GEOKALKYL – GIS-ASSESSMENT OF BUILDING FOUNDATION REINFORCEMENT COSTS AND CARBON FOOTPRINTS

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EXTENDED ABSTRACT

Our cities are growing and face many challenges. One of these challenges is the need for more sustainable land use and ground construction. This can be achieved through various interventions at the early stage of city planning. One example is reusing excavated soil material at the construction site instead of sending it to a landfill. This approach saves on transportation and reduces the need to extract virgin soil and rock material. Another example is minimizing the carbon footprint from construction works by choosing building sites with favorable geological conditions, thus limiting the use of cement and lime for soil stabilization and building foundations. Further contributions can be made by considering and preserving essential ecosystem services within our cities. The Swedish Geotechnical Institute (SGI) has developed a planning tool, 'Geokalkyl', that addresses the above-mentioned aspects, thereby contributing to both reduced construction costs and a lesser environmental and climate impact, resulting in more sustainable land construction.

Geokalkyl is a calculation system founded on the principles of Geographic Information Systems (GIS) and is designed to visualize the cost and carbon footprint of foundation reinforcement in municipal development areas. Geokalkyl, primarily intended for municipal departments in urban and environmental planning, is recommended to be implemented in the early stages of development planning.

The tool includes geoprocessing functions designed according to specific geotechnical reinforcement methods. To conduct analyses within Geokalkyl, access to the National Elevation Model and National Soil Type data is required. Additionally, a defined analysis area and a site plan that includes both roads and buildings are necessary.

During the analysis processes within the Geokalkyl tool, the interpretation of soil types is carried out in accordance with the Geotechnical Terrain Classes (GTC). This classification system has its roots in both Australian and American models but has been adapted specifically for Swedish soil conditions. The underlying hypothesis, modified for Swedish terrain, suggests that terrain sections that are homogeneous in topographic, geological, and geohydrological aspects share identical geotechnical characteristics. Within the classified segments, aspects such as the general thickness of the soil layer, suitable construction categories, and guidelines for geotechnical interventions like filling, excavation, and groundwater regulation are specified.

Based on the specified number of floors for the buildings, Geokalkyl estimates the load on the ground surface. By then correlating this load with the soil's classification according to

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the GTC system, Geokalkyl recommends one of the following reinforcement measures: *preloading, excavation, lime-cement columns* or *piling*. Subsequently, standard values are retrieved for estimating cost and emissions of carbon dioxide equivalent.

In recent years, Geokalkyl has undergone significant enhancements and expansions. A particularly notable addition is the 'Mass-Balance' feature. Using the GTC model, excavated materials are sorted into different quality classes. This allows for a quantification of the excavated volumes that can be reused, as well as the volume that needs to be transported to a landfill. In a subsequent step, the reusable volume is compared with the current need for fill material, providing a balance calculation between available resources and needs. Based on predefined standard values, Geokalkyl then estimates the anticipated costs and carbon dioxide equivalent emissions.

Geokalkyl can be used for various scenarios. The reinforcement measure proposed by Geokalkyl is mainly determined based on the load of the building and the type of soil on which the building is planned to be erected. Through the strategic placement of buildings considering their load and the specific soil type on the site, an optimal situational plan can be achieved that promotes both economic and environmental sustainability. Against this backdrop, the user can apply Geokalkyl for various layout plan options within the same analysis area, to thereby identify the most optimal layout plan with respect to economy and environment. An alternative scenario where Geokalkyl can be used arises when a developer is faced with the choice between several possible areas for a given situation plan. By adjusting the position of the situation plan and applying Geokalkyl to each specific location, the user can visualize the land construction costs and carbon dioxide equivalent emissions for each individual development option.

Another complement to Geokalkyl is EkoGeokalkyl which focuses on ecosystem services. It identifies specific soil functions within given planning areas so that they can be considered early in the planning phase. The tool focuses on two main soil functions: the soil's capacity to support vegetation and its permeability to water. EkoGeokalkyl categorizes the soil based on these functions into three levels (high, medium, low) to enable efficient documentation and visual integration with construction plans.

Through its automated geoprocessing functions and visualized analysis results, Geokalkyl provides an interactive perspective on costs and emission volumes of carbon dioxide equivalents associated with ground construction work for different development alternatives. This allows decision-makers to effectively compare and evaluate various development options.

Geokalkyl has been tested in several cities. The Eskilstuna municipality has an urban development project that aims to connect and integrate the districts of Fröslunda, Lagerberg, and Råbergstorp. Geokalkyl has been utilized to calculate the geotechnical costs for the proposed structural plan, thereby contributing to the prioritization of tasks in future development plans. Gävle municipality is working on an urban transformation project for the "Näringen" area. In this project, Geokalkyl has been employed to optimize the placement of buildings within the development area at an early stage, considering both geotechnical and economic perspectives. In the municipality of Malmö, the tool ekoGeokalkyl has been used to evaluate ecosystem services during the development of Nyhamnen.