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Application of Walls to Landslide Control Problems: Proceedings of Two Sessions. Amer Society of Civil Engineers, Soft Cover. Very Good / No Jacket.

Check new design of our homepage! How to Prevent Landslides - Acquaint Yourself With These Methods With recent trends showing a significant rise in the number of landslides, as well as loss of life and property attributed to them, being well-versed with different methods to prevent them can be of great help. HomeQuicks Staff Last Updated: Feb 26, While the definition of a landslide, which states that it is a slide of large mass of dirt and rock downhill, may make it seem pretty simple, a look at the aftermaths of this natural disaster puts forth a gruesome picture of the same. Whether landslides are really natural disasters, or have we humans dug our own grave? While deforestation, construction, mining, and other such causes of landslides attributed to human activities can be curbed, there also include some simple measure which can help you prevent landslides in regions wherein slopes are unstable. Landslide Threat If you stay in a mountainous region - irrespective of whether your house is located at the top of the mountain or close to its base, you are vulnerable to the problem of landslide. While the problem may vary in terms of degree from one region to another, ruling out a landslide is something that is not quite a wise thing to do. For instance, the chances of the same are even more if your region is prone to earthquakes or if some other agents of erosion - such as sea waves and wind, are continuously acting on the landform on which you have built your abode. Similarly, the chances of a slope caving in to immense pressure is high, if mining, stone quarrying, logging, and other activities are common in your region. Even land clearance for agricultural practices can cause landslides as the trees which hold the otherwise unstable soil together are cut in large numbers. Soil erosion caused by flowing water is by far the most common reason for landslides. This can include natural streams and rivulets as well as drainage from the homes which have been constructed on the hilltop, as both have the tendency to slowly erode a chunk of the slope to an extent wherein the entire slope just gives in to increasing pressure. Constructing a dwelling on a steep slope is not at all a wise option, but the fact that we are facing a severe shortage of land with increasing population has made many people opt for the same. As we mentioned earlier, soil erosion is one of the most common reasons of landslides, and therefore preventing it can help you reduce the risk of landslides by a significant extent, if not eliminating it all altogether. Prevent Soil Erosion The foremost thing to do is to divert the discharge water away from slopes by constructing gutters and using sandbags. If there is no scope for diverting - especially in case of natural sources of water, you can contain its speed by building small dams; so as to ensure that the amount of erosion is in check. The velocity of water determines how much soil is eroded, and hence containing its speed is bound to be helpful. It is important to make sure that you divert or contain the water flow - and not stop it altogether, as stopping it will result in pressure build-up over a period, which might give in at one point of time. Never redirect storm drain or street gutter down a slope, even if it seems to be an easy way out. Instead you can use flexible pipes and divert this water in a safe manner. Plant Vegetation Yet another simple way to prevent landslides is to plant trees and small shrubs on the slope. As these trees and shrubs grow, their roots hold soil together, and help in reducing erosion of soil which is likely to make the slope unstable in course of time. In fact, there exist quite a few species of plants with shallow roots which are specifically used to protect the top layer of the soil in mountainous regions. You can inquire about these plants in the nursery in your neighborhood, and plant them along the slope. Retaining Walls Retaining walls can also be of great help, but only when you make sure that you construct them properly. You can resort to one of the different types of retaining walls available on the basis of geology of your region. While a concrete retaining wall is an ideal option, a wooden retaining wall or a crude stone retaining wall will also work fine. Similarly, building a sea wall will be an ideal option if the landform in question is subjected to sea waves. Altering the Slope Gradient If possible, you should opt for grading of the slope - wherein you remove the material from upper part of the slope and put it near the base and reduce its gradient. As it is a bit tricky task, it would be wise to get help from someone who has a professional expertise in such work. At the same time, you should refrain from resorting to activities like digging and piling garbage on unstable slopes - both of which happen to be possible triggers of a landslide. While these measures are helpful in reducing the overall risk involved, it is not possible to rule out the occurrence of these natural disasters, even after taking all these precautionary measures. There exist several natural causes of landslides, including tectonic movements, ground water, snowmelt, etc.

