UDC 624.131.65

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AN EXAMPLE OF THE CLIMATE IMPACT ON THE LANDSCAPE AND ARCHITECTURE CHANGES

Extreme droughts have appeared in the year 2003, and extreme precipitation in the year 2006. on the area of northwest Croatia. Its influences on arhitecture and landscape will be shown in this paper. Quantities of precipitation within a certain area and during a certain period of time vary from time to time and are related to season of the year and soil moisture. In a more general sense, precipitation certainly has an effect on the state of the surroundings, i.e. the landscape; this paper deals withthe influence of precipitations and droughts on architecture, i.e. buildings and structures. in a technical sense. The central examples are: - influence of extreme precipitation on landscape by appearence of sliding of natural slope, and influence of extreme droughts on the soil of buildings' foundation where the moisture content is reduced.

Keywords: *precipitation, landscape, landslide, drought, moisture, soil, constructions, damage.*

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ПРИКЛАД ВПЛИВУ КЛІМАТУ НА ЗМІНИ ЛАНДШАФТУ ТА АРХІТЕКТУРИ

У 2003 році на північному заході Хорватії спостерігалися надмірні посухи, а у 2006 р – надмірні опади. Показано вплив цих процесів на архітектуру та ландшафт. Кількість опадів на цій території впродовж указаного періоду змінювалася час від часу залежно від сезону та вологості ґрунту. У більш загальному сенсі опади безпосередньо впливали на стан навколишнього середовища, тобто ландшафту. Розглянуто вплив опадів та посухи на архітектуру, тобто на будівлі та споруди, в технічному сенсі. Основним прикладом є вплив надмірних опадів на ландшафт, що виявився у зсуванні природного схилу, а також влив надмірної посухи на ґрунт під фундаментом будівлі, де зменшився вміст вологи.

Ключові слова: *опади, ландшафт, зсув, посуха, волога, ґрунт, будівлі, дефект.*

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ПРИМЕР ВЛИЯНИЯ КЛИМАТА НА ИЗМЕНЕНИЯ ЛАНДШАФТА И АРХИТЕКТУРЫ

В 2003 году на северо-западе Хорватии наблюдались экстремальные засухи, а в 2006 г. – чрезмерные осадки. Показано влияние этих процессов на архитектуру и ландшафт. Количество осадков на данной территории в течение указанного периода колебалось время от времени в зависимости от сезона и влажности грунта. В более общем смысле осадки непосредственно влияли на состояние окружающей среды, т. е. ландшафта. Рассмотрено влияние осадков и засухи на архитектуру, т. е. на здания и сооружения, в техническом смысле. Основным примером является влияние осадков на ландшафт, которое проявилось в сползании природного склона, а также влияние экстремальной засухи на грунт под фундаментом здания, где уменьшилось содержание влаги.

Ключевые слова: *осадки, ландшафт, оползень, засуха, влага, грунт, здания, дефект.*

Introduction. The increasing of the water level and it's retention under the construction in the geotechnical profession is clearly known to cause different effects depending on the composition of the soil.

By increasing the water level it is possible that under the construction consistency of the soil decreases and this causes rapid settlement, which clearly causes damage to the building.

Reduction of the water level and soil drying below foundation caused soil settlement, which directly damage the construction, ie, leads to the appearance of cracks in the building.

The above phenomena and their direct impact on the construction shall be described in the following paper.

One example how the impact of increased water levels and precipitation at a particular time of year can have on the landscape is presented in the article on the same authors published in the conference in Brno 2010th year (listed in the references).

