300	2300	1000
3	Interior finish	Plaster layer	0.0050	0.67	1500	1000

Internal door

No.	Layer	Material / Description	Thickness [m]	Thermal conductivity λ [W/m·K]	Density [kg/m^3]	Specific heat capacity [j/kg K]
1	MDF plate	MDF plate	0.05	0.12	600	1700

Glazing:

Triple glazing (3-pane thermal insulation glazing), aluminum frame

g-value = 0.36, U-value = 0.836 W/m²K,

U-value of frame= 1.6 W/m²K, frame fraction of the total window area= 0.15,

Thermal bridges:

connection	External wall /internal wall	External wall / external wall	External wall / internal slab	External window perimeter	Roof / external wall	Roof / internal wall
Psi-value (W/mK)	0.0804	0.145	0.168	0.232	0.1248	0.0796

Appendix B: Occupancy, appliance, and lighting densities and Ventilation requirements

	Occupancy	Equipment	Lighting	Mechanical Ventilation	Window opening	Heating power
Space type	m²/person	W/m²	W/ m²	L/(s*m²)	Open/close	W/m²
Office	10	10	15.9	-	Window schedule	50
Technical room	0	100	0	4	Always closed	-
seminar room	3.2	1.8	14.8	1.86	Always closed	50
Corridor	0	0	5	0.5	Always closed	40
Restroom	0	0	16	10	Always closed	40
Common room	2.1	37.2	5.8	2.68	Always closed	50

Appendix C: Internal Gains & Schedules

The internal heat gains for occupants, lighting and appliances are reported in the next tables, together with the hourly ratio of the peak values given in Appendix C.

Office

	Day type	Hour of the day																							
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Occupancy	WD	0	0	0	0	0	0	0	0.2	0.6	1	1	0.8	0.4	0.6	1	0.8	0.6	0.2	0	0	0	0	0	0
	WE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Equipment	WD	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.6	0.8	1	0.8	0.4	0.6	1	0.8	0.6	0.2	0.1	0.1	0.1	0.1	0.1	0.1
	WE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Light	WD	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
	WE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Technical room

	Day type	Hour of the day																							
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Occupancy	WD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	WE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Equipment	WD	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	WE	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Light	WD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	WE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Seminar room

	Day type	Hour of the day																							
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Occupancy	WD	0	0	0	0	0	0	0	0	0	0.6	1	0.4	0	0	0.6	1	0.4	0	0	0	0	0	0	0
	WE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Equipment	WD	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.6	1	0.4	0.1	0.1	0.6	1	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	WE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Light	WD	0	0	0	0	0	0	0	0	0	1	1	1	0	0	1	1	1	0	0	0	0	0	0	0
	WE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Corridor

	Day type	Hour of the day																							
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Occupancy	WD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	WE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Equipment	WD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	WE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Light	WD	0.2	0.2	0.2	0.2	0.2	0.2	1	1	1	1	1	1	1	1	1	1	1	1	1	0.2	0.2	0.2	0.2	0.2
	WE	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Restrooms

	Day type	Hour of the day																							
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Occupancy	WD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	WE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Equipment	WD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	WE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Light	WD	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
	WE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

