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MITIGATION OF SLOPE FAILURE

I. INTRODUCTION

Heavy and sustained rainfall from winter storms cause billions of dollars in property damage annually nationwide. A significant area of the City of Los Angeles consists of mountainous and hillside terrain that is subject to slope related geologic hazards, such as, debris/mud flows, rockfalls and landslides. The purpose of this information bulletin is to provide information on what to do in the event a property is damaged by slope failure.

II. HISTORY OF LOS ANGELES' HILLSIDE DEVELOPMENT AND THE GRADING CODE REQUIREMENTS

Much of the developments in the hillside areas were constructed a long time ago, with building booms in the 1920s and after WWII in the late 1940s and early 1950s. Slopes where commonly graded with very steep gradients, primarily to construct roads (see Photos 1 and 2 below). Grading regulations were not part of the building Code at that time. Roads were constructed by grading very steep slopes, many of which remain to this day. When heavy rains occurred in 1952 (which was preceded with about 10 years of drought), landslides and mud flows damaged many properties all over the hillside areas of the City. This inspired the development of the nation's first grading code requirements. Hillside development after approval of the grading ordinance in late 1952 required grading permits, the input of a soils engineer, less steep slope gradients and other regulations. The purpose of this code is to safeguard life, limb, property and the public welfare by regulating grading on private property. Concurrent with the establishment of the grading code requirements, the Los Angeles Department of Building and Safety (LADBS) established a Grading Division, which was charged with administering the new code. Subsequent revisions of the grading code required the input of engineering geologists, building setbacks from slopes, paved drainage devices for slopes, and planting of graded slopes; all by 1960.

However, through the years, Los Angeles' climate (very wet years separated by periods of drought) continued to provide hard lessons. For example, during the heavy rains of 1969 debris flows coming off nearby slopes into residential structures below caused a lot of losses. Although the risk of slope failure can never be completely eliminated, gradings code requirements have been revised over the years to achieve more resilient slope stability.

Photo 1: Steep slopes for road construction, 1923

Photo 2: Development around 1928. Note the steep road cuts.

III. GEOLOGIC HAZARDS

Landslides, rockfalls and debris flows have been a recurring problem in the City of Los Angeles. As the Los Angeles area is geologically active, with several active faults, the geologic formations of the City are quite varied in rock type and the amount they have been weakened/deformed by earthquake activity. As such, some hillside area can be susceptible to slope failure.

When the rainy season comes (October to April), most of the rainstorms are of such low intensity that they do not trigger slope failures. Some intense storms may trigger only a few failures in a "normal" rainy season. However, during heavy rainy seasons when the ground is already saturated from previous rain, even relatively short high-intensity rainstorms could cause many kinds of slope failures. Even more so if there are back to back heavy rainy seasons, or recent wild fires that have denuded the vegetation.

Here are the various types of slope failures:

1. Mudflows

The most destructive type of slope failures are mudflows, also referred to as debris flows, and soil slips or slumps (see Photo 3). These occur when soil becomes saturated from abundant rainfall on steep slopes. They usually happen without warning and can move with destructive force down to the bottom of the slope. Photo 4 shows an example of a mudflow.

The type of failure discussed above are sometimes referred to as debris flows. However, a debris flow more often refers to the phenomena when water in drainages areas pick up mud and debris from materials brought down the slope into the flow of a large drainage area. This presents a dangerous situation at the mouths of canyons where structures can be overwhelmed by huge amounts of debris

Photo 3: Typical soil slips/mudflows originating from topographic swales on steep slopes. This type of failure is particularly dangerous for rear bedrooms facing the bottom of the slope.

Photo 4: Soil slip/mudflow

2. Rock Falls

Rock falls occur where bedrock is exposed on steep slopes. Usually rock masses contain fractures and other planes of weakness that if become saturated can fail. The falling rock fragments can remain intact (remain as large pieces), or become pulverized with the start of movement. (see photo 5).

