Implementing underground infrastructure in geological 3D-models - case study Darmstadt 3D -

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1) Introduction

Typically geological 3D-models do not include other information such as underground infrastructure. As well city models do not consider the coexistence and interaction between underground infrastructure and geological data. Therefore especially in urban areas respective models do not support needed functionality. To overcome this gap, the case study Darmstadt_3D has been initiated. The work aims to discover the process of including and using building information in a geological / hydrogeological 3D underground model of Darmstadt (Hesse). Therefore, specifications about the measurements and the position of the basement floors and the foundation are required. The first implemented buildings are public edifices, due to the size and the data availability (case example: darmstadtium – convention and science center; Fig. 1). In the next step derived buildings, respective foundations, without further underground information are put into the model.

2) Data Set, Methods And Visualization

Provided data is received as paper-based, constructional drawings / floor plans (Fig. 2). As a first step all existing and available data (from several municipal authorities, engineering or architect's offices, owner) will be gathered and, if necessary, scanned in. Via CAD software (here AutoCAD) the raw data is vectorized (Fig. 3) and converted into serviceable GIS files (including a consistent spatial reference and assigned height values to all components / points).
The bigger part of the city buildings are not public and construction documents are unavailable (Fig. 5). Therefore, the measurements of the foundation are estimated (Fig. 6), based on primary dimensioning formulas (additional to basic requirements such as a minimum depth of 80cm to build into frost free soil). A decent estimation about foundation dimensions depends on data such as the area, perimeter, height and the building material for an approximated load. Suitable structures are surface foundations as strip footings and raft footings.
In the next step a 3D modeling software (here GOCAD) is used to generate a single volumetric object (Fig. 4) of the prepared GIS files, containing all data. The elevation model (raster size 1m x 1m) determines the top of the volume.

3) Results And Discussion

The implementation of underground infrastructure is a realizable task but the accuracy of infrastructure objects depends on the available data. Anyhow, estimations of missing structures are viable to maintain a city-wide coverage. This approach leads to a more precise geological model since respective parameterized objects replace geological objects and thus support more reliable processing downstream. From a hydrogeological view the building can be assumed as an impervious layer instead of e.g. a near-surface, high permeable weathered layer), which is going to influence a groundwater flow model significantly. Furthermore the comparison with surrounding geology (faults, unconsolidated sediments) and the groundwater settings can be helpful to identify potential risks for the technical infrastructure (e.g. subsidence, exposure to water).

Fig 1. darmstadtium - convention and science center (darmstadtium.de)

