

## LACK OF ATTENTION TO GEOLOGICAL CONDITIONS INVESTING IN LAND PLOT FOR CONSTRUCTION

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### Abstract

**Decisions – where and what type of building to build – are very important, determine the quality of life of residents, profitability and returns of companies. Considering of long-term asset acquisition decisions, purchasers or investors seek for proper and worth to invest land plot for construction. In real estate valuation literature usually the list of 7 or 12 factors influencing value and price of land plot is presented and broadly discussed. Certain factors raise property prices and others bring them down. Despite its importance, the influence of geological conditions on the appraised land plot are seldom investigated. Authors discuss how strongly land plot geological conditions can affect costs of prospect construction, thus decrease net present value of real estate investment project and profitability of property. In this paper the implication of negligence or underestimation of soil conditions valuation is highlighted and illustrated by case studies which show how such inobservance has resulted in a huge rise of unexpected costs of construction and loss of time.**

**Keywords:** Construction costs; Geological and soil conditions; Land plot valuation factors; Real estate development; Geological investigations.

## 1. INTRODUCTION

It is generally accepted that construction and real estate sectors are key drivers for the economic and social development of a country. Changes in these sectors have an observable impact not only on other sectors of economic activity, but on the well-being of populations as well. Construction products – buildings and civil engineering structures are long-term, expensive, necessary (to live or produce other goods) property that is firmly connected to the ground and therefore “tied” to a certain area. Decisions – where and what type of building to build – are very important, which determine the quality of life of people, profitability of companies as well as other results of their activities, the environment, the landscape and must be taken with responsibility in accordance to the territorial planning of the area [1]. Both the land and buildings are expensive. Davis and Palumbo [2] in analysis of the price of residential land in large US cities document-

ed that over the past decades just about every large city in the US has experienced a significant increase in the average share of home value attributed to the market value of residential land. They estimated that residential land value represented from 33 percent until 81 percent share of average single-family home’s value in large US cities.

An investment in real estate is generally considered as type of investment with the best financial returns in long term. Investing in it, individual buyers or real estate (RE) developers face financial risk, they are looking for less risky alternatives. Certain factors raise property prices and others bring them down. The real estate sector is characterized by its heterogeneity, high levels of complexity, and the often-confidential nature of its transactions, which means relevant information for decision-making support is limited [3]. Each particular land plot is unique and if site becomes available for RE development, its value rises. Avoiding to face

risk, it is necessary to observe in detail the factors which may influence property prices.

In scientific and professional literature two groups of value's factors are distinguished: general or macro-economics and individual. In real estate valuation literature usually the list of 7–12 factors influencing value and price of land plot is presented and broadly discussed. These individual factors are location and its subfactors, improvement, land use purpose, urban zoning, taxes, ecological conditions (mainly air pollution and noise level) or environmental contamination, parcel size and shape, the relief (topography), construction costs, geographical stability. Unfortunately, the influence of soil type and conditions on the appraised land plot is seldom investigated in the real estate valuation literature. Cost of foundations is significant in total building's construction cost, on average comprises approximately more than 10 percent of total cost and depending on geotechnical conditions of site can vary from 10 to 30% of all investment. Geotechnical conditions of site are obtained from geotechnical investigations. Preliminary investigations do not allow to get full information about site engineering geological and geotechnical properties.

In this paper the risk to face construction costs rise due to the lack of attention to soil type and geological conditions in valuation of land plot for construction is highlighted. This negligence is illustrated by case studies – how such inobservance resulted in huge rise of unexpected costs of construction and loss of time.

## 2. MAIN INDIVIDUAL FACTORS INFLUENCING LAND PLOT PRICE

Location with its subfactors has a significant impact on real estate prices and value. Value depending on location includes such main subfactors as developed infrastructure of the district, transportation, specifics of the district, surrounding districts and its prestige.

Neighbourhood factor is very important – areas with developed infrastructure (proximity to employment centres, education institutions, medical facilities, shops and local services). The relationship between house prices and local public goods and services has been widely studied in the scientific literature [4]. Bohman and Nilsson [5] research results reveal that the largest regional labour markets have the greatest effect on the prices of the housing. A prestigious school in the area can drive demand for a particular property within a district, furthermore, having strong

schools in district can affect home prices by as much as 10 percent over a neighbouring district [4]. Property in the areas with developed infrastructure, compared with inferior infrastructure areas, has higher value.