Chapter 2 : Application of Walls to Landslide Control Problems

Geologic aspects of landslide control using walls / by Robert L. Schuster and Robert L. Flemming The analysis of wall supports to stabilize slopes / by Norbert R. Morgenstern Evaluation of landslide properties / by Dwight A. Sangrey.

This document was prepared by the staff of the California Coastal Commission to discuss techniques which may eliminate or reduce the adverse effects of grading along the California coast. This report has not been approved by the Commission. Unfortunately, grading often results in negative alteration of the environment. Visual degradation caused by grading is often dramatic in mountainous areas and along coastal bluffs where flat areas have been created by grading. Grading may also disturb the natural habitats of plants and animals in areas on or near a project where grading occurs. The large areas of exposed earth at sites where grading has occurred can lead to increased erosion and siltation, as well as shifts in depositional areas. Changes in sedimentation rates and patterns can result in contamination of surface and groundwater systems, which in turn may result in lower quality of public drinking water as well as pose a threat to the stability of an environmentally sensitive habitat. Although some grading is required for most construction projects, the California Coastal Commission is concerned about unnecessary or excessive grading and its effects on the coastal environment. Various designs and construction techniques exist to lessen the extent and effects of grading. Figure 1 illustrates the key steps in project planning and development where grading can be reduced. Even with carefully planned development, most sites will require some grading. Engineered structures used often in conjunction with drainage controls may be used to stabilize slopes and allow construction with minimal grading. The method of stabilization is chosen based upon evaluation of the type of hazard involved, magnitude of the problem, potential triggering mechanisms, threat to life and cost. The primary focus of this paper is on the various engineering techniques to stabilize a site with minimal landform alteration. This discussion is not intended to replace professional site inspections or designs by engineering geologists and civil engineers. The techniques discussed here should be considered only after all planning and design options have been exhausted. It also must be recognized the some hazards cannot be mitigated sufficiently to make a site safe for development because the environmental or engineering costs of the mitigation are too high, or, in some cases, because no solution currently exists. Furthermore, not every site can support the same scale and intensity of development, so even if a site is developable, it might not be suitable for a specific project. The issues of land use and site planning will not be discussed in this paper; however, these issues have a very direct and obvious impact on grading and the level of landform alteration required for project development. However, many locations have one or more development constraints and even with the most innovative site designs, some slope modifications will often be required and engineered structures may be needed to make a site suitable for development. There are many engineering techniques to solve stability problems, all of which require varying degrees of natural terrain alteration. The method of stabilization is chosen based upon evaluation of the type of hazard involved, magnitude of the problem, potential triggering mechanisms, threat to life and property, and cost. Effective stabilization methods should only be determined after an evaluation of geologic and hydrologic conditions is completed by a certified engineering geologist and a registered professional engineer. Slope alteration as a method of stabilization commonly involves variations of the cut and fill technique. The most common technique used to stabilize slopes is a buttress fill Figure 2. Buttress fills are used to stabilize poorly consolidated or incompetent bedrock, and have been used frequently for the relatively weak sedimentary formations in southern California. A typical compacted fill buttress is constructed by removing the outer face of a cut slope and replacing it with engineered, compacted fill. The buttress fill mass is designed specifically to retain the slope behind it, usually with a factor of safety of at least 1. Such a buttress is "keyed" into competent underlying materials to provide adequate support. Key widths along the toe of slope typically range between 15 and feet. Buttress fill slopes are generally constructed with a finished grade of 2: Rather, the fill is constructed along a slope face to mitigate surficial slope failures, such as ravelling, erosion and rockfalls. The base width of stabilization fills is commonly half the height of the slope. Buttress fills involve large amounts of grading