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EXCESS MOISTURE - A MAJOR REASON WHY PRODUCING LANDSLIPS

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Abstract

The soil is a porous medium with variable physical time and space that determine certain features of the mass of water flow. Sometimes these features prevent the formulation of mathematical laws describing these processes, requiring approximations of the physical process. For this reason, the approach to water movement through saturated soil to drain requires simplification actual physical processes and how they can be expressed by means of contemporary knowledge. This paper refers to a study on the factors and measures to combat a natural hazard. Natural hazards are several ways, and occur in different circumstances, but this paper will present the production conditions of landslides and methods / measures to combat them. It is known that excess moisture is one of the triggers of landslides. Also, to halt and prevent these natural disasters, various measures are necessary. Besides the determinants of a landslide, the study presents some of the measures against landslides, focusing on the drainage method. Water flow through saturated soil for drainage is a case of plane- parallel motion of fluid particles moving in transverse planes against the perpendicular axis of drainage.

Key words: *landslide, natural hazard, drainage horizontal, hydraulically conductivity, porous environment, excessive humidity*

INTRODUCTION

Landslides are movements of the rocks that form the sides of mountains, hills, embankments or other hydrological works built by people.

Rock movements may occur along the side slope and, as a result of natural phenomena or due to human activity [9].

Landslides leaks and damage not as big as other disasters, but they are dangerous and may lead to the destruction of buildings by moving the rock layer or coating.

Also, landslides can bar the course of rivers, creating lakes temporary or permanent, can produce even destruction of dams by forming a strong wave on entering the lake, suddenly a large rock. [6]

Landslides are a class of natural risk phenomena that define the movement, the movement itself to rocks or deposits on the slopes and the resulting landform. [11]

Typology of landslides Romania

Genetic peculiarities, geological conditions and triggers, for triggering dynamic specifics, activation, reactivation, dynamic stabilization, massiveness and depth of the masses of slippery material, morphogenetic aspects, terrestrial elevation, relief gear that focuses outburst etc., could lead to the possibility of the individualization and typing the specific forms of relief in Romania.

Such features are criteria for defining some types of landslides which dislocated mass of material [12]:

- Superficial landslides, which often involves materials with slope surfaces exceeding approximately 5 degrees (for easy labile materials) and 10-15 degrees when deposits on the slopes and connecting surfaces become wet harder and their dislocation is slower.
- Slips deep (depth) define outbursts of land which causes deposits and rock in place on a section of frequently exceeding 2-5 m depth, reaching even tens of meters. The deeper slips in certain regions are consistent with the so called "massive" slides, which can affect relatively large peak and hilly areas. The reasons why specific slides have such a potential are their size, in terms of length, their resistance to long and repeated reactivation which lead to the creation of

other types of slides. They meet and support role for other categories of genetic manifestation of geomorphological processes (and possibly a different geomorphological) the emergence of other forms of relief, etc.

In this context, the paper aimed to present the determinants of landslides and also some of the main methods/measures to combat them focusing on the drainage method.

MATERIALS AND METHODS

This paper is based on an analysis of factors that determine a natural disaster, a landslide default and measures to combat it.

Methods or measures against landslides are different depending on the triggers that caused natural hazards.

A selection of the control and prevention measures against landslides is presented in this study, namely: to remove the excess water from the slopes, the drainage of surface water and groundwater, the horizontal interception drainage, horizontal drainage, horizontal drainage and systemic stabilization using vegetation improving the physical and mechanical properties of rocks, etc.

And in particular, the main measure to fight against landslides and eliminate the excess is water drainage.

RESULTS AND DISCUSSIONS

Excess moisture, paradoxically manifests itself on slopes, especially on the slopes of the wetter areas with weak soil and low permeability of the lithological substrate, with a weak internal or external drainage.