Location encompasses other major locational considerations, such as transportation (highways, good public transportation networks). In selecting land plot for house or other building, most purchasers or RE developers look initially for a good neighbourhood but also for one with easy access to. A site with highly visible frontage along an important commercial highway gets a higher value for commercial buildings or industrial building but it is not desirable for a residential use [6]. Public transportation (developed rapid rail systems in conjunction with bus networks or other transportation alternatives) is also important factor affecting location desirability [7] and relates directly to land plot's value. Transportation networks affect property values in two key ways: positively, via the increased accessibility that they provide, and negatively, due to the negative externalities associated with being close to them. The findings of empirical study of Kilpatrick et al. [8] reveal that proximity to the transit corridor alone without direct access conveys a negative impact on nearby housing values.

When it comes to property investment, the purchaser should consider developments that already are in motion and which are planned in surrounding area. This valuable information about development directions and prospective construction objects could be found in strategic planning documents of the city (e.g. municipality's Master plan, which includes statement of strategic directions, structure plans and concept plans for the development of future urban areas). Skoczko and Oszczapińska [9] analysed areas according to the number of population (in agglomerations), where sewage system building would be economically viable and could change individual sewage treatment systems. According to Raslanas et al. [10], the information about planned improvements is a key factor influencing the increase or decrease in value of real estate investment (the value increases if development direction goes along with considered to purchase land plot). RE specialists' state, urbanization can increase property prices by 30 percent [11].

Architects [12] are considering how the principles relating to quality of place also determine the quality of life. RE valuers noticed that some people want their living place to match and emphasize their lifestyle, community, and social status. Price, depending on prestige of the area may vary by about 25 per-

cent [13], expressed in increased value of residential district. Safety level of the district has close relationship with desirability of location and influences the property values. Some studies have found that violent crimes lead to lower home prices [14].

The value of the land is determined by the best use to which it can be put [15]. The urban residential zones which create additional value to the land plot should be further analysed. The information about these zones may be gathered in previously mentioned strategic planning documents regarding the land use purpose and its location. Municipal or local government laws (e.g. zoning) dictate for which purpose (residential, commercial, industrial, other) real property can be used in certain areas, as well regulate form, design and compatibility of development. It is very important that the zoning restrictions correspond to the land use purpose of the prospect building. In opposite case, the construction will not be allowed: in construction industry, a site can become available for development after planning permission is given [16]. It is estimated that zoning indirectly affects land value and directly increases tax rates (and they get capitalized into the value of the land). Muellbauer and Murphy explains that land-use restrictions and planning constraints have a big impact on the scope of land plots suitable for building, subsequently on value of the land and on the value of the property developed on that land [17]. Henneberry et al. [18] analysed and estimated the effect of planning on the property sector of the local economy: as planning regimes become tighter, the local supply of space decreases and this has a negative effect on local economic activity and a positive effect on local rents. However, these laws can be modified or suspended if construction of the property will serve to help the community advance economically, which come in the form of increased land and housing costs from restrictions on the availability of developable land [19]. Planning blight and developments with adverse effects on a local community may lead to falls in the price of land in a particular area.

Chiodo et al. [4] analysed how local real estate taxes affect the supply and demand and, consequentially, the value of homes and land in a certain area as well as commercial properties and industrial projects. An increase in property tax rates would result in a decline in the value of residential property [4] making it cheaper for residents to live outside the centre and commute [11]. Potential buyers will calculate (capitalize) the tax into the price proposed for the land plot. Consequently, the price will be higher. Decrease

in taxation can boost investment. Changes to zoning within a town or a city can affect the value of a property. Likewise, rezoning part of an area previously classed as residential to an industrial development may cause a decrease in value of adjacent properties [20]. Other important factor influencing land plot price is ecological conditions or environmental contamination, mainly air pollution and noise level. Nowadays healthy living is becoming a status symbol in society [21], as more consumers opt to flaunt their passion for wellness through paying for health-improving things and health-giving leisure activities. Urbanised districts with increased air pollution in the environment and high traffic noise level are less attractive for housing buyers and developers, and prices here are accordingly lower. Study performed by Zavadskas et al. [22] showed that the prices of apartments of houses in the same living district area differed depending on the property location. It appears that apartment prices of the houses located at the main street are lower from those further away from the street in the same area. Scientists made a conclusion that air and noise pollution exerts a rather sizeable influence on property prices, and owners are aware of it [22, 23]. Moreover, recently scientists attempt to estimate influence of visual clues on property value's reduction. The facts are that those land plots (for a residential use) which have nice landscape, are farther from the main street, have proximity to the greenery and/or water get a higher value. In academic and specialty literature it is considered how the price of the site depends on the cost of construction and it is stated: the construction cost of prospect building directly and indirectly influences property prices. The higher the cost of prospective construction, the less will be available for developers to bid for the site [16]. The costs for construction materials are obvious influences. Less obvious ones are financing costs, land costs, and indirect costs (building permit fees, sewer tap fees, or rezoning costs).