Causes of settlement and character of damages

a) hydroconsolidation b) soil swelling

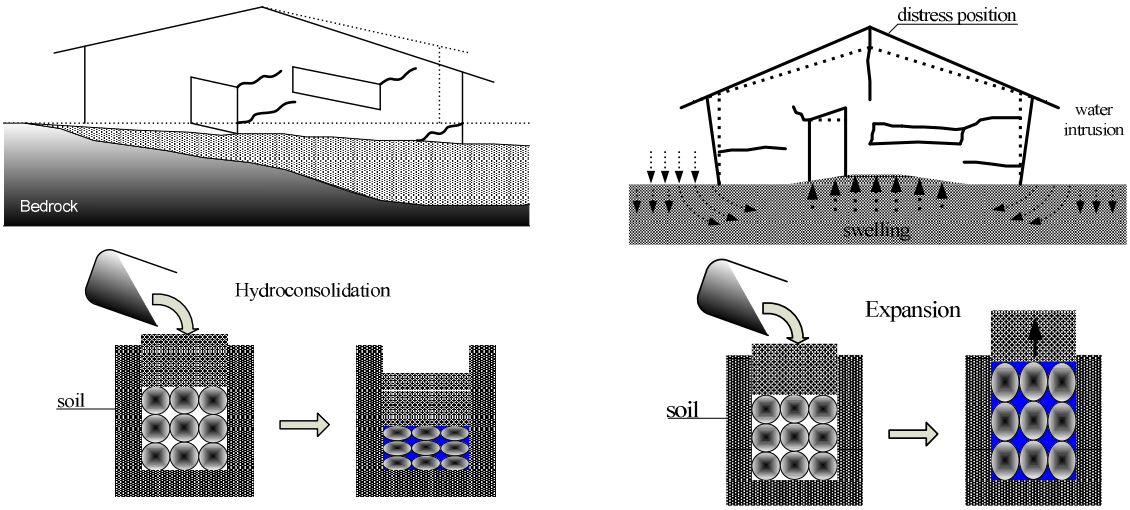


Fig. 1. Settlement, changes in soil consistency

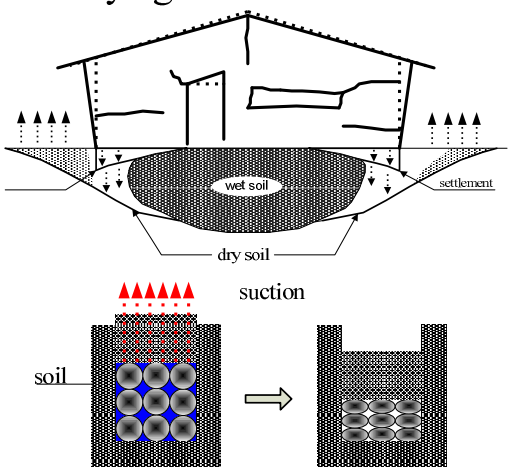
By increasing the water level it is possible that swelling of the soil appear under the building, causing stress on the contact area of the construction and soil, as shown in the following figure.

Swelling of the soil is a dangerous threat to the construction, especially because it has the potential of spreading of the expansive type of soil that is far greater than their shrinkage. Excess of the moisture can get into the soil in various ways: by cracking or leakage of plumbing pipes, high level of groundwater and surface water that is the most common cause of swelling (especially in a poor or no drainage performed, and from the rain).

Very often shrinkage of the soil leads to settlement, particularly at construction with shallow foundations. The water evaporates from the soil especially in the long hot and dry periods, the soil is shrinking, and if the impact

of shrinkage reaches below the foundations of constructions causing settlement and cracks in construction. Clayey soil settlement in Croatia reaches a depth of 1.0 to 1.5 m, today, in some cases due to the impact of global warming settlement reaches to 2.0 m. In India shrinkage reaches 2.0 to 3.0 m, in Java 4.0 - 5.0 m, and there are construction foundation in clay are very deep.

a) soil drying



b) crack details on the building

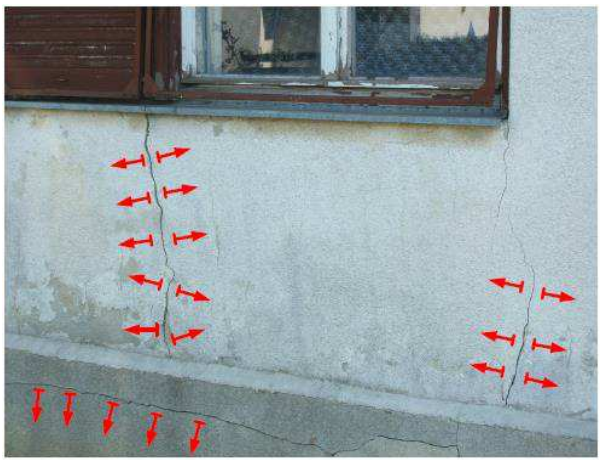


Fig. 2. Soil drying and cracking

During construction of the foundation soil can have an optimum moisture, but during dry periods it can be lost, leading to settlement of the construction. Settlement are larger at the ends of the construction because in this part the soil dries out quickly.