Excess moisture is located on the slopes, having as source stagnant waters in lowland areas, coastal springs that occur on the slopes and concentrated waters from the slopes. [4]

Excess moisture on slopes is usually more damaging than on flat land, because most times it is a potential factor for triggering landslides.

On the other hand, although they occupy smaller areas, spreading their prints scattered on a uniform dampening effect of excess moisture manifesting larger areas on which agricultural operations are hindered or delayed.

The areas with excess moisture on the slopes are met in the Transylvanian Basin, the North of Moldova and the Carpathian hills, in the springs of the coastal land area and this means approximately 230,000 hectares [4].

Removing the excess moisture and combat landslides are more commonly used than soil erosion.

To establish measures to prevent and combat excess moisture on the slopes is necessary to study the natural environment of the area, to clarify the causes of waterlogging, the determinants of its manifestations and the damage it causes. Sloping land is characterized by a greater geomorphological, lithological and hydrogeological variation, and requires some further studies, especially topographical, pedo-lithological, hydrogeological and geotechnical studies. Hydrological studies must address and specify the characteristics of the aquifer, groundwater piezometrical elevation, groundwater drainage lines, on the slopes knowing that groundwater does not drain evenly.

For the geotechnical characterization in terms of the area it is needed to make a profile for the first waterproof layer, stating the nature, depth and slope waterproof layer overlays and hydraulic conductivity. [4]

Classification of landslides

Due to the large number of factors and combinations of these factors, a large variety of landslides could appear.

Among the many criteria that led to the classification of these phenomena over time, one can mention the following ones: [10]

-depth slip - is one of the main characteristics of landslides, it is found that the depth of the rupture zone could lead to the development of the sliding surface in relation to land area. The landslides classification depending on the maximum depth is presented in Table 1.

Table 1. Classification of landslides depending on the depth of their occurrence

Type of slip	***Depth H_{max} = [m]***
Sliding surface	$H_{max} \leq 1m$
Shallow landslides	$1m < H_{max} \leq 5m$
Deep landslides	$5m < H_{max} \leq 20m$
Very deep landslides	$H_{max} \geq 20m$

Source: [10]

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-***sliding speed*** is the speed of the mass of earth sliding down (Table 2).

Table 2. Classification of landslides depending on the speed of sliding

Type of slip	*Speed v = [m/s]*
Sliding extremely fast	v > 3m/s
Sliding very fast	3m/s ≥ v > 0,3m/min
Moderate slip	0,3m/min ≥ v > 1,6m/ month
Slow slip	1,6m/ month ≥ v > 1,6m/year
Very slow slip	1,6m/year ≥ v > 0,006m/year
Extremely slow slip	v ≤ 0,006m/year

Source: [10]

-***direction of evolution process of sliding*** - depending on the direction in which the sliding phenomenon evolves towards the accumulation slip away, there are: *sliding detrusor* (progressive) and *move slides* (regressive);

-***position related to the sliding surface slope or slope stratification*** - according to this criterion, landslides can be: *consistent*, *in-consistent* (about a landslide, that is oriented in the layers tilt) and *a-consistent*;

-***landslides age*** - this criterion takes into account the time elapsed from the occurrence of slipping and stage activity. Thus, landslides can be: *current or active landslides* and *mudslides old or discharged*;

-***moving-mass movement*** - is how the moving-table moves. As a result, depending on the character of movement, landslides can be: *sliding rotational* and *translational slides*;

-***nature of the material to be slipping*** - landslides may affect the structure's natural slope or may reactivate old body slumps. So, they are divided into: *sliding – first order* and *second-order slides*;

- ***a distance that slipped through the material*** - depending on the feature, landslides include: *proper sliding* and *sliding type flow field*.

The slide includes three phases [9]:

-preparatory phase, slip slow early (ante-threshold processes);

-slipping proper (crossing the threshold geomorphology);

-natural stabilization (balancing processes post-threshold)

In the case of conventional processes, typical landform is defined by [4]:

-ditch detachment,

-slip body,

-head slipping and

-sliding surface.

