Research in Environmental Geological Disasters and Prevention Countermeasures of Mountainous Area Highway

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特　　集

Research in Environmental Geological Disasters and Prevention Countermeasures of Mountainous Area Highway

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In this paper the natural environment geology disasters of mountainous area highway are firstly elaborated, and such geological disasters and their origin as collapse, landslide, mud fluid, Karst, flood damage, special soil, earthquakes and so on is analyzed emphatically. At the same time, such environment geological disasters easily caused by people as roadbed of filling and cutting, constructing bridge and tunnel, changing water course, and so on, are elaborated in detail during constructing mountainous area highway. In view of the construction and operation of mountainous area highway faced by the natural and artificial environment geological disaster, it is proposed that forecasting and preventing geological disaster and effectively developing environmental protection countermeasures.

Keywords : Mountainous area highway, Environmental geological disasters, Environmental protection, Protection countermeasures

1　INTRODUCTION

For a great quantity excavations and backfill volume of earth and rock, the mountainous area highway construction changes the natural ecological environment, induces environment geology question, causes the environment geology disaster, like the collapse, the landslide, the mud fluid and so on, often result in the serious ecological damage, the life and property heavy loss. Geological disasters relate not only to natural condition but also to the human factor. Therefore, when constructing mountainous area road, Effective preventive measures should be taken in order to avoid or the reduce geology disasters influencing traffic and destroying the ecological environment destruction along the line[1,2].

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2　MOUNTAINOUS AREA ROAD NATURAL GEOLOGY DISASTER

Inside and outside dynamic geological action of nature produces such environment geology disaster as the earthquake, the collapse, the landslide, the mud fluid and so on, these disasters are caused by natural factors, and have the mutual relation, mutual influence, mutual restriction with the highway engineering, moreover immediately influence the geological environment and operation environment of highway.

2．1　Collapses and its origin

Giant clod under action of gravity on the high and steep slope suddenly violently falls, topple, roll, collapse downward, this phenomenon is called the collapse. The collapse is the common disaster in mountainous area highway, its oncoming force is swift

and violent, often destroys the roadbed and bridge, blocks in tunnel entry, wrecks the vehicle, causes the direct harm to the road. Both the natural factor and the human factor can cause collapse's occurrence (Fig. 1).

The collapse predominant type includes: falling rocks, landslide, bank failure, collapses. The origin of inducing collapse is as follows (Fig. 2):

Fig. 1. Disruption traffic for Collapse

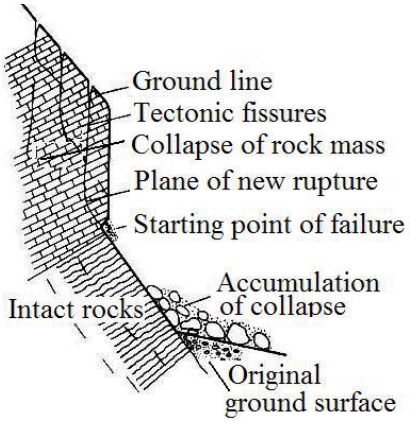

Fig. 2. Collapse schematic drawings

Firstly, Landform condition is the basic factor causing collapse, certain slope and the altitude difference are the basic conditions which the collapse occurs. According to the investigation, when the gradient is bigger than 50° or 60° or the altitude difference is bigger than 50 meter, the slope composed of the hard rock possibly give rise to collapse. Sloping fields which is composed of the loose material may presents the collapse when the slope surpasses it's angle of repose, generally, when the gradient is bigger than 45° and the altitude difference is bigger than 25 meter, the slope possibly present the small collapse, the altitude difference is bigger than 45 meter, the slope possibly present the large-scale collapse. The collapse may occur in loess area when the slope gradient is above 50°. The mountain canyon, the cliff, and the steep coast are sector where the collapse easy to occur.

Secondly, Geological condition: The lithological character and the geologic structure are also the important conditions which the collapse occurs. The slope composed of complete bedrock which have the compact structure and no crack cannot cause collapse even if the slope is very steep. Otherwise the broken rock with loose structure is easy to have the collapse. When the hard rock alternate with the soft rock, the slope is easy to cause the collapse as a result of the differential weathering which causes the hard rock to be prominent and creases the free face. The existence of the massive jointings or the fault will accelerate the weathering and disintegration process of the rock, and as become the important condition under which the collapse will occur. The rock layer structure, including fault plane, clearage plane, layer plane, schistosity surface, the combination of these, is collapse's another important condition. When the tendency of the rock stratification plane or the divisional plane consistent with the slope tendency, the inclination angle is big and under free face, the rock is easiest to have the collapse along the tectonic plane. Speaking of the new regional tectonic movement characteristic, the area where the tectonic movement is quite intense, and where the stratum is compressed to be broken, and where the earthquake is frequent, is the region where collapses mostly take place.

Third Climatic conditions: The intense physical weathering is the foundational condition which the collapse occurs. Because temperature difference is big in arid, half arid area and the freezing and thawing process is intense in high and cold mountainous area, the rock weathering is intense in these areas, and the cliff, steep slope is easiest to present the collapse. The rainstorm, the rain of day after day, and the snow and ice melting and so on, often are collapse's triggering factors, with the moisture content massive permeating in the rock mass and the soil body, the load of slope is increased, simultaneously, the rock mass internal structure is also greatly affected, finally, the collapse is caused to occur. The rainstorm and the rain of day after day are also easy to cause the flood, and cause the wide range bank failure, result in serious disaster. The mountain highway along the river bank road section is much longer, the bank failure is very big traffic threat to the road.

Human factor: During constructing or reconstructing road, As human excessively excavates the mountain, quarry an excess of earth and rock in the toe of slope, the sustaining power of the toe of slope is weakened and the collapse may cause to occur. Moreover, in the broken region of rock mass, the big explosion will also cause the collapse. During road designing, constructing and operating process, according to above conditions, engineers should analyze comprehensively, decide sector and time where collapse easy to occur, take the corresponding prevention measures in order to guarantee that the construction and operation security, and to protect the ecological environment.

2．2 Landslides and origin condition

The so-called landslide, is refers to phenomenon that the massive soil bodies or the rock mass in the slope under the action of gravity and influence of other factor, slide downward wholly along certain sliding surface or

belt. The landslide is one geological disaster which is met frequently in the mountain road construction (Fig.3). The landslide generally is composed by such three major parts as landslide wall, the sliding surface and the landside mass (Fig. 4). The large-scale landside mass's structure is quite complex, its front end is the landslide tongue and the landslide drumlin. In the landside mass there are landslide terrace, basin, lake, crack etc. The harm degree of landslide varies with the scale of it, the large-scale landslide's harm is quite serious, may amount to even several billions cubic meters, destroy the road, jam the river course, deposit the reservoir, and the landslide origin is as follows.

Fig. 3. Road failure caused by landslide

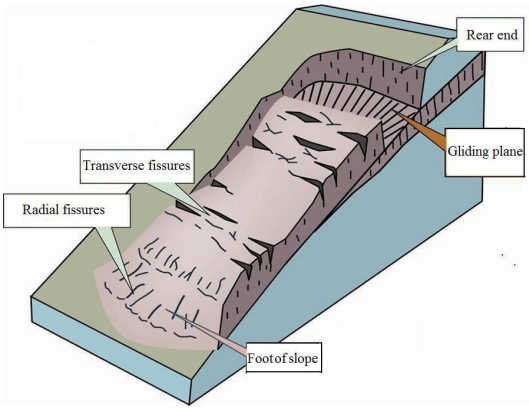

Fig. 4. Landslide schematic drawing

First, Geological condition: The landslide mainly appears in the loose deposit layer. Loose deposit, particularly after clay and loess immersion, the cohesive force decrease and the slide increases greatly. Bedrock area landslide often relate to such weak rock as shale, clay stone, marl, slate, phyllite, schist and so on. When the lithological characters composed of slope varies, landslide is easy to produce, especially the above is loose deposit and the bellow is the hard rock. The sliding surface of landslide are most weaken plane of structure, such as stratification plane, fault plane, fault crushed zone, divisional plane, plane of unconformity and so on. Moreover, it is also helpful to produce landslide when the tendency of rock layer consist with the tendency of the slope.

Landform condition: Looking from the landform characteristic, the small slope, the gentle fluctuation, the good vegetation cover hillside, is quite stable and not easy to produce landslide; high and steep slope or cliff, cause weaken plane of slope to form free status, the upside soil body or the rock mass are at the non-steady state and are easy to produce the landslide; The concave bank steep ridge where the river water corrodes intensely is the sector where landslide easy occur; The both banks in loess area often present the giant landslide belt.

Precipitation and ground water condition: The precipitation and the water from the snow and ice melting are often triggering conditions of the landslide. The majorities of landslides happen during rainfall time, generally the heavy rain results in the big landslide, the light rain results in small landslide, and no rain no landslide. The ground water is also important cause to urge the landslide occurs, the overwhelming majority landslide produce along the weaken plane of rock mass saturated ground water.

Other conditions: The earthquake is important triggering condition of the landslide. Also the human factor that influence mainly the landslide presents to four aspects, excavating the toe of slope destroyed steady state of natural slope; piling up the waste or building house on the top of slope enlarge the load; not suitable big blasting for construction; improperly draining water and so on.

2．3 Mud fluid and origin condition

The mud fluid is one kind of mighty torrent, which includes such massive solid matter as silts, stone and so on, suddenly burst, last short, the oncoming force is fierce, has the formidable destructive power. It buries villages, destroys the cities and transportation, cause the huge disaster. The mud fluid is various to be having the direct harm to roadbed, bridge and culvert and the structure attached to them, mainly by such ways as burying and filling, covering with mud and silt, washing and hitting and so on. Simultaneously, the mud fluid deposit often compress and the jam river course, cause the water level to rise, submerge roadbed along upstream river, or force main riverbed to change flow, wash out roadbed on the opposite shore, create the

Fig. 5. Burying road and tunnel for mud fluid

indirect flood damage (Fig. 5). The reason that the mud fluid cause huge harm is mainly because its disintegration, the transporting, and the deposition is extremely intense and changing surface of the ground is very big. The mud fluid mainly include such two kinds of as the coherent mud fluid which refer to the solid matter occupy 40% above total quantity of mud fluids, and the thin mud fluid which refer to the solid matter occupy 40% total quantity of mud fluids.

Fig. 6. Mud fluid forming schematic drawing

The mud fluid occurrence is decided by three conditions, firstly, rich solid detritus; secondly, the massive water bodies which is not only mud fluid constituent but also important dynamic condition; thirdly, the suitable landform condition. Therefore, the standard mud fluid basin may divide into three areas, the upstream formative region three side of which is surrounded by mountain and one side of which is exit, and where solid detritus and water source composing of mud fluid is mainly collected area; The middle flow area, which is the channel by which the mud fluid release outside, where is the big deep ditch in the terrain; the downstream stack area, where the mud fluid material stop (Fig. 6).

2．4 Several other kind of natural environment geology disaster

Karst: The karst phenomena grow much in southwest and the Central South of China, it can cause the roadbed settlement, destroy the smooth road surface, affects the roadbed stability. The karst's influence upon the road geological environment is mainly includes, In the scope of the roadbed stress, if there are the limestone cave, the underground river etc., the limestone cave roof collapse and causes the roadbed to sink suddenly under the action of additional load and the vibration function; Such different forms as Karst limestone cave, solution channel, clint, funnel and so on cause the bedrock surface to be big fluctuation, or there exists the soft soil and causes differential settlement of roadbed; when foundation is embed in bedrock, if there lies solution groove, the vertical karst crevasse, swallow hole and so on, they will cause the rock layer bellow foundation to glide along the tendency to weak structural plane and produce new geological disasters[3,4].

Road flood damage: The road flood damage is a phenomenon and process that refers to the road and engineering facility along the road suffered by water and to be seriously destructed, it occurs under such combined factor action as climate, hydrology, geologic, and the human activity, it is a universal question which coexists all over the worlds and belongs to one kind of common natural disaster. The light flood damage causes roadbed and pavement to damage, and affects the highway passing through capacity; the heavy washes away the bridge, the culvert, and the protection project, interrupt traffic, brings about quite serious loss. Statistics indicated that in western region the repair expense for highway flood damage emergency every year is total to ￥5 million equally, moreover the road flood damage is getting more and more serious[5].

Special earth geology disaster: Because our country is vast in territory, some regional special soil type are often met with in the project practice, for example, collapsible loess, expansive soil, saline soil, the soft soil, frozen soil, laterite and so on, these special soil types have respective special engineering geological characteristic. When carrying on the construction in these areas, some special engineering geology question will be encountered. From example, expansive soil widespread in western area of China, because the water content non-average change, it causes the non-average swelling and shrinkage of expansive soil, and result in the roadbed having the intense crosswise wave distortion, the pavement cracking, the roadbed collapsing[6,7].

Earthquake: When the earthquake occur, it may cause such road construction damage for vibration as twisting the road and bridge, resulting in the ground of the road and bridge to lose stability and function, causing the ground to liquefy and collapse etc. Simultaneously, the earthquake is also one of the important reasons to induce collapse, landslide, mud fluid. In mountainous area, the road geology disaster and loss caused by the collapse, landslide and the mud fluid which are induced by earthquake is more serious [8].

3 MAN-MADE GEOLOGICAL DISASTERS IN MOUNTAINOUS AREA HIGHWAY CONSTRUCTION

According to the authoritative department statistics, the economic loss caused by geological disaster reaches ￥27.4 billion every year. After a great deal of investigation and research, now approximately 50% of geological disaster having taken place is relative to the human activity.

3.1 The environment geological disaster induced by filling and excavating the roadbed

Destruction slope stability: The soil and rock mass though which the road passes remains a quite complex residual stress during their forming process, when the residual stress is not be influenced and destroyed by the external force, it keeps the rock and soil mass natural balance to be stable. During excavating or filling in roadbed process, no matter what kind of construction steps and the way is adopted, Constructing the road may changes the original shape and natural balance of rock and soil mass to a certain extent, long-term, the repeated load of vehicles and the action of the ground water or the rainfall will induce the slope failure as a result of fatigue.

Destruction hydrogeological conditions: Because a great quantity of earth and rock is excavated during highway construction process, highway construction will cause the shallow the water-bearing stratum to be cut off by the highway roadbed, and will cause the shallow layer groundwater system to be destroyed, and enables the ground water not to flow downstream, and will destroy such water supply systems as well and springs etc. and some ground water to appear at the hillside where the road cut off, thus causes the roadbed and slope stability to be failure. When the deep cutting is excavated, if the water level of the roadbed is lower than that of groundwater, water level of groundwater will drop, and causes the entire local water level of groundwater to drop, will also influence the neighbor watershed to be changed, will affect the recharge and flow of groundwater in the water supply system of neighbor area, moreover, the ground water which enter the