and disturb large areas during construction. Earth removal and, the sharp, unnatural lines of a finished buttress slope are apparent when compared to the irregular contours of more natural landforms. Contour grading can be used to reduce the visual impacts of the graded areas by designing the finished slope face to more closely conform to natural contours. Contour grading does not reduce the quantity of grading, but can create rounded or undulating landforms designed to resemble the unaltered slopes on and adjacent to the construction site. The Department of Planning for the City of Los Angeles has prepared planning guidelines for contour or landform grading, which were adopted by the City Council City of Los Angeles, These guidelines are also used in some neighboring communities and in portions of Los Angeles County. Aside from aesthetic impacts, earth exposed during the construction of a buttress can cause accelerated erosion and siltation when drainage and soil retention methods are not utilized during grading. Sheetwash and gullying remove soil from exposed slopes as drainage patterns develop within the slope and along low-lying areas at the base of the slopes, resulting in extensive siltation at adjacent locations. However, utilization of proper erosion control methods e. Water control is generally maintained through installation of surface and subsurface drainage devices within and adjacent to potentially unstable slopes. Surface and subsurface drainage design must include consideration of the effects of surface runoff and groundwater migration on the stability and water quality of adjacent sites Powers, ; Gedney and Weber, In landslide areas drainage design is especially important because an influx of water from irrigation, disposal of sewage effluent or leaks from water storage devices can raise groundwater levels, increase pore-water pressure, and load slopes, thus causing an increase in failure potential Broms and Wong, Control of surface and groundwater flow is also important in minimizing erosion and siltation both on and off site. A properly designed drainage system should increase slope stability and decrease erosion and siltation. Drainage control is particularly important in bluff top stabilization along the coast. Bluff top stabilization is often best attained by designing final site contours that direct surface water away from the bluff to storm drains Kuhn, Designing a surface contour that directs water away from the bluff results in reduced infiltration and groundwater recharge in areas adjacent to the bluff, thus reducing the risk of bluff failure. Runoff and infiltration of water along a slope or over a bluff face can often be reduced by planting vegetation on top of the slope or bluff, as certain types of vegetation anchor soils, which in turn reduces erosion. A vegetative cover that does not require irrigation must be chosen because the infiltration of the water from irrigation can result in increased failure potential. However, vegetation is ineffective in stabilizing slopes where movement has already begun, so in many situations, vegetation cannot be used as the sole stabilization method. Surface drains are instrumental in controlling erosion of slopes and in drainage control adjacent to fill slopes. The most common surface drainage devices used in prevention of slope erosion and failure are terrace drains. Terrace drains are commonly 3 to 5 feet wide, 18 inch deep, V-shaped structures that are paved with 3 inches of reinforced concrete or gunite. A problem with terrace drains is that often they are left exposed, which degrades the aesthetics of a hillside. This can be minimized by concealing the structures with vegetation. Pipe drains buried at the surface can perform the same function as terrace drains, but are not advised because buried pipes often get plugged and drainage control is hindered. Terrace drains also get clogged by debris and drains are effective only if they are periodically cleaned and maintained. Surface water control on sites that are already developed may require construction of drains or repaving of areas such as parking lots or accessways to direct water away from slopes or a bluff. However, at many sites, construction or reconstruction of water control devices may not be possible without reducing the stability of the bluff face. In these situations, the only available drainage control may be to contain and redirect runoff over the face through channels or piping that extend to ocean at the toe of the slope. If conduits are used to divert runoff, they must be maintained regularly and replaced immediately should a leak develop. Subsurface Drainage Systems Stability of a slope generally increases with decreased seepage, pore-water pressure, and slope weight, all of which may be achieved with installation of subdrains Gedney and Weber, The main functions of subdrains are to remove subsurface water directly from an unstable slope, to redirect adjacent groundwater sources away