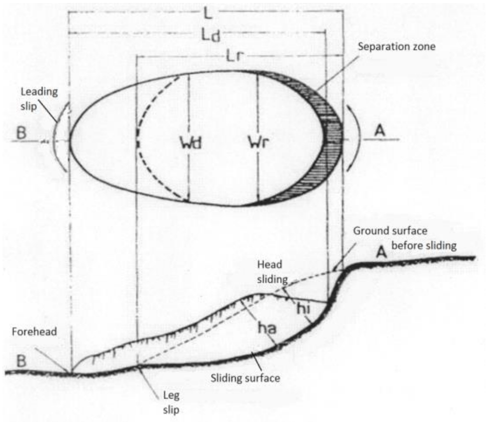

Fig. 1. Main morphometric characteristics of a landslide
Source: [4]

Causes, manifestations and determinants of excess moisture on the slopes

Like the flat land, on the slopes the excess moisture comes from precipitation and groundwater sources. Rainfalls influence excess moisture by volume, intensity and time they fall.

Groundwater is the main source of excess moisture on slopes because the manifestations are more varied, influenced by their succession, tilt and features of layers. Excess surface moisture coming from rainfalls is manifested by over-wetting or ponding of water in the depression areas on hillsides and slopes sloping uneven area sudden switch from a steep slope to a small or a stretch of level ground. Excess moisture groundwater or springs over-wetting manifests itself in the following situations: to change the slope that leads to the decreasing permeable coating thickness; the sudden change in a positive sense, the slope layer waterproof base and thus in the same direction and the groundwater; the slope contact with the ground plane, which can have the effect of decreasing the occurrence of the coating and groundwater; at the intersection with aquifers slope [4].

Waterlogging caused by sources must be analyzed separately as it has various characteristics. By spring, the groundwater reaches the surface. Depending on the geological situation and the force that causes water, the sources differ downward or upward gravity and springs. Downward springs are the most common and come from aquifers. The water in these layers has a downward movement, the infiltration and to output, under the action of gravity. This includes springs from descending layer of the valley, terraced, scree, and alluvial cones. Descending layer springs come from aquifers between two impermeable layers. They appear to date only in situations when the aquifer is intersected by the action of erosion of rivers. Descending springs occur frequently in the slopes of the valley. Some valleys appear as lines sources [4].

Appear at the bottom springs terraces with permeable contact between deposits of waterproof. The springs are characterized by an upward movement of water through aquifers, first descending line, and then, until they reach the surface, have an upward trend. Water circulation area is under the influence of pressure standpipes. The main causes of excess moisture on the slopes can be of geo-morphological, pedological and anthropogenic nature [5]. Geomorphology of the terrain, the presence of some form of negative or flat micro-relief by changing the slope local land, water and favors accumulation of excess moisture appearance. The soil favors the appearance of excess moisture in the presence of horizons or waterproofing layers with differing permeability, which prevents infiltration and movement of water in the soil and subsoil, or the presence of a vertical horizon surface or substrate show that wetting and swelling clays type montmorillonite greatly reduces its permeability [5]. Man, through erosion control, works to retain water on slopes (waves and channel level) by updating the areas with excess moisture groundwater or springs by terracing slopes lands with internal drainage unsatisfactory, may favor the emergence of excess moisture.

Factors that lead to landslides

Landslides around the globe are responsible for producing significant damage, in terms of both human lives and material side. It is well known that these phenomena with devastating influences unfavorably, both human life, with adverse implications for economic and environment, affecting fauna and flora.

The complexity and myriad forms in which these phenomena can occur is due to the many factors that determine the onset.

The causes of landslides are a consequence of actions duration caused by external factors, acting on slopes or embankments. These factors can be *natural* or *anthropogenic*. Most often, failure occurs because cumulating effects on the mass of the earth. [10] [1].

