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HIGHWAY TRANSPORTATION AGENCY
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

LANDSLIDE PROBLEMS ON CALIFORNIA STATE HIGHWAYS

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LANDSLIDE PROBLEMS ON CALIFORNIA STATE HIGHWAYS

By

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A landslide means a variety of things to different individuals. To the average citizen a landslide, like volcanic eruptions, floods and hurricanes means some awesome and destructive force of nature that is capable of destroying life or of causing extensive property damage. Even small slides that cause closures of highways or delays to traffic evoke much interest and often raise the tempers of the travelling public. The geologist has an interest in landslides because they are one of the major factors in the sculpturing of the earth's surface. The landslide provides the geologist with an opportunity to study another facet of the earth's crust and to add to the development of the geological history of the planet on which we live. The lawyer may look at a landslide in the light of the legal complications that may need untangling in our courts. To the Highway Engineer landslide means a problem to be solved. The economics of the cost of correction or avoidance of the problem vs. the benefits to be gained by building a facility that is exposed to landslide danger is only part of the problem.

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The risk of loss of life or of property damage are serious factors that the Highway Engineer must consider. Although there is a certain amount of danger in any unstable earth or rock slope, highway landslide problems are not generally connected with protecting the lives of people from the direct danger of the moving mass. The danger to life is more apt to be by creating an additional traffic hazard that drivers may not be warned of sufficiently. More often the major immediate concern is to maintain traffic service and safety and to take remedial actions to keep the highway facility from suffering costly additional damage. Damage to adjoining property is always a concern to Highway Engineers.

During January 1965 a pickup truck driven by construction workers who were restoring flood damaged US 299 west of Willow Creek was caught in a slide. One man who was riding in the truck box was buried in slide debris. He had to be rescued by the other workers. Although there was danger of loss of life the worker escaped without injury. Yes, he was wearing his hard hat. The truck was totaled.

Undoubtedly there are numerous other incidents where deaths or serious injuries have been the result of landslides on highways. Most of these accidents in California have involved construction workers who have exposed themselves to more than normal risks. Generally, landslides on highways are not a great threat to large numbers of unsuspecting or uninformed citizens. Dam failures such as the Vaiont Dam disaster in Italy are more apt to cause mass death and destruction from landslide damage.

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Earthquakes or floods coupled with landslides may cause a natural disaster as occurred at Hebgen Dam in Montana.

What is the cost of landslides to the State Highway Program in California? I am certain that no one can assign an accurate cost figure to this work. We know that on some major highway construction jobs we spend as much as 10% of the contract allotment for subdrainage items. This type of work is intended to remove water to reduce the risk of landslide. We also know that it is not uncommon to provide a contingency fund of 5% of the contract to take care of unforeseen work that may be occasioned by landslides. It would seem like a reasonable estimate that an equal amount is often included in planned landslide correction work as part of a construction contract. Add to these costs the increased cost for right of way and construction of longer routes to avoid known landslides and the cost of restoring highway facilities that have been damaged by landslides and you can see that a tremendous amount of our highway finances goes each year to cope with one of natures greatest hazards. Not only is the loss of highway money serious but there is an unaccountable loss to the highway users who are forced to increase transportation costs due to loss of portions of our highway system.

When property adjacent to a highway is damaged by landslide there is seldom a question of who is legally responsible. If there has been any work done on the highway that can be even remotely connected to the precipitating causes of the landslide it will be the State who pays the bill. Seldom is the State able

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to collect for damages to a highway caused by slides originating outside of the right of way from causes not connected to the highway itself. These are generally considered an act of God. Highway administrators must maintain a constant vigil to try to prevent subdividers and other developers from creating situations that may trigger landslides that will damage highways. The above statements are a generalization and any major legal decision must be made by the courts and to attempt to predict in advance the outcome of such action would indeed be foolhardy. Each case must be decided on its own peculiar circumstances.

There is the case of one building along the Feather River which was destroyed by a landslide. This building was the third at this location. The two previous buildings had been destroyed by landslides. This is indicative of the disregard that certain segments of our population have for landslide dangers.

The California Division of Highways divides landslides into two groups. Material that moves into the roadway from a cut slope or natural ground is called a slide. Movement of embankment material or natural ground that destroys or moves the roadway fill slopes or surface is called a slipout. This two-part classification greatly oversimplifies the task of describing landslides that occur along California highways.

Other classifications of landslides come from the description of the physical properties of the material in the moving mass and from the shape the slide assumes. A rock fall may be composed of hard, durable blocks of rock from as small as a child's building block to as big as a house. A mud flow may consist of soil

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particles all smaller than silt and water mixed to the consistency of thick minestrone soup. Most landslide masses are composed of a heterogeneous combination of materials representing all of the soils and rock formations in the vicinity.

Other descriptions of landslides and their classification and nomenclature have been well established. A good reference for classification and identification of landslides and descriptions of landslide problems and the corrective procedures for solving these problems is "Highway Research Board Special Report 29 - Landslides and Engineering Practice" by the committee on Landslide Investigations. Suffice it to say here that all of the various types and combinations of landslides occur in California and in many cases they in some way involve a highway. Although we have areas in the State where landslides are more prevalent than they are at other localities, each of our eleven highway districts have major engineering problems involving the natural mass movement of soil and rocks. No one district has a corner on all stability problems. Basically there are certain soil properties that tend to create instabilities. Plastic soils in even small percentages combined with ground water are the factors causing most landslides in California. The problem soil may be only a very thin layer between joint blocks in a massive rock formation and the total amount of ground water may be only enough to lubricate the soil.

Slides range in size from a few loader buckets of material that has fallen onto the shoulder from a cut bank to many millions of cubic yards. A slipout may involve a small amount of material

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that has been lost from the toe of a fill slope to a failure like the one that closed Interstate 80 during the 1960 Winter Olympics. That slipout destroyed both roadways of the split-level freeway and threatened the old existing highway that was carrying westbound traffic at the time. The volume of moving material in this slipout approached two million cubic yards and the cost of the resoration work was approximately one-half million dollars due to the emergency nature that meant an all-out crash program to get the traffic through.

How can the cost of landslide damage to highways be reduced? It is more costly to repair a highway failure than it is to do the work necessary to prevent the failure if the work is done during initial construction. Based on this premise the way to reduce cost of landslides is to recognize the factors and to plan and construct the preventative features that will avoid high maintenance costs. We should be aware that if our engineering judgment is faulty and if we over design and build costly preventative works where there is little danger of landslide failure we will soon expend more money than the corrective work to repair slides would cost if we did little or no preventative work. Some where in the great in-between lies the happy balance of spending the right amount to prevent landslides and of assuming the right cost of repairing highway failures. The only way to achieve this state of success is to do the best job of planning based on the widest experience that we can obtain consistent with the cost of planning.

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The responsibility for planning, design, construction, and maintenance of highways in California rests with our eleven districts with the responsibility for review and approval and the establishment of guide lines belonging to Headquarters in Sacramento. Each district has departments to handle each of these functions plus certain service departments to handle the backup work. Headquarters has counterpart departments who review and guide the districts' activities so that all of them operate in coordination and within the statutes that govern the operation of the division. The United States Bureau of Public Roads also checks all phases of projects involving federal finances for compliance with federal regulations. Whenever any of the above organizations recognizes a landslide problem it is referred to the Foundation Section of the Materials and Research Department for analysis and recommendations. This is not to say that the Materials and Research Department assumes the District's responsibility for the four major highway functions. We provide the back-up service that supplies the responsible Engineer with the information that allows him to cope with another major problem.

The Foundation Section of the Materials and Research Department coordinates the efforts of the various groups of the Division of Highways concerning landslide problems, their identification, and proposals for their solution. This section is well equipped and staffed to handle this work. We have, at the present time, twenty men in our Field Exploration Unit who are responsible for taking soil samples and rock cores to aid in

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measuring the dimensions and physical properties of soil masses. Our Soil Mechanics Laboratory Unit is equipped to do all types of soil testing. Our well equipped Geology Unit is staffed by eight Engineering Geologists. We have seismic and electrical resistivity equipment to supplement our other types of sampling equipment. We use X-ray spectography and differential thermal equipment to identify problem minerals. Although it is true that these people work at a number of other tasks landslides and their problems represents a large portion of the work of this section.

The first people from the Foundation Section to get involved in a landslide investigation after the recognition of the problem by the staff is generally one of our Foundation Engineers or Engineering Geologists. When the information available from the study of the geology is not sufficient for a solution seismic surveys are employed or a boring program for obtaining subsurface information is undertaken. Soil samples are tested and cores are evaluated to find strength values for a stability analysis. Some of our analysis work is done on an IBM computer. When the maximum information consistent with cost is obtained a decision on how to handle the particular problem must be made. Once a plan of action is decided upon it may be necessary to revise it when more information becomes available as the job is opened up. It takes a combined effort by all departments both in the district and in headquarters to recognize, evaluate and solve landslide problems.

Damage to highways is only part of the picture of the landslide problem. Many times it is necessary to build a bridge or

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other highway structure in a locality that is subjected to landslide danger. Many times the selection of a route for a highway to avoid landslide problems is made possible by the use of bridges. Bridges and their appurtenant structures must often be protected from landslide. There is a $150,000 overcrossing structure on Interstate 80 that required $40,000 worth of horizontal drains to dewater an active slide in order to make the bridge site reasonably safe from damage. Designers and foundation engineers in our Bridge Department are well aware of landslide problems and spend many hours coping with them. The Engineering Geologists in the Bridge Department do the investigation work and make the recommendations for the bridge foundations. They are cognizant of landslide problems and the dangers of slides are evaluated and enter into the determination of their recommendations.

A distinction should be made at this point between natural landslides and slides that are caused by construction practices. Many of California's landslide problems were inherited from Mother Nature. These natural slides can often be recognized and avoided by careful route planning and design. Some slides are so great in extent that they cannot be avoided. It is often necessary to assume a continuing maintenance problem in order to provide a needed highway facility, or it may be necessary to expend large amounts of time and money to alleviate a landslide problem during construction. Slides caused by construction practices are an indication that either the problem was not foreseen or that corrective and preventative measures were insufficient due to erroneous factors being used in the analysis of stability.

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A large number of reports and articles have been prepared and published that cover procedures for avoiding, minimizing, and correcting landslide problems. It is not necessary to go into a description of the details of landslide correction work in this paper. The California Division of Highways uses the following methods for slide correction:

1. Horizontal drains for dewatering wet unstable earth masses.
2. Stabilization trenches to dewater and key-in embankment areas over wet, steep foundations.
3. Strut fills to support the toe of unstable areas.
4. Unloading at the top of slides.
5. Interceptor trenches to keep water out of slide areas.
6. Change of alignment and grade to avoid known unstable areas.
7. Flattening and benching of slopes.
8. Vertical drain wells.
9. Stripping to remove unstable material.
10. Buying right of way to include the limits of a slide.

On some slides a combination of several of these methods are used. Other corrective work is tried in special cases and experimentally.

There are probably few organizations that handle as many broad and varied landslide problems as does the California Division of Highways. If there is one thing this vast experience has taught, it is that there is no easy answer to a landslide, and that the best theoretical analysis of a landslide problem

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based on the best test data available must be tempered with a large measure of good common practical knowledge.

We feel that we have a responsibility to the public to provide the best possible solutions to the landslide problems we encounter and we constantly strive to improve our abilities to cope with this problem.

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