Such occurrences have been recorded in Croatia, as shown in the diagram (fig. 3).

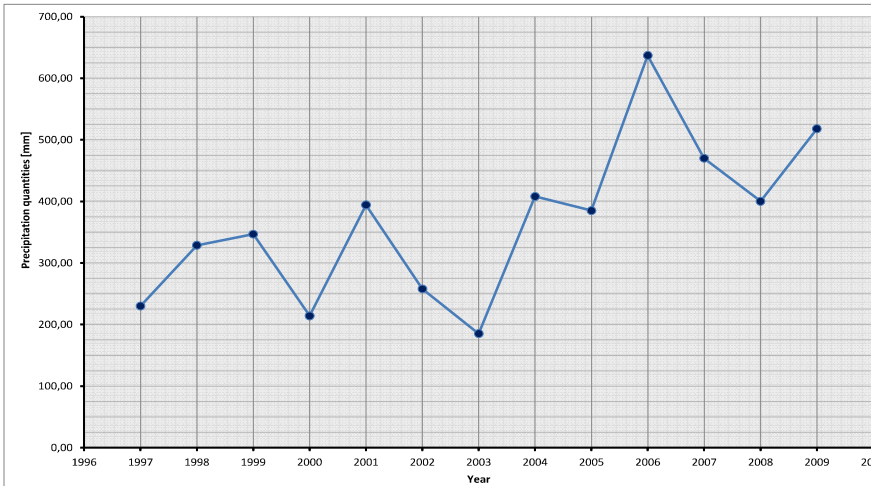


Fig. 3. Diagram of presipitation in northwestern Croatia, 1997–2009

As an extreme case of soil drying emphasizes by the Year 2003., as shown in the diagram. The whole year was dry, so the problem of soil drying under the foundations occurs frequently. On the other hand, the Year 2006. was permeated by continuous precipitation with the fine rain that was slightly watering soil that led to the maximum saturation after the winter and slow melting of snow. It is logical that in this rainy period the evaporation of water from the soil is minimal.

The diagram shows the levels of precipitation for the period of 14 years and is adjacent to seven months (XI. – V. month of the year) so that in this period it's possible to compare the amount of precipitation and to clearly identify the periods of maximum and minimum, which resulted in damage to buildings.

The sunshine is most at the corners of construction that are facing the southeast and southwest. The soil is dried, and the corners of the building frequently break and crack (fig. 4).

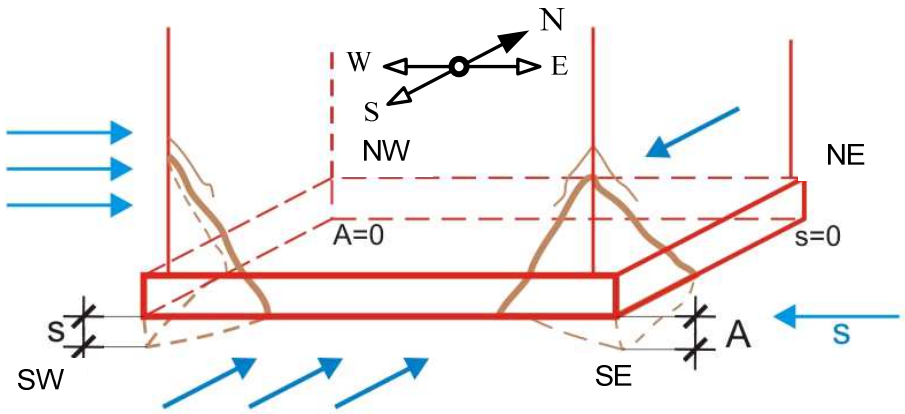


Fig. 4.Damage to the building due to soil shrinkage

The soil dries at least in the corners of the construction toward the northeast and northwest and in this corners cracks do not occur. If we mark the initial porosity of soil with n, porosity after shrinkage with nS', and on the border of shrinkage with nS, we can determine the settlement of soil layer with thickness h.