Natural Factors

Natural factors may be divided into three subcategories: *climatic and meteorological factors, natural biotic and mechanical factors. Weather-climatic factors* are most important in any form: precipitation, temperature, freeze-thaw phenomenon, the effect of wind, drought, etc. Of all these factors, climatic-weather, precipitation, either as water or as snow, they are responsible for causing the highest number of landslides. Water from this phenomenon comes to seep into the ground, influencing the flow and direction of groundwater flow, with negative consequences on the stability of the slope lands.

For example, homogeneous clays and forces that occur as a result of water infiltration, causing the formation of slip planes at great depths. This is actually normal due to the reduction effort, which is caused by water infiltration, or forces that up, facilitating increase in volume along the slip plane, even if the weight of the upper layer is greater.

Pore water pressure should not be seen merely as a factor that reduces the total unit effort. Many landslides are lamellar due to the presence of water in massive shows. The first rupture does not occur at the base of the slope but at a point where the water comes to the surface massif. Then produce movements of blocks of land being covered springs, and thus obstructed the free discharge of water, soak the ground.

Slips caused due to development of a strong-pressure groundwater at the contact zone of the lower strata more permeable layers with low permeability is manifested by a rapid propagation of surface breaking. The emergence of new cracks is a matter of hours, fragmenting the land surface into large blocks stretching, even if the inclination massive ground is relatively small. [10], [2].

Biotic category includes the presence or absence of vegetation growth of microorganisms that can lead to chemical transformations, with the possibility of electric potential between the layers and increasing gas pressure in the pores and the nature of vegetation.

Natural mechanical factors are extremely varied and are consistent with the geographic area of the site which shows the potential of slipping. In the category of these factors include: erosion, abrasion, suffusion, of natural causes explosions, earthquakes, volcanic eruptions, etc. [2], [3], [12].

Anthropogenic factors

The second category of factors that may trigger landslides are human factors. They depend strictly on human interaction with the environment. These factors include: excavation activities, uncontrolled leakage of water from hydro networks that contribute to natural hydrostatic regime change, changes related to the initial purpose of using different locations, additional loads of massive ground vibrations, etc. Also in this category of factors may be included uncontrolled deforestation in Romania last year, a phenomenon that led to the conversion of large areas of safe areas and areas with potential slip.

Methods to combat landslides

These methods are different and must take into account the peculiarities and circumstances which led to the situation venue. The difficulty stabilizing the landslide is on determining exact causes and how the information can be taken necessary engineering works which is suitable for every situation.

It should be known in detail the geological structure of the mountain, meaning the hair layers front slope, the character stratifications, the inclination of the slope, tectonic area, hydrogeological conditions at the site, chemical composition and depth that is hosted hydrostatic level, details of any construction the load side and not least, the physical and mechanical properties of rocks.

Adoption of measures to stabilize the site or in certain cases, to limit the effects of the landslide must necessarily be preceded by the establishment plan slip and obviously the depth at which the phenomenon inside the slope.

Depending on all aspects of the above, that the civil engineer has to take into consideration, he chooses the optimal stabilization [10], [3], [12]:

-*Profiling slope* - can be achieved either by reducing the load acting on the upper part of the slope, either by increasing the base weight slip. Such reduction is achieved embankment slope. The advantage of such a solution is provided by the simplicity and lack of execution works very complicated, which normally use concrete.

-*Drainage of surface water and groundwater* - is highly effective, as required in most cases (if the table is made of soft rock slope) because water is the main factor that determines production slip phenomenon. Thus, by this measure to avoid damage physical and mechanical properties of the lands that make up the slope and decrease cohesion.

-*Making filters reverse to reduce the effects suffusion* (washing process and transport of fine particles of rocks loosened by the action of circulation of groundwater) - filters reverse, having a higher permeability than the land on which it protects, plays the role of collecting, draining water and hindering, also suspensions carried in stream water.