from the subject property and to reduce hydrostatic pressures beneath and adjacent to engineered structures Scullin, Many slopes cannot be effectively dewatered and therefore, this technique cannot be applied everywhere. An important consideration in design of all drainage systems is short and long term maintenance. Over time drainage systems can clog; pipes can corrode or rupture, and other problems can arise which would prevent the system from functioning properly. Such problems can counter or diminish the beneficial effects of the drainage system, possibly leading to slope damage or failure, structural damage or the need for extensive remedial grading. The described drainage systems are generally installed along with other mitigation devices to increase slope stability. The methods outlined in this section require various amounts of grading, however, the included techniques generally result in less landform alteration than does cut and fill. The differences in grading and degree of landform alteration are generally reflected in the installation method and the size of a particular engineered mitigation device. This section includes descriptions of the effective applications, limitations, installation, and maintenance of various engineering devices. Ground Inclusions A ground inclusion is a metal bar that is driven or drilled into competent bedrock rock which is not highly fractured or broken up to a provide stable foundation for structures such as retaining walls and piles, or to hold together highly fractured or jointed rock. Ground inclusions can be used at times as alternatives to the foundation piles which are typically used to support structures within mountainous or steep areas. The size and thickness of a retention system can also be diminished by using a system stabilized with inclusions Juran and Elias, Elimination of deep foundations and a reduction in required size of a support structure make the use of inclusions an important method in reducing grading and minimizing visual impacts of a project. Three common types of ground inclusions are ground anchors, soil nails and rock bolts. Permanent ground anchors are tendons which are placed in competent rock or soil to control displacements and provide vertical and lateral support for engineered structures and natural slopes Juran and Elias, Anchors are frequently used in waterfront structures and to tie-back retaining walls to prevent failures due to rotational loading or failures due to buoyant forces of water. Soil nailing is a soil reinforcement technique that places closely spaced metal bars or rods into soil to increase the strength of the soil mass Broms and Wong, Figure 4. Soil nails are either installed in drilled bore holes and secured with grout, or they are driven into the ground. The soil nails are generally attached to concrete facing located at the surface of the structure. The function of the facing is to prevent erosion of the surface material surrounding the soil nails, rather than provide structural support Broms, This facing can be constructed to mimic the look of the surrounding landform and provide spaces for vegetation; however, the facing will not be the same as the existing top soil. Soil nailing is a method that can be used to control shallow landslides. In these situations, movement is controlled by inserting 15 to 30 mm bars in drilled holes, generally spaced 2 meters apart, which are then filled with grout. The bars must extend beyond the failure zone into stable rock, and are typically between 3 and 10 meters in length Broms and Wong, Rock bolting is a method of securing or strengthening closely jointed or highly fissured rocks in cut slopes by inserting and firmly anchoring a steel bar in predrilled holes that range in length from less than one meter to about 12 meters Bates and Jackson, Figure 5. Rock bolts generally have heads that expand following installation and are classified according to their method of anchorage: Like soil nails, these bolts generally are attached to some type of facing. Limitations and considerations for the use of ground inclusions are usually in the area of long term stability. Metal inclusions are generally protected from corrosion by a sealant or grout; however, in environments where there is frequent interaction with groundwater, breakdown of inclusions is accelerated. Also, the effects of creep on the structural integrity of a wall or other anchored systems must be considered in the design of a structure Juran and Elias, There are specific soil liquidity and plasticity limits that are not suitable for the use of anchors Cheney, Construction above the anchors may be limited, and excavation would undermine the stability of any anchors present Cheney, Piles Piles are long, relatively slender columns positioned vertically in the ground or at an angle battered used to transfer load to a more stable substratum. Piles are often used to support or stabilize structures built in geologically unstable areas.