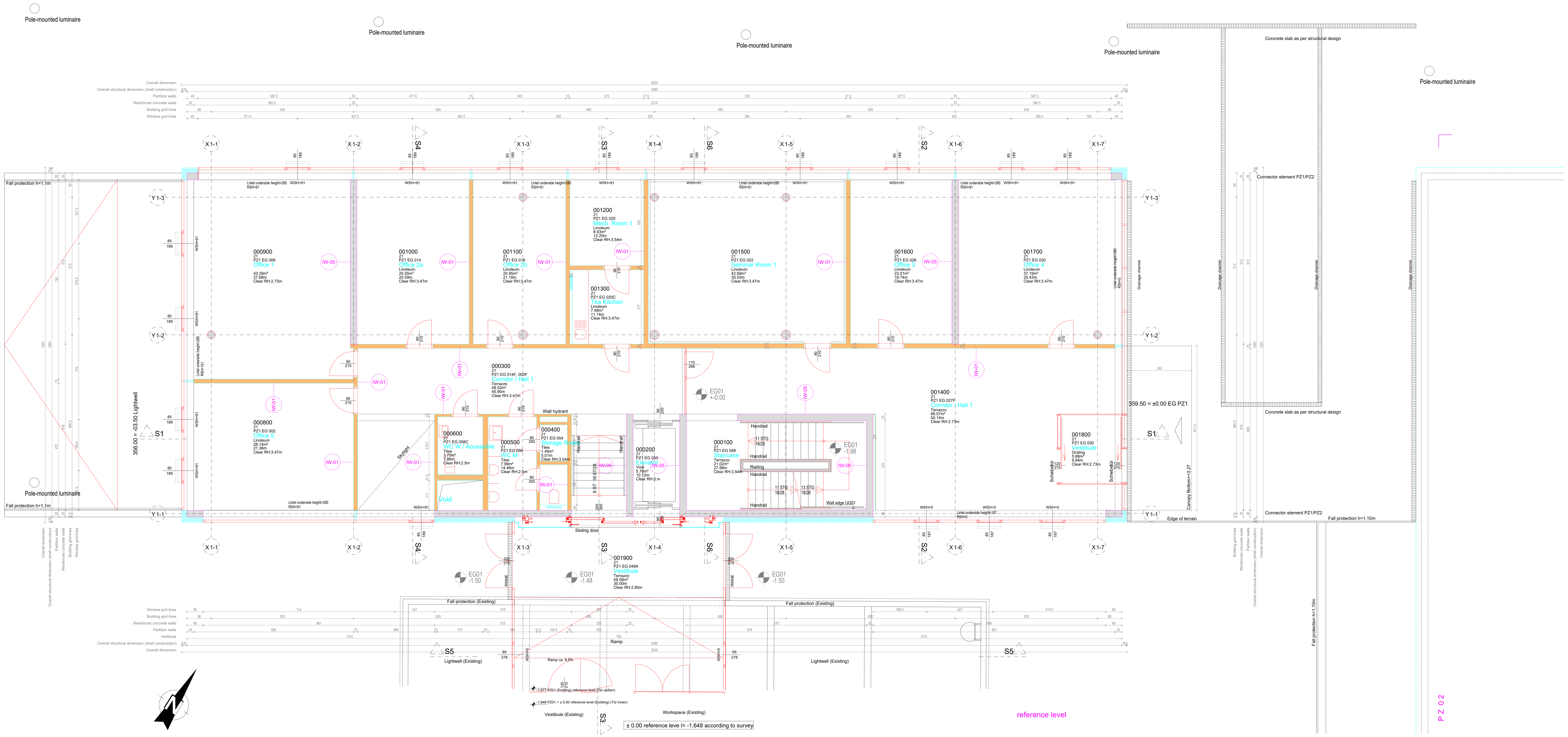
Common room

	Day type	Hour of the day																							
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Occupancy	WD	0	0	0	0	0	0	0	0.2	0.2	0.2	0.4	0.8	1	0.8	0.4	0.2	0.2	0.2	0	0	0	0	0	0
	WE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Equipment	WD	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.4	0.8	1	0.8	0.4	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1
	WE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Light	WD	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
	WE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix D: Site and Building