Photo 5: Rockfall from granitic rock

3. Landslides

Landslides consist of deeper slope failures that usually involve bedrock, either exposed or covered by soil. These failures are typically slower than the surficial mudflow failures described above. Some of these landslides are reactivation of ancient slides that may not have been previously recognized. While the size of these massive landslides varies, they can be quite large and extend to several properties. These larger landslides can activate after the storm event, and even after the rainy season. This is because it takes time for the rain water to percolate deep enough to where potential slide planes exist. (see Photo 6).

Photo 6: Landslide involving layered sedimentary bedrock~~, 2024~~

IV. DURING A MAJOR STORM EVENT

Landslides and debris flows are at high potential during a major storm, or even a normal or light storm during a wet rainy season. During such time, the City's Emergency Operation Center (EOC) is active and provides useful information and warnings, the EOC is part of the Emergency Management Department (EMD). It is recommended that all residents sign up for notifications at NotifyLA. The National Oceanic and Atmospheric Administration (NOAA) Weather Radio and website (National Weather Service, NWS Los Angeles Area) also provide emergency alerts.

When a damaging landslide occurs on your property, call 311 to report the damage unless it is imminent threat, in which case call 911. During a major storm, the EOC will coordinate with the LADBS to send out inspectors to assess the damage. The first priority of these inspectors is to make a rapid screening (damage) assessment and, if needed, to "tag" properties with either a Red or Yellow tag. Properties and/or structures are Red tagged if there is an imminent hazard to the entire property or structure. Yellow tags are placed when only part of the property or structure presents a hazard (see Photos 7 and 8).

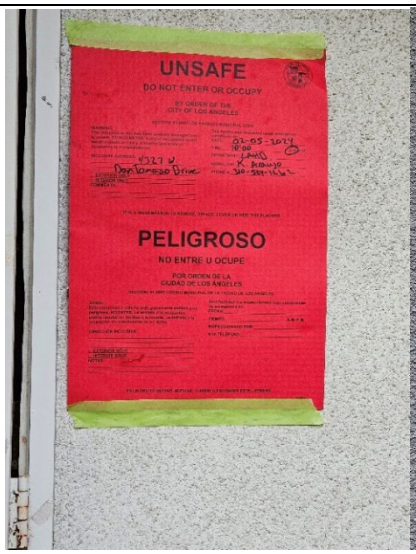

Photo 7: A red tag placed on a house assessed to be in imminent danger.

Photo 8: A yellow tag placed on a house assessed to be only a part of the property or structure a hazard

After an incident (especially if it occurred during the night), a Grading inspector and/or engineering geologist will revisit the site and perform another assessment. The tags placed may be revised, depending on what's observed at that time.

Once a slope failure is inspected by the LADBS inspector, the LADBS will send the owner a notification letter to inform the owner about the failure. The Los Angeles Municipal Code (LAMC) Section 91.7005.7 requires that all slope failures are repaired within 180 days of the notice. However, repairing a slope failure often times take time and costly resources which may take longer to complete. Requests for an extension of time are common and are usually granted.

When a property owner receives a slope notification letter from the LADBS, it is important to contact the LADBS, within 60 days of receipt, to confirm its receipt and notify the LADBS regarding the plan for mitigating the slope failure.

A slope failure can become a serious life safety issue for the property owner and the neighbors and need to be addressed. Due to the safety concerns, the LADBS will follow up with the property owner to make sure the failure is addressed and the hill is stabilized. Although the LADBS will diligently work with property owners to provide adequate time to deal with these difficult situations, ignoring the notices can result in further escalation including an Order To Comply and substandard orders especially in situations where the neighbors are concerned about their own safety.

Slope failures can be devastating to property owners and the work needed to mitigate the damage can sometime be intimidating and confusing. The LADBS will provide guidance to property owners and their consultants throughout the process whenever needed.

V. WHAT TO DO AFTER A SLOPE FAILURE

After a slope failure, it is important to follow any instructions provided by the Fire Department and LADBS especially as it relates to areas of the structure or property that are deemed to be off limits.