Chapter 3 : ATTACHMENT 3: Overview of Engineering Techniques to Reduce Grading

*Application of Walls to Landslide Control Problems: Proceedings of Two Sessions [Nev.) ASCE National Convention (Las Vegas, R. B. Reeves, American Society of Civil Engineers Committee on Earth Retaining struc] on calendrierdelascience.com *FREE* shipping on qualifying offers.*

Shotcrete[edit] As defined by the American Concrete Institute , shotcrete is mortar or concrete conveyed through a hose and pneumatically projected at high velocity onto a surface. Shotcrete is also called spray-concrete, or spritzbeton German. Drainage[edit] The presence of water within a rocky hillside is one of the major factors leading to instability. Knowledge of the water pressure and of the runoff mode is important to stability analysis, and to planning measures to improve hillside stability. Hoek and Bray provide a scheme of possible measures to reduce not only the amount of water, which is itself negligible as a cause of instability, but also the pressure applied by the water. The proposed scheme was elaborated taking three principles into account: Preventing water entering the hillside through open or discontinuity traction cracks Reducing water pressure in the vicinity of potential breakage surfaces through selective shallow and sub-shallow drainage. Placing drainage in order to reduce water pressure in the immediate vicinity of the hillside. The measures that can be achieved to reduce the effects of water can be shallow or deep. Shallow drainage work mainly intercepts surface runoff and keeps it away from potentially unstable areas. In reality, on rocky hillsides this type of measure alone is usually insufficient to stabilise a hillside. Deep drainage is the most effective. Sub horizontal drainage is very effective in reducing pore-pressure along crack surfaces or potential breakage surfaces. In rocks, the choice of drain spacing, slope, and length is dependent on the hillside geometry and, more importantly, the structural formation of the mass. Features such as position, spacing and discontinuity opening persistence condition, apart from the mechanical characteristics of the rock, the water runoff mode inside the mass. Therefore, only by intercepting the mostly drained discontinuities can there be an efficient result. Sub horizontal drains are accompanied by surficial collectors which gather the water and take it away through networks of small surface channels. Vertical drainage is generally associated with sunken pumps which have the task of draining the water and lowering the groundwater level. The use of continuous cycle pumps implies very high running costs conditioning the use of this technique for only limited periods. Drainage galleries are rather different in terms of efficiency. They are considered to be the most efficient drainage system for rocks even if they have the drawback of requiring very high technological and financial investment. In particular, used in rocks this technique can be highly efficient in lowering water pressure. Drainage galleries can be associated with a series of radial drains which augment their efficiency. The positioning of this type of work is certainly connected to the local morphological , geological and structural conditions. Geometry modification[edit] This type of measure is used in those cases in which, below the material to be removed, the rock face is sound and stable for example unstable material at the top of the hillside, rock blocks thrusting out from the hillside profile, vegetation that can widen the rock joints, rock blocks isolated from the joints. Detachment measures are carried out where there are risk conditions due to infrastructures or the passage of people at the foot of the hillside. Generally this type of measure can solve the problem by eliminating the hazard. However, it should be ensured that once the measure is carried out, the problem does not re-emerge in the short term. In fact, where there are very cracked rocks, the shallower rock portions can undergo mechanical incoherence, sometimes encouraged by extremes of climate, causing the isolation of unstable blocks. The measure can be effected in various ways, which range from demolition with pick axes to the use of explosives. When explosives are used, sometimes controlled demolition is needed, with the aim of minimising or nullifying the undesired effects resulting from the explosion of the charges, safeguarding the integrity of the surrounding rock. Controlled demolition is based on the drilling of holes placed at a short distance from each other and parallel to the scarp to be demolished. The charge fuse times are established so that those at the outer edges explode first and the more internal ones successively, so that the area of the operation is delimited. Protection measures[edit] A boulder catching net on a trail at Multnomah Falls , Oregon, USA, erected to protect hikers from debris falling down the steep incline. The protection of natural and quarry faces can have two different aims: Protecting the rock from alteration or weathering Protecting infrastructure and towns from rockfalls. Identification of the cause of alteration or the possibility of rockfall allows mitigation measures to be tailored to individual sites. The most-used passive protection measures are boulder-gathering trenches at the foot of the hillside, metal containment nets, and boulder barriers. Boulder barriers are generally composed of suitably rigid metal nets. Various structural types are on the market, for which the manufacturers specify the kinetic energy of absorption based on an elemental analysis of the structure under projectile collision conditions. Another type of boulder containment barrier is the earth embankment, sometimes reinforced with geo-synthetics reinforced ground. The advantages of such earthworks over nets are: Geometry modification[edit] The operation of re-profiling a slope with the aim of improving its stability, can be achieved by either: Lowering the angle of the slope, or Positioning infill at the foot of the slope Slope angles can be reduced by digging out the brow of the