Construction product (building) is very expensive. Analysing single-family houses sales price breakdown history in USA [24], it could be found that the price share of finished land plot comprises on average 20 percent and construction cost is approx. 60 percent from total sales prices. The cost of labour, the cost of land, and to some extent the cost of the materials can vary from place to place and depend on the nature of the particular home being built. As example, real estate cost breakdown of homeowners in USA [25] was summarized by authors (see Table 1).

**Table 1.**  
Real estate cost breakdown of homeowners (source: Home advisor survey 2017 [25])

Category	Low cost, \$	Average cost, \$	High cost, \$	Most spent between, \$
Seal a Basement or Foundation Costs	650	3 837	9 200	2 060 – 5 837
Repair a Foundation Costs	500	3857	10 663	1 761 – 5 955
Level Concrete Slabs Costs	300	850	2 075	500 – 1 207
Install Basement Flooring Costs	200	2 843	10 000	1 524 – 4 241
Install Basement Countertops Costs	400	2 909	7 000	1 911 – 4 087
Remodel a Basement Costs	5 000	18 724	40 000	10 852 – 27 002
Clean Carpeting Costs	75	174	350	120 – 235
Refinish Hardwood Floors Costs	600	1 570	3 450	1001 – 2 156
Install a Driveway Costs	1 000	3 871	9 000	2 203 – 5 760
Install Blown-In Insulation Costs	450	1 346	3 000	875 – 1 897
Install Batt, Rolled, or Reflective Insulation Costs	500	1 543	3 382	969 – 2 151
Install Spray Foam Insulation Costs	500	1 905	5 100	1 029 – 2 930
Install Electrical Wiring or Panel Costs	125	1 270	4 000	549 – 1 996
Install Solar Panels Costs	1 985	20 074	40 000	12 738 – 28 283
Install Gutters & Downspouts Costs	200	916	9 000	546 – 1 303
Install Seamless Gutters Costs	300	908	2 000	570 – 1 255
Paint a Home Interior Costs	400	1 670	4 120	938 – 2 442
Paint a Home Exterior Costs	730	2 624	5 600	1 704 – 3 728
Install Telephone Jacks and Wiring Costs	50	161	411	108 – 261
Install a Computer Network or Wiring Costs	100	377	1 000	191 – 599
Install Flooring Costs	200	2 843	10 000	1 524 – 4 241
Install Countertops Costs	400	2 909	7 000	1 911 – 4 087
Install Landscaping Costs	485	3 219	9 400	1 536 – 5 075
Install a Patio or Pathway Costs	800	3 081	9 000	1 755 – 4 552
Build a Deck Costs	2 000	6 916	15 000	4 085 – 9 885
Clear Land or Prepare a Construction Site Costs	375	2 592	7 000	1 270 – 4 031
Build a Barn, Shed or Playhouse Costs	560	3 020	6 500	1 807 – 4 451
Install a Water Heater Costs	325	956	6 000	725 – 1 261
Install a Roof Costs	2 000	6 854	30 000	4 690 – 9 034
Install Vinyl Siding Costs	2 500	9 274	20 000	5 811 – 13 468
Build Stairs or Railings Costs	424	2 067	5 000	1 066 – 3 200

**Table 2.**  
One-storey residential house installation costs share, in percentage

Category/ House part	Costs share, %
Foundation Costs	11
Exterior Walls Costs	18
Concrete Slabs Costs	8
Install a Roof Costs	6
Roof Cover Costs	7
Home Exterior Costs	2
Internal Wall Costs	4
Flooring Costs	10
Install Windows Costs	4
Install Doors Costs	3
Home Interior Costs	6
Install Home Heating Costs	7
Install a Water Supply Costs	2
Install Electrical Wiring or Panel Costs	5
Other	7
Total	100

For comparison, the share of one-storey residential house in Lithuania construction costs, using data of Lithuanian construction costs estimating company JSC “Sistela” and summarised by authors, are given in Table 2.