To repair the slope failure, the property owner will need to secure the services of a licensed consultant having expertise in geotechnical engineering, engineering geology and materials testing. The consultant may coordinate their work with other technical experts such as civil engineers and land surveyors. These consultants will analyze the slope failure and come up with proposed designs to mitigate the failure and obtain necessary grading and building permits from the LADBS. Once the permits are obtained, a license contractor will be able to commence the physical work of repairing the slope failure. During construction, the LADBS inspector will perform the necessary inspections to verify that the work is in conformance with the approved plans and the building codes.

The Department does not maintain a list of licensed geologist or geotechnical engineer and can't make a recommendation, however, you can visit the California Engineers and Licensed Surveyor website. Also, you may request a list of all applicants that submitted to the Department during the past 12 months by filing a PRA request at www.ladbs.org/services/special-assistance/custodian-of-records.

VI. SLOPE REPAIR AND MITIGATION

The types of mitigation vary widely, depending on the type and size of the failure. It could range from removing the debris from a small remote soil-slip and replanting, to reconstructing a whole hillside with grading (removal and reconstruction), with soldier piles.

Minor soils slips may be able to be repaired using the pipe and board method where the slope is too steep to leave as is, where erosion and future soil slips are still possible (see Photo 9). The LADBS may consider pipe and board methods as "remedial" because, while not discussed in the building code, they improve the site condition and won't involve building new structures, including conventional retaining walls. A permit to construct a pipe-and-board system is required.

It is common with many repair methods that drainage, erosion and other protective devices, such as concrete swales, deflection and impact walls, debris basins and debris fences are part of the mitigation. These devices need to be maintained, at least between rainy seasons. A Maintenance Affidavit is required to be recorded with the Los Angeles County Recorder's Office, where the current and future owners of the property agree to maintain the devices shown on the mitigation plans, prior to obtaining a permit.

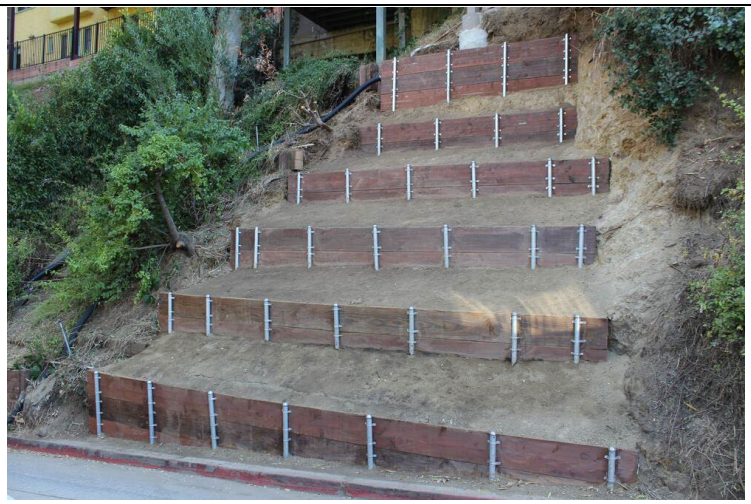

Photo 9: A surficial failure repaired using the pipe-and-board method.

Another mitigation/repair method that is not in the building code and only approved and permitted on a remedial basis, is anchored netting, where there is rock fall potential (see photo 10). This is a good alternative where steep slopes (45 degrees or steeper) cannot be trimmed to a code-compliant gradient because of property line constraints or such trimming would eliminate the building pad. This involves anchoring (with rock bolts or "soil" nails for deeper potential failures) a strong steel mesh against the slope.

Photo 10: An unstable rock slope repaired with anchored steel mesh.

To repair larger and deeper landslides, which typically involve underlying bedrock and may extend beyond any one property, requires considerably more effort. Typical mitigation involves extensive grading and/or soldier piles (reinforcing piles) including retaining walls (see photo 11).

Photo 11: A major landslide repair in progress using grading, soldier piles and retaining walls.