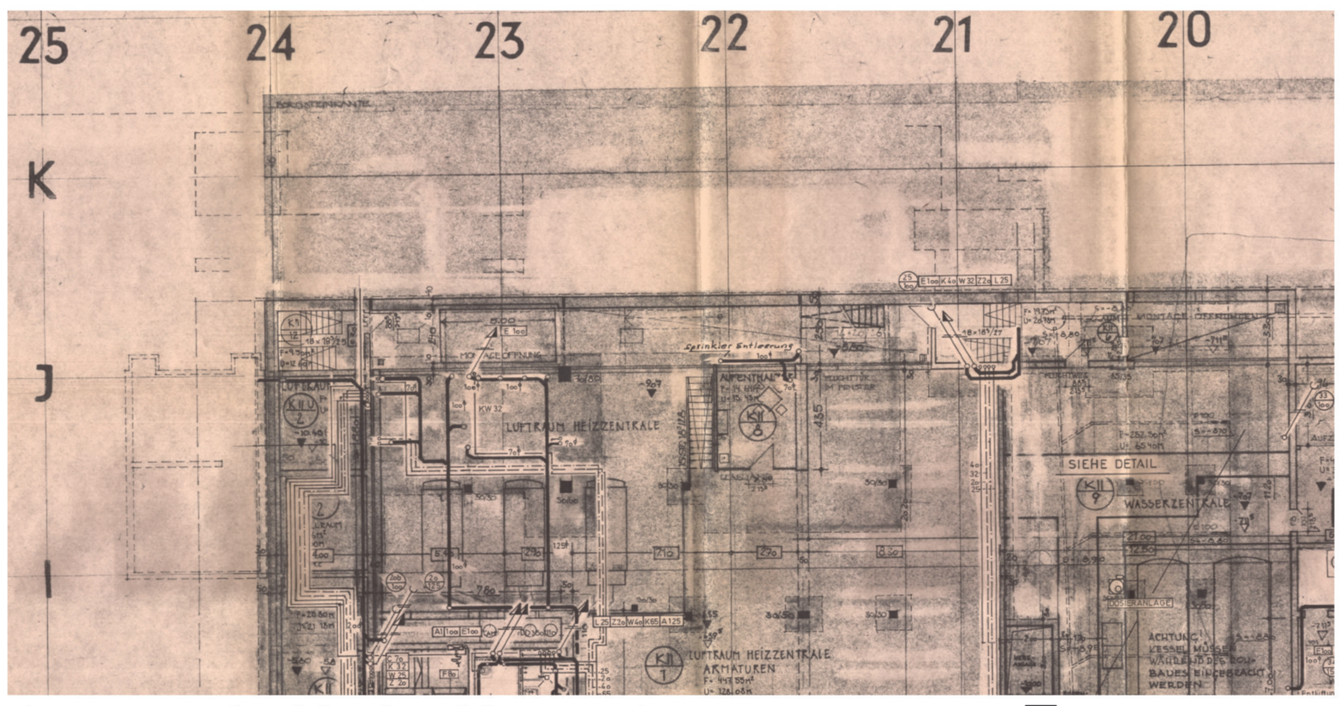

Fig. 2 Constructional drawing of the convention center (Tiefbauamt Darmstadt)