-*Stabilization using vegetation* - grassing, various plantations and reforestation measures are helpful with satisfactory effects due to preventing erosion, water absorption and avoiding the appearance of cracks in the soil shrinkage by drying the surface massif. It should not be neglected phenomenon of "reinforcement" that tree roots can have on the mountain.

-*The works of resistance* - are made in order to enhance slope stability or consolidation already produced landslides. The most commonly used are retaining walls. Another benefit of this type of work is that it provides slope erosion protection and abrasion major rivers (longitudinal walls, gabions, Fascia, etc.).

-*Use of tensioned anchors and cables* - is another solution stabilization, especially where the rocks rocky.

-All category resistance works are part and solutions involving *pilots, caissons, straps and molded walls*. These solutions offer very good results but involve high costs and difficulties can arise in execution.

-*Improving the physical and mechanical properties of rocks* aims to increase the shear strength in the massive sliding. Improvement can be made using electrical processes (electro osmosis), chemical (injection rocks with different chemicals) or thermal (burning or freezing rocks).

Influence of maximum shear strength on triggering landslides

Landslides occur both in soft rock and rocks rocky, indicating that the phenomenon manifests itself differently in the two types of rocks. Thus, unlike the hard rock, the phenomenon of slip occurs suddenly, without being preceded by some obvious signs in soft rocks and in particular clays, slipping occurs relatively slowly, showing deformation clear ground surface [9].

Mobilizing resistance to shear rock, as well as in other materials is dependent on a certain amount of displacement. By shear tests are obtained diagrams effort - which offers travel information on the maximum or peak shear strength *(tf)*, and the last or residual *(tr)* [10], [8].

Effort normal value and nature of the terrain dictates the appearance trips are necessary mobilization of the two values (peak value and the residual). When sliding surface intercepts several rocks of different nature, the safety coefficient calculation must take into account the possibility of ceding progressive. This problem is associated with the fact that the peak value of the shear strength is obtained simultaneously for all the material subject to the breaking of [10], [8].

Failure to mobilize progressive and permanent resistance to shear be taken into account when we are dealing with nature rocks rocky. Where layers are weakened, showing cracks, bear in mind that they do not show a peak, their disposal is producing as a result of relatively large displacements. On the other hand, morphometric surfaces "*fracture - fissures*" and this bridge determine the concentration of tensions, local giveaways, as a result of small displacements and mass displacement that slip jerky.

In clay rocks shear strength mobilization takes place within slips regressive disposal propagate from the bottom [10], [12], [8]. Width sliding area is strictly dependent on geological pressure that arises at the base of the slope. This interdependence of geological pressure and sliding terrace width can be represented in the form of a parable, thus moving-mass width increases with geological pressure at the base of the slope.

As previously stated, the behavior of mass moving-where the rocks were soft, highly dependent on the mobilization of shear strength. In turn, it is influenced shear strength and moisture. For this reason, most landslides were the main cause rainfall.

The friction between particles is influenced by the presence of water and adsorption complex, which leads to a lower angle of internal friction than if non-cohesive lands [8]. If we have a significant percentage of clay fractions and a high humidity, internal friction angle has low levels close to 0. The greater the content of dust and sand fractions, internal friction angle reaches 20 ° -25 °.

Earth structures influence the angle of internal friction. A flocculation-like structure will have a greater friction angle because the links between components particles, while a dispersed structure will be much lower friction [4], [8].

Soil structure and water existing in its influence and cohesion.

$$\boldsymbol{c = cw + cs + cp} \quad [4], [7]$$

where:

cw - electro-molecular cohesion (primary) generated by the action of complex adsorption and solid particle;

cs - structural cohesion (the cementation) while on cementing ties between the particles;

cp - cohesion capillary pore capillary meniscus on earth.

Primary cohesion is all the more pronounced the more complex adsorbed water is low and decreases with increasing water adsorbed cohesion. The cementation cohesion is the component of cohesion which can be defeated only by disturbing the natural structure of the land and the destruction of links between particles. This destroys the loess land easier, because the cementation bonds between particles are easily damaged by water [4], [7].

