Efficient use of natural stone in the Leningrad Region and South-East Finland

3.

Durability of stone on construction

Southeast Finland and Leningrad region

Results

Visual inspection had revealed on each site presence of some weathering effects.

Non destructive tests, performed mainly in Finland, demonstrated that the material showing visibly weathering effects had lower properties compared to non weathered one, but the extent of weathering had mainly affected only the surface layer. In this case Ultrasonic velocity and Schmidt hammer had been a reference, while Ground penetrating radar had helped in understanding the architectonical structure of the built.

Finnish sites had been maintained during the years and weathering effects are generally minor compared to St. Petersburg area. Granitic rocks, containing mainly quartz, muscovite and feldspars are well resistant to chemical weathering. Chemical analysis showed that concentration values are similar between exposed and non exposed surface, and in some rock types are similar to original bedrock material.

Deposition of pollutants comparing the composition of the dust and surface of the granite could be pointed out for St. Petersburg area. Still, from chemical data, applying weathering coefficient analysis could be seen that the material had been affected by weathering, as for example by the action of wind.

Vegetative growth had been found in Finland mainly on the castle sites, while in St. Petersburg in larger extent. The analysis showed presence of fungi, mosses, lichens, algae in the top layers of the material, penetrating into the grain boundaries that started to enlarge for combined action of climate and vegetative growth. Material showed weathering effects at microscopic levels, as breaking of crystal structure, but even boulder material had still shown good physical properties.

The granitic material on construction site had been definitively durable and from the study conducted could also be seen the positive effects of good maintenance during the years.

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Petersburg Complex Geological Expedition
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This project is co-funded by the European Union, the Russian Federation and the Republic of Finland
ENPI
South-East Finland - Russia ENPI CBC 2007 - 2013

Weathering effects

Granitic rock had been widely used in the areas analysed during the project. Different kind of hard silicatic rock either quarried or collected on site had been used as structural elements in the constructions. The material had been exposed to atmospheric and antropogenic actions for several years and it is possible to evaluate from the surface possible weathering signs.

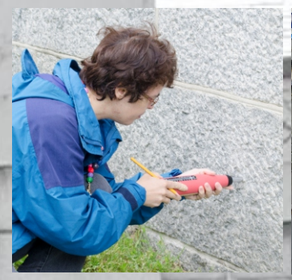
Physical, chemical and biological factors can affect the weathering of a granitic rock. Freezing and thawing loosens the mineral structure of the rock surface gradually, the abrasive action of dust and wind mechanically abrade the surface often starting from the selvages of the slabs. Chemical weathering is caused by internal and external factors and it is dependents on rocks' chemistry and environment (water, wind, temperature changes, gases and aerosol particles) as well as mineral and chemical composition of the rock.

Chemical weathering included dissolution, hydrolysis enhancing mineral replacement (e.g replacement of feldspar with kaolin), extraction of minerals by mechanical effect accelerated by solid particles, oxidation where oxygen reacts with the rock minerals producing oxides (e.g. iron that produces iron oxides - rust) causing staining and, as hydroxide, change in volume.

Biological growth acts both as physical and chemical weathering agent, largely diffused on construction sites, has therefore been considered important in the research.

On site the following weathering effects had been analysed:

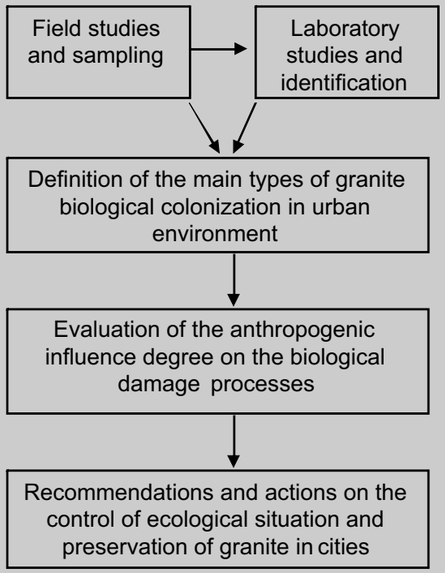
Peeling and exfoliation,
Rudd surfaces,
Deepenings and cavities,
Hollows and chipping,
Stone flaking-off,
Fractures and fissuring,
Deformations,
Mushrooms, Seaweed,
Lichens, Mosses,
Dung of birds,
Atmospheric mud depositions,
Granular disintegration,
Loss of colour,
Crusts,
Bio-films of different composition,
Ovoid weathering,
considering the climatic and microclimatic condition of the site.



Research methodologies

Evaluation of stone deterioration has been conducted coupling field and laboratory analysis, using both destructive and non destructive tests to assess the properties of the structures and of the materials.

Schematic view of the research conducted:



Visual inspection, supported by high definition images, has been essential for visualizing the macroscopic effects of the weathering.

The typology of construction and its characteristics were studied using Ground Penetrating Radar with two high frequency antennae (900 and 1600MHz).

The properties of the material on site had also been assessed using Ultrasonic Pulse Velocity and Schmidt Hammer Hardness Test.

Thermal camera image analysis has been performed to assist assessment of both interior and surface weathering to reveal differences in humidity and temperature.

Additional chemical and petrographical analyses have been performed in the laboratory to identify anomalies in rock structure and composition, influence of pollutants and weathering results. Research on biological colonization had been conducted at macroscopic and microscopic level, in addition to in vitro research.