Reviewing real estate literature, in addition to the above-mentioned factors, determining the market value of the appraised site, the following individual factors could be land plot's shape and size [13]. Land plot characteristics have a substantial impact on the cost of preserving farmland [26]. The size of a land plot affects the initial value of the site. Raslanas [13] argues that a square plot of land is less valuable than rectangular, wider land plot is more valuable than a narrow, and the correct shape of the land plot can be advantageous to use than irregular.

In addition, the relief (topography) is important not



only to the development of the land, but also to the desirability of the land. Pleasant relief with woody green hills may be highly desirable for residential usage and may bring a premium in a residential community. Šarkienė [27] points that surface with different ground levels allows to design a house with more expressive architecture, but its' design and, especially, construction requires extra costs. Therefore, the investors which plan usage of the land plot for commercial or industrial development may not appreciate mountainous relief and woody terrain.

The influence of soil type and conditions on the appraised land plot are seldom investigated in the real estate valuation literature with rare exceptions on geographical stability [28]. It is agreed that specific areas of geographical or geological instability which are prone to the effects of natural phenomena, such as flooding, tsunamis, earthquakes, or volcanic activity, are poor choices when buying property and require consideration of safety aspect [20]. Raslanas [13] highlights that a level of ground water, parcel's drainage is important in valuation of property, as well as its soil and subsoil conditions – depending on the soil composition there is a different construction cost of the same type of building. Antuchevičienė et al. [29] analysed such geo-factors as gravity and magnetic fields, concentrations of geochemical elements in the soil, soil lithology, relief and landscape in order to evaluate impact of different geo-factors on human diseases and psychic disorders. Bell [30] observed numbers of detrimental conditions (among them soil conditions and geotechnical issues) that can affect real estate values. Finally, Gwozdź-Lason [31] argued that local geotechnical properties of the ground ought to be included in the property valuation process as an attribute having an influence on the value.

In general, it could be stated that in real estate valuation literature a very little attention is paid to soil conditions (geotechnical conditions factor) of site.

Analysis performed by authors showed that according to geotechnical conditions, building's foundations price share can be from 10 to 30% of all investment. These numbers could be confirmed examining data in presented Tables No. 1 and No. 2. Foundations' type and cost depend on soil condition and geotechnical properties. The parent material of Lithuanian soils is the Quaternary deposits of the last and penultimate glaciations [32]. Sediments consist of glacial loam and sandy loam (42%), glaciofluvial sand and gravel (40%), and glaciolacustrine clay (4%). Some areas are covered by organic deposits, mainly peat

[33, 34]. Geotechnical properties are obtained from geotechnical investigations.

The composition and amount of the geotechnical investigations shall be adjusted to the particular investigation phase and the geotechnical category, which can be primary, design and additional (EN 1997-1:2004 [35]). Preliminary investigations shall be carried out to assess the general suitability of the site, compare alternative sites if relevant, estimate the changes that may be caused by the purposed works, to plan the design and control investigations. Design geotechnical investigations have I, II and III geotechnical categories, which depend on construction site geological conditions and building complexity class. These investigations should be carried out to provide the information required for an adequate design of the temporary and permanent works, to provide information required to plan the method of construction and to identify any difficulties that may arise during construction, also any project can not be prepared without design investigations. Total (preliminary and design) engineering geological and geotechnical investigations price is usually less than 1% of all investment. Preliminary investigations prices comparing with design investigations is usually having a ratio 1/3.

According to Lithuanian construction technical requirements, all geotechnical investigations must be registered in Lithuanian Geological Survey (LGS). All registered investigations reports are uploaded in LGS information system and it is possible to check maps of: boreholes, cartographic boreholes, deposit, geomorphological map 1:200 000, groundwater extraction boreholes, pollution sources, pre-Quaternary geological map 1:200 000, Quaternary geological map 1:200 000. So, from an institutional economics point of view, buying a new land plot it is possible to check the information in LGS and to have a first impression about site geological and geotechnical conditions. This information allows to form the imagination of site geological and geotechnical conditions investigations quantity and quality.

In the next sections of this paper two case studies will be presented to highlight importance of geological and geotechnical conditions of site and to show costs of neglecting such geotechnical investigation before buying the land plot, preparing building design and beginning of the construction.

### 3. COMMERCIAL BUILDING CASE

In this section of the paper a case of a site for commercial purpose land and commercial building project is presented.