Image Source: Institute of Thermal Engineering, TU Graz

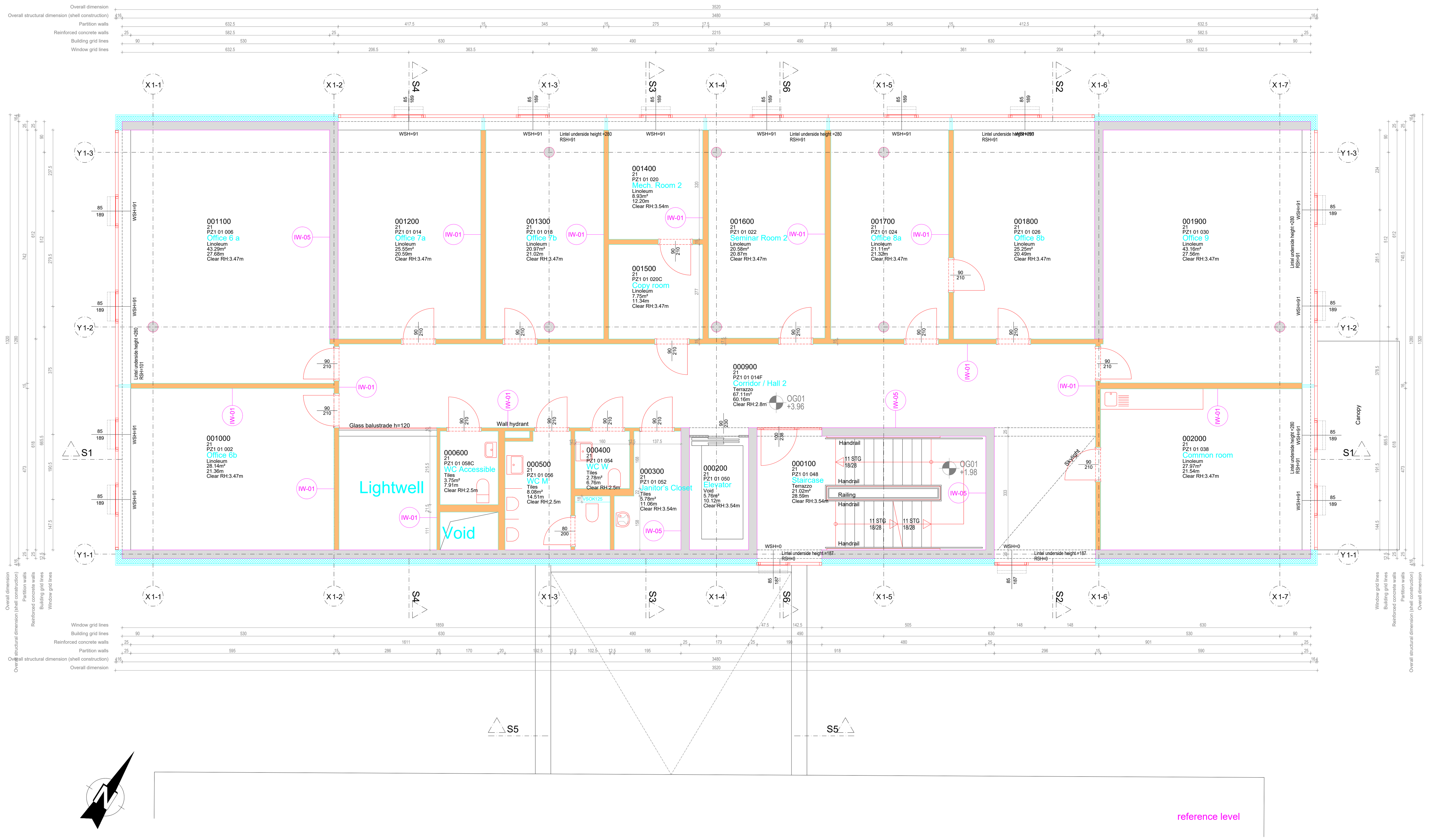
Site Plan. Ground Floor



63106_01995_017_00_EG01
63106_01995_017_
Floor wing
446.75m²
1411.08m³

Plan EG / 1:100

Site Plan. First Floor



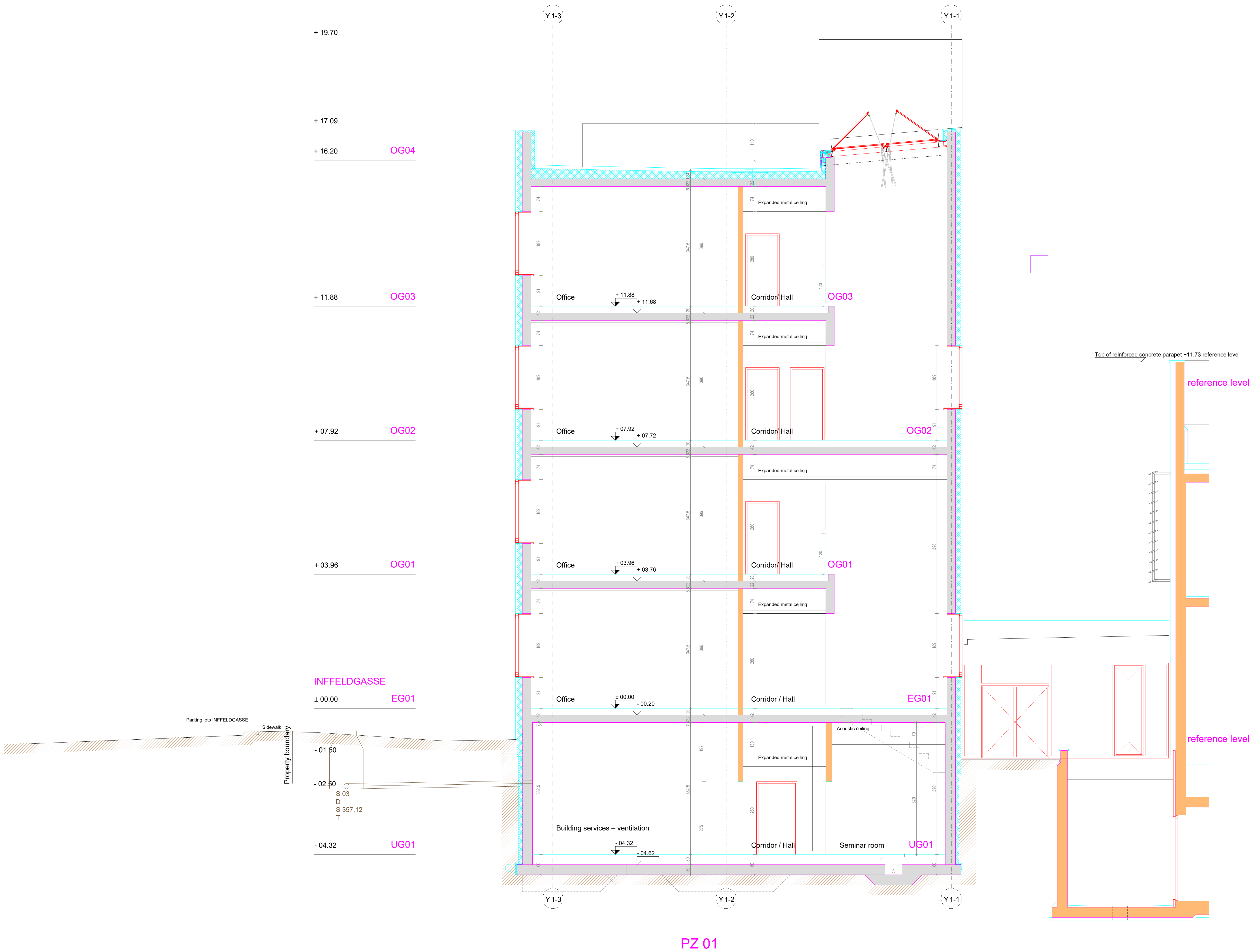
63106_01995_017_00_OG01
63106_01995_017_
Floor wing
387.00m²
1291.59m³

Plan OG1 / 1:100

Site Plan. Section 1-1

Schnitt 1-1 / 1:100

Site Plan. Section 4-4



Schnitt 4-4 / 1:100 / Color