Capillary cohesion disappears with the disappearance of capillary water and often can be neglected. Thus, we can list the main causes underlying the fracture and progressive mobilization of landslides [10]:

-emergence of new successor sliding surfaces;
-differential movement of rocks along the sliding surfaces that develops;
-creep depth;
-appearance of residual stresses in the rock mass;
-gradual destruction of the mountain, and the action of water infiltration caused by frost;
-gradual redeployment of forces normal due to changes in the normal exercise of sliding along the surface;
-variation of pore water pressure in rock mass, moving-mass displacements due.

Drainage of higher quantities of water from micro-depressions exhaust directed inflow leakage shallow water on slopes and diverting streams through ditches coastal area upstream of the ditch detachment to make the reduction of displacement and, where possible stagnation / outburst halting land. It is understood that such a draining should last until the effects are found, proving slipping out of its dynamic phase, after which they may be applied and technical operations building sectors slopes risk situations being removed [4].

Horizontal drainage interception. Removing excess moisture in the mesh and cloth located to date is carried out by means of interception drainage, which is designed to intercept the water-bearing layer upstream of the cloth. Intercept drains are placed transversely to the direction of flow of the water, the upper limit of the excess of water.

For aquifer with depths up to 2-2.5 meters, drains are posing even waterproof layer, because in this case ensures a more efficient water capture. To determine the most appropriate route interception of drains will be a recognition of their route through delimitation low of the stagnant water, the vegetation study, key elements that enable knowledge of water movement on slopes. Drains will be built of stone or corrugated PVC tubes with a maximum diameter of 40-60 cm tall filter layer. Collector drains that meet only a collector will run without filtering prism. Coastal springs that appear to date is captured using drainage capture that converge in a home visit, where water when growing vineyards and orchards, is discharged through a drain collector in ponds specially designated [4] .

Horizontal drainage lands with horizontal drain excess water table is the ideal solution permanent. Water circulation on the slopes is done on certain routes; evenly distributed drainage scheme is different from flat land. Therefore will not design a systematic network of drains dense, evenly spaced, and pictured at the same depth. These lands will follow drains groundwater circulation routes, resulting in different schemes of those on flat land, as distances, lengths and depth, but the situation requires execution of a large number of homes, falls and changes in direction. Drains may be of Fascia, stone, PVC tubes, and ceramic, located at a depth of 1.20-1.60 meters. Whatever type of drain, there is a danger of warping higher than on flat land, the pad is required [4], [5].

Horizontal systemic drainage is recommended to be used when at the foot of appearing areas with excess moisture in the soil profile, on hillsides with slopes up to 8-10%. In this case, use diagrams and technical elements of flat land suitable for drainage [4].

-Existing drainage water from aquifers under the slopes can be another way of preventing movement on the slopes, thus making the possibility of lowering the degree of soaking materials and rocks that are part of them. Wells and ditches for drainage conveniently located, allowing acceptable discharge of large quantities of water. Such a process is particularly necessary for the slopes situated in the vicinity of settlements at risk of outbursts geo-morphological field [4].

Original approaches to problems of leakage through the soil to drain to determine the technical elements of planning that is presented in this paper based on a conception of modern physics, based on experience in the theory and practice of drainage.

- The leak water through the ground case is fed to the drain of the plane- parallel motion of fluid particles moving in cross-sectional planes perpendicular to the axis of the drain;
- If homogenous and isotropic media drainage process described by *Darcy 's law* and continuity equation which shows the current function;
- Analytical solutions applied in solving this problem are applicable only under certain conditions imposed on the domain geometry that studies the movement of filtrate or the values they can take debit or hydraulic conductivity;
- Solutions have the advantage that the numerical approximation can be fine as desired, which leads to accurate results.