In this case, before buying the land plot for construction preliminary geotechnical investigations were carried out. Unfortunately, preliminary investigations were realized not in all construction site (see in Fig. 1, point No. 61; 62; 63). According to carried out engineering geological and geotechnical investigations and data obtained from them, the technical project of the commercial building was prepared and calculations of return of investment in this project were estimated. This situation occurred due to having short time of all project realization time. Preliminary investigations did not allow to get full information about site geotechnical properties and investor did not want to wait for design investigations report, which should appear later in 2–4 months' period. Nevertheless, commercial parcel was bought and only after buying the design geotechnical investigations in all construction site area were carried out (see in Fig. 1, point No. 58; 60). According to design geotechnical investigations in investigations point No. 58 (Fig. 1) the 14.77 m thickness technogenic (t IV) soil layer was indicated. This result was totally unexpected, because according to preliminary geotechnical investigations data the technogenic soil layer was only 1.95–2.68 m deep in the site (see in Fig. 1, point No. 61; 62; 63).

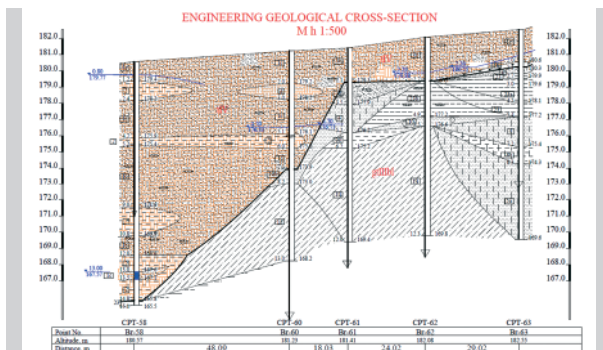


Figure 1.

Commercial approach in one of the sites engineering geological cross-sections: 1b – top soil; 1c – technogenic soil with fine sand, top soil, gravel, detritus, rubble and construction debris; 2 – technogenic soil with silty sand, organics and sand; 4 – silty sand (yellow); 5a – silty sand (grey); 6 – fine sand; 10 – medium sand; 10b – medium sand, unsaturated; 14 – clayey silt; 15 – clayey silt with lenses of sand; 18b – silty clay; 20 – clay; 23 – clay with lenses of silty sand; 23a – clay (layered); 23b – clay with lenses of sand

Technogenic soil usually is unsuitable to be a bearing soil layer for planned object. Obtained unexpected thickness ( $\approx 14.8$  m instead of  $\approx 2$ – $2.7$  m) of technogenic soil layer resulted in:

- Necessity to redesign building and change the technical project, because foundations and floors' construction solutions had to be changed;
- Additional geotechnical investigations in construction site;
- According to the first calculations it was necessary to install 374 continuous flight auger (CFA) piles with diameter 0.4–0.6 m, length 3–14 m, in total  $495.87 \text{ m}^3$  of concrete for construction of a designed commercial building. After redesign and additional geotechnical investigations recalculated quantity of CFA piles was significantly bigger – 665 units with diameter 0.4–0.8 m, length 3–11 m, in total  $1076.16 \text{ m}^3$  of concrete, where floors' construction is also loaded on the piles;
- Floors construction should be reinforced as an overlaying slab;
- As result, foundations and ground floors construction installation investments increased to  $\sim 2\,000\,000$  Eur, project implementation time prolonged by 5 months, thus decreased net present value, profitability and return of investment of the building construction project.

Only after identification of technogenic soil layer depths, the commercial parcel area history was analysed. Around 1980 close to the commercial parcel area was a road to construction debris dump. To save the time some drivers were disposing construction debris in commercial parcel area from investigation point 58 to 61 (see Fig. 1). Knowing that data about the State-owned property was presented for the first time in 1994–1995 in the Lithuanian Statistic chronicle [36], there is nothing strange that drivers were not paying attention to environmental protection. This (commercial parcel) area was very comfortable to dispose the construction debris, because the road was very close and it was in a half way to construction debris dump. When the commercial parcel area was bought (in  $\sim 2012$ ), the grass was growing in that place, all area was almost flat and nobody thought that under the grass can be technogenic soil layer up to 15 m. Only in the beginning of the 1960s the geological-geophysical investigations of Klaipėda port and Lithuanian marine areas of the Baltic Sea were started [37].

#### 4. INDIVIDUAL HOUSE CASE

For individual house building process it is very important to know the foundation installation price in advance. Usually it is worth to invest into individual house if foundation price does not exceed 30% of total house construction price. If the foundations installation price is more than 30%, usually it is not worth to build the individual house according to economic aspects. To avoid high costs of foundations installation, it is worth to realize geotechnical investigations [38], which are not so expensive comparing to total individual house price. Such an approach is presented in Figs 2 and 3.