$$s = h\frac{n - n_s'}{1 - n_s'}. \tag{1}$$

On the border of shrinkage porosity is:

$$n_s = \frac{w_s \cdot \gamma_s}{\gamma_w + w_s \cdot \gamma_s}. \tag{2}$$

Ifwe combine these equation and the expression of settlement we obtaine:

$$s = h\frac{\gamma_s \cdot (w - w_s')}{1 + \gamma_s \cdot w} \Rightarrow s = h\frac{\gamma_s \cdot \Delta w}{1 + \gamma_s \cdot w}. \tag{3}$$

The lowest soil moisture is on the surface, gradually increases in depth, while the depth to which affects drying h, moisture is constant.

Occurrence and slope slidings characteristics. Numerous slope slidings appeared within a short period of time and that was remembered for number and speed of slidings. Slidings were spotted on different places, and the most common appearance and greatest damages were on roads. Immediately after visual oversight of slidings examinations have began to determine the reasons of its occurance in such a short period of time i.e. Mostly they appeared within the month of june 2006, more precisely, the last two days of june.

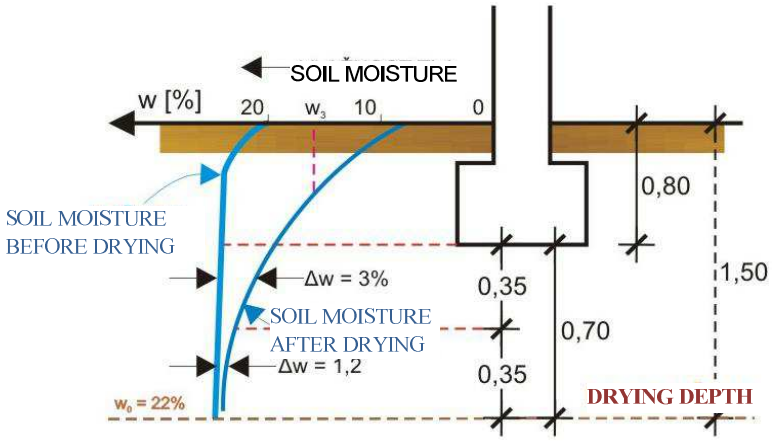


Fig. 5. Settlement of a foundation due to droughts

The first thing to do was to examine the precipitation quantities in the last several years measured in the local weather stations. It immediately became clear that the precipitation was constant during winter and spring months and in noticeably heavier comparing to recent years. The year was extremely watery, with dizzle and snow meltingwatering the soil that led to maximum saturation after winter. It is logical that in this rainy period water perspiration from the soil was minimal.

Final culmination after all those negative circumstances (for slope sliding) within the month of June heavy raining (cca. 150 mm of height) happened. Last two days of May had 35 mm. That peek was the moment when fast slidings with the speed of 1m/h were visually obvious (slipping).

On the roads shifts even larger than 1 m occurred, and in some extreme cases more than 10 meters. Slidings happened after and during heavy raining. Road slidings were most common on the curves. The sliding upstarted on the most curved part of the road where overflow of surface water from upper to lower road sections (i.e. from upper to lower part of hill slope) happened.