slope, usually in a step-wise fashion. This method is effective for correcting shallow forms of instability, where movement is limited to layers of ground near the surface and when the slopes are higher than 5m. Steps created by this method may also reduce surface erosion. However, caution is necessary to avoid the onset of local breakage following the cuts. In contrast, infill at the foot of the slope has a stabilising effect on a translational or deep rotational landslide, in which the landslide surface at the top submerges and describes a sub-vertical surface that re-emerges in the area at the foot of the slope. The process of infill at the foot of the slope may include construction of berms, gravitational structures such as gabions , or reinforced ground i. The choice between reducing the slope or infilling at the foot is usually controlled by location-specific constraints at the top or at the foot of the slope. In cases of slope stabilisation where there are no constraints usually natural slopes a combination of slope reduction and infilling at the foot of the slope is adopted to avoid heavy work of just one type. In the case of natural slopes the choice of re-profiling scheme is not as simple as that for artificial slopes. The natural profile is often highly irregular with large areas of natural creep, so that its shallow development can make some areas unserviceable as a cutting or infill point. Where the buried shapes of older landslides are complicated, depositing infill material in one area can trigger a new landslide. When planning this type of work the stepping effect of the cuts and infill should be taken into account: It is very important to ensure that neither the cuts nor the infill mobilise any existing or potential creep plane s. Usually, infilling at the foot of the landslide is cheaper than cutting at the top. Moreover, in complex and compound landslides, infill at the foot of the slope, at the tip of the foot itself, has a lesser probability of interfering with the interaction of the individual landslide elements. An important aspect of stabilisation work that changes the morphology of the slope is that cuts and infill generate non-drained charge and discharge stresses. In the case of positioning infill, the safety factor SF, will be less in the short term than in the long term. In the case of a cut in the slope, SF will be less in the long term than in the short term. Therefore, in both cases the SF must be calculated in both the short and long terms. Finally, the effectiveness of infill increases with time so long as it is associated with an appropriate infill drainage system, achieved with an underlying drainage cover or appropriate shallow drainage. More generally, therefore, re-profiling systems are associated with and integrated by surficial protection of the slope against erosion and by regulation of meteoric waters through drainage systems made up of ditches and small channels clad or unclad and prefabricated to run off the water collected. These surficial water regulation systems are designed by modelling the land itself around the body of the landslide. These provisions will serve the purpose of avoiding penetration of the landslide body by circulating water or into any cracks or fissures, further decreasing ground shear strength. Surface erosion control[edit] See also: Erosion control Water near the surface of the hillside can cause the erosion of surface material due to water runoff. This process tends to weaken the slope by removing material and triggering excess pore pressures due to the water flow. For defense against erosion, several solutions may be used. The following measures share the superficial character of their installation and low environmental impact. Geomats are anti-eroding biomats or bionets that are purpose-made synthetic products for the protection and grassing of slopes subject to surface wash. Geomats provide two main erosion control mechanisms: Geogrids made of geosynthetic materials Steel wire mesh may be used for soil and rock slope stabilization. After leveling, the surface is covered by a steel-wire mesh, which is fastened to the slope and tensioned. It is a cost-effective approach. Wicker or brushwood mats made of vegetable material. Very long and flexible willow branches can be used, which are then covered with infill soil. Alternating stakes of different woody species are used and they are woven to form a barrier against the downward drag of the material eroded by free water on the surface. Coir coconut fiber geotextiles are used globally for bioengineering and slope stabilization applications due to the mechanical strength necessary to hold soil together. Coir geotextiles last for 3â€”5 years depending on the weight, and as the product degrades, it converts itself it to humus, which enriches the soil. Anti-erosion Solutions Anti-erosion solutions with the use of bionets: Typical anti-erosion solutions with geomats.

Chapter 4 : The Analysis of Wall Supports to Stabilize Slopes

Application of Walls to Landslide Control Problems. The evolution of tieback restraint systems is presented. Case histories describe current practices for tieback design and construction and give examples of how the requirements were met for stabilizing specific slides.

Chapter 5 : How to Prevent Landslides - Acquaint Yourself With These Methods

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Chapter 6 : Solutions to prevent and correct landslides. | Team Renovate Official Blog

Landslide protection can also include mechanic rock applications including wire meshing, retaining walls, soil nailing and rock bolting. Retaining walls as a landslide solution Retaining walls are structures designed to restrain the soil.

Chapter 7 : Landslide mitigation - Wikipedia

APPLICATION OFWALLSTO LANDSLIDE CONTROL PROBLEMS Proceedings of two sessions sponsored by the Committee on Earth Retaining Structures of the.

Chapter 8 : How to Reduce the Effects of a Landslide â€“ World Landslide Forum

This paper reviews many of the design considerations surrounding the topic of tiedback landslide suppressor walls primarily for soils app1ications.