Geological investigations of the parcel (Fig. 2) have shown that the soil has very bad geotechnical properties for construction, and it was decided to make additional geotechnical investigations (Fig. 3). After analysing all geotechnical data, it was found that economically it is worth to shift slightly all building into another part of construction site.

Slightly shifted house position (see Fig. 3) allowed to decrease foundation installation cost, which is not exceeding more than 30% of all house construction cost. Nevertheless, all additional geotechnical investigations and house redesigning process increased a period of obtaining the construction permission and it was issued only after 5 months.

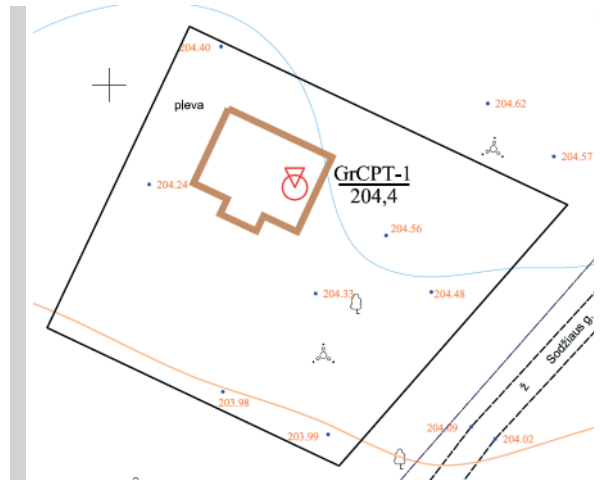
## 5. CONCLUSIONS

In real estate valuation (both in professional and in scientific literature) usually these individual factors which affect land plot value are broadly investigated: location and its subfactors, development improvements, scope and type of prospect construction, purpose of land use, urban zoning, taxes, law restrictions, stage condition, housing construction costs, shape, size and topography of a parcel.

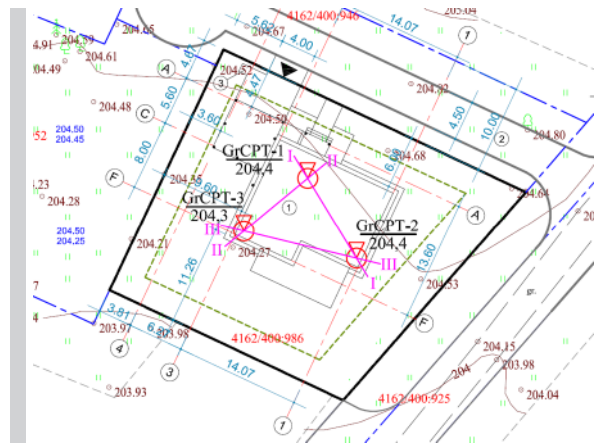
Usually, the desirability and value of a land plot for a house or other building often depends on urbanization or changes in the surrounding area, such as improvements in the infrastructure like new roads, schools or other public facilities, and purpose of land use.

After analysing RE literature and case studies, it was found that a very little attention to soil conditions (including geotechnical conditions factor) of site is paid, despite its importance.

The presented two case studies show implications of incomplete geological investigations on building construction projects.



**Figure 2.**  
**Initial geological investigation point GrCPT-1**



**Figure 3.**  
Additional geological investigation points GrCPT-2 and  
GrCPT-3

Analysis performed by the authors has shown that according to geotechnical conditions, building's foundations price share can be from 10 to 30% of all investment, when total (preliminary and design) engineering geological and geotechnical investigations price is usually less than 1% of all investment (preliminary investigations prices comparing with design investigations is usually having a ratio 1/3). It is economically efficient to invest in building construction when the foundations installation cost comprises less than 30% of total construction cost. Foundations cost strongly depends on geotechnical properties of a land plot.

Factual information on geotechnical properties has to be obtained from geotechnical investigations. Geotechnical investigations of the parcel can be pri-



mary, design and additional.

Usually decision to invest in land plot for construction is based on primary geotechnical investigations only, which do not allow to get full information about geotechnical data. Even experienced investors rely on such type of geotechnical investigations, as presented first case study shows. The bigger development project is planned, the more complex geological investigations must be done. Neglecting influence of soil condition and considering main factors influencing land plot value only, has led to 2 million Eur additional costs, significant time loss, thus decreased net present value and lower profitability of investment project in presented first case study of commercial building.

Neglecting influence of soil condition – having no full picture of geotechnical properties of the site – and considering main factors influencing land plot value only results to significant time losses, costs of redesign and other indirect costs as second case study shows.

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