Regarding the calculation of the distance between drains by H_{max} we obtained the following graphs and the calculation of *Hontus-Carabineanu formula* (*):

$$\frac{L}{2} = -0.7185 \cdot D + D \cdot \sqrt{0.5163 - 3.1240 \cdot \frac{k}{q}\left(1 - \frac{H}{D}\right)}$$

(m) [4].

And the calculation for determining the final distance between drains obtained has the form - *Hontus-Carabineanu formula* (**):

$$\frac{L}{2} = -0.7185 D + D\left[0.5163 - 3.1240 k\left(\frac{1 - \frac{H}{D}}{q}\right)\right]^{1/2} \quad (m)$$

[4]

where:

D - distance between the drains and impermeable layer (m)

k - hydraulic conductivity (m/day)

H - groundwater hydraulic load (m)

q - discharged by drainage flow (l/s ha)

Strengthening resistance by damming the type of massive fences and deep as their sole fixed with the mass movement of materials and exposed rocks sliding along steep. Such technical corrections are effective for medium depth and shallow landslides, if there is a high percentage of their insurance status of stability returning to the slopes with starting field [9].

Strengthening the slopes with torrential correction works (if undermining it by a watercourse) and/or walls (in the case of valley roads) [9].

Remove excess water from the slopes

Remove excess water from the slopes can be achieved by capturing and removing water from surface and groundwater flowing to the area with excess moisture and even lowering of the groundwater depression areas - thalwegs. Depending on the source of excess moisture and intensity of the event, we recommend the following disposal methods: deep loosening, drainage-mole, modeling - leveling on slopes, if excess moisture manifests short time; collection and disposal channels and shoals drain, where ponding temporary or permanent; horizontal drains of interception (capture with free cavity filled with filter material or coarse) in the case of springs in strips or over-wetting and isolated spots; horizontal drains, systematic, if over-wetting in isolated spots or "mosaic" associated with secondary measures; horizontal drainage associated with amendment if excess moisture associated with processes "salinization" sewers or drains horizontal platform for over-wetting roads or terraces; Vertical drainage catchment ponding evacuation of small depressions located in the watershed, on the slopes with risk of landslides if the situation is favorable geomorphological - free shallow aquifer [4].

The presentation methods of removing excess moisture on the slopes are of a remarkable complexity of the issues that must be considered when choosing solutions, trouble insufficiently studied the theoretical and practical in Romania.

So far, it has paid greater attention to combating soil erosion compared to remove excess moisture and preventing landslides. As a result, the arrangement of slopes when plantations were reported alive fitting errors that favored the maintenance of excess moisture and even landslides. [11] The basic principle in removing excess moisture on the slopes is related to improving water flow to surface slopes and preventing groundwater supply. Therefore, to combat erosion will not provide water retaining works, but works to foster leak interception and prevent the water supply from the slopes in a short time. The paper base is the leveling downhill slope, replacement channels coastal level and wave horizontal channel and waves inclined to be to intercept water runoff to lead them into outlets and discharge them from the slopes. The terraces will be designed to trim outlets to 1-3%. Channel coastal location will be the slope changes, limits land uses, roads, particularly in upstream areas of stagnant water.

CONCLUSIONS

The complexity and the numerous forms, where landslides may occur is due to the factors that determine the onset of the phenomenon.

The forces acting in a destabilizing effect on the massive earth must overcome this resistance, for the phenomenon to be triggered.

The foundation for premises in large slope and showing layers of fillings must be chosen so that the loads transmitted by construction can be covered properly without affecting the balance of morpho-dynamic site.

While tracking and managing controlled hydrostatic level of surface waters, the sites that are at risk of sliding is also a method that can give satisfactory results. Construction of infrastructure works may cause changes in steering and water circulation areas of surface and depth.

The original calculation formula presented in this study is able to solve some practical problems with the design or rehabilitation facilities for underground drainage and combating erosion under certain conditions.

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