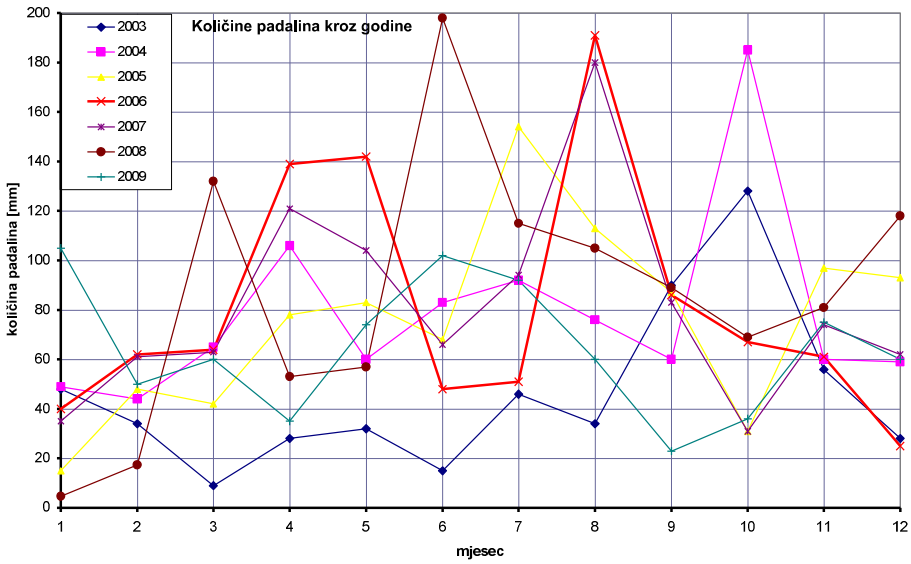


Fig. 6. Precipitation level trough years 2003 – 2009

Landscape is quite diverse, with lowlands, slightly sloped terrain, sloped terrain, considerably sloped terrain and steep terrain, meaning from 0 to 55 degrees.

Road building, over the obstacles: erosion gutter, ravine, gullies, i.e. occasional water torrents as well as rills, was obligatory on those soft grounds that are sensitive to creeping and sliding. That means that needed hydrotechnical drainage elements are of different categories.

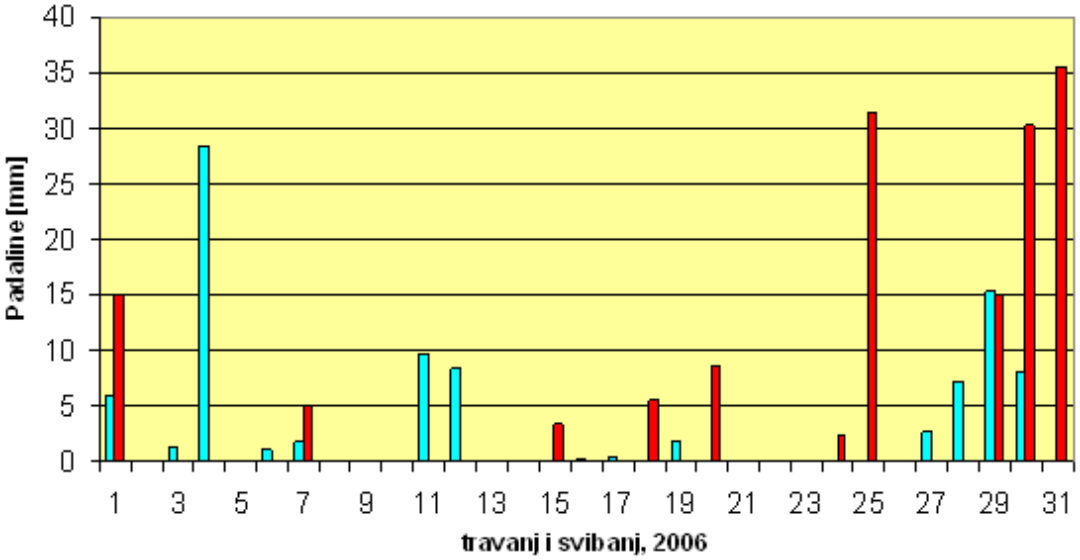


Fig. 7. Precipitatin level throughout April and May 2006

Conclusion. Increase or decrease the water level under the construction greatly affects the construction, and sometimes leads to a rapid settlement or uplift, depending on the type of soil on which the constructon is built. Swelling and shrinkage of soil (due to drying) may have consequences in which construction is damaged (cracking).

Apart from the water early in the design of constructions should take consideration of the terrain morphology, location of future constructions, and especially the type of soil, because they do not respond equally to water saturation or the drying out.

This text can be used as a remark in the design, rehabilitation design and especially in forensic identification and clearance causes of construction damage.

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Надійшла до редакції 09.10.2013