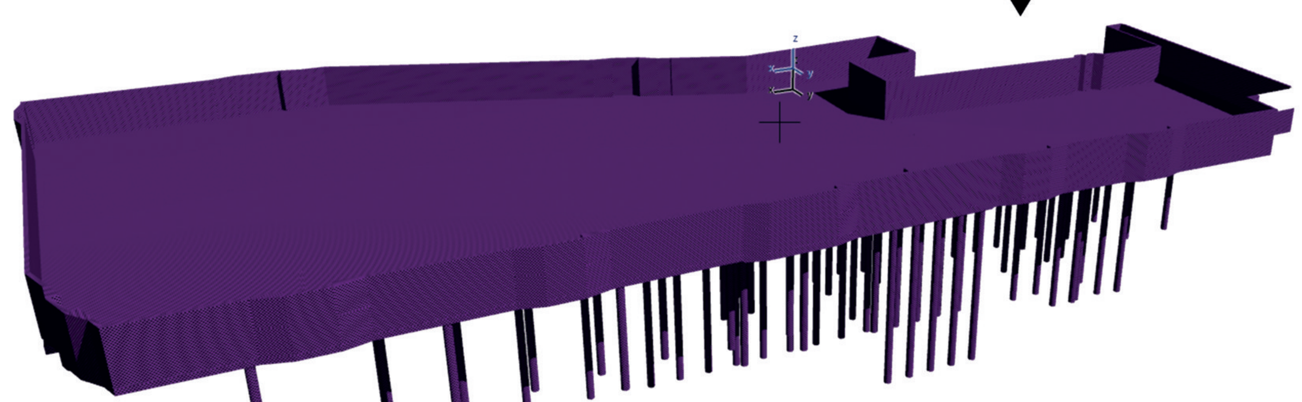

Fig. 3 Vectorized CAD object of the darmstadtium

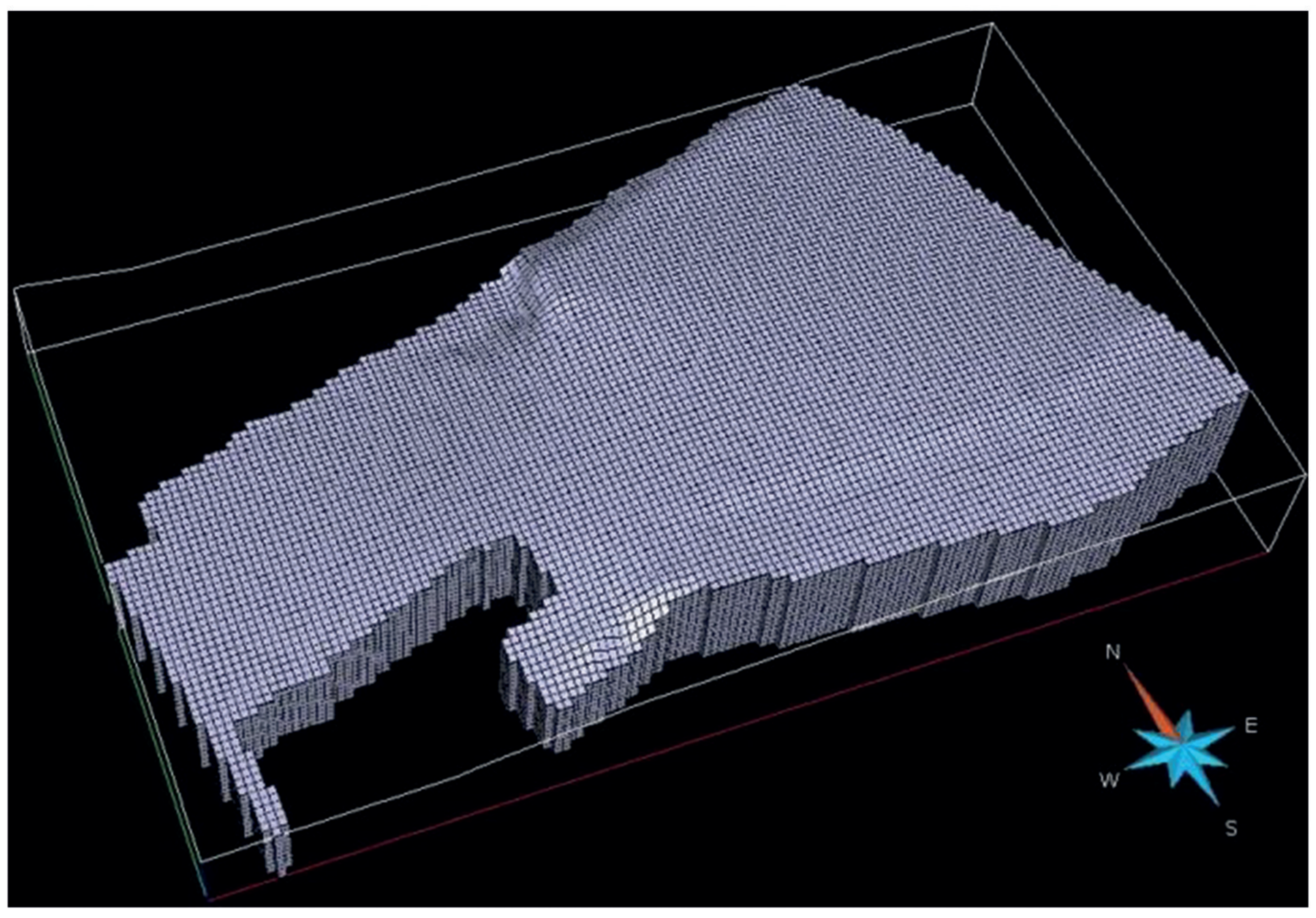

Fig. 4 3D foundation / basement floor model of the darmstadtium

Fig 5. Figure ground plan Darmstadt (geoportal.hessen.de)

Table

poly

FID	Shap	GML_ID	SHAPE_	extent	heigt	building_load	foundation_width	foundation_depth	total_depth
0	Poly	DEHE06120	106,49	41,35	15	232	0,93	0,38	2,6
1	Poly	DEHE06120	110,09	42,47	15	233	0,93	0,38	2,6
2	Poly	DEHE06120	180,61	54,36	15	299	1,2	0,54	2,7
3	Poly	DEHE06120	198,12	57,54	17	351	1,4	0,66	2,9
4	Poly	DEHE06120	181,88	54,52	15	300	1,2	0,54	2,7
5	Poly	DEHE06120	97,15	40	17	248	0,99	0,41	2,6
6	Poly	DEHE06120	174,87	60,85	17	293	1,17	0,52	2,7
7	Poly	DEHE06120	117,99	45,23	17	266	1,06	0,46	2,7
8	Poly	DEHE06120	107,74	42,37	12	183	0,73	0,3	2,5
9	Poly	DEHE06120	97,93	45,54	17	219	0,88	0,35	2,5
10	Poly	DEHE06120	95,76	44,96	17	217	0,87	0,34	2,5
11	Poly	DEHE06120	100,39	40,79	17	251	1	0,42	2,6
12	Poly	DEHE06120	121,45	44,27	17	280	1,12	0,49	2,7
13	Poly	DEHE06120	117,35	45,38	17	264	1,05	0,45	2,7
14	Poly	DEHE06120	129,6	46,45	17	285	1,14	0,5	2,7
15	Poly	DEHE06120	194,15	61,09	17	324	1,3	0,6	2,8
16	Poly	DEHE06120	274,25	75,67	17	370	1,48	0,71	2,9
17	Poly	DEHE06120	125,67	44,96	15	252	1,01	0,42	2,6
18	Poly	DEHE06120	85,66	42,75	15	180	0,72	0,3	2,5
19	Poly	DEHE06120	130,16	51,29	9	137	0,55	0,3	2,5
20	Poly	DEHE06120	97,01	39,42	9	133	0,53	0,3	2,5
21	Poly	DEHE06120	153,84	51,49	17	305	1,22	0,55	2,8
22	Poly	DEHE06120	153,78	51,32	17	306	1,22	0,55	2,8
23	Poly	DEHE06120	268,98	71,14	15	340	1,36	0,64	2,8

Fig. 6 Estimated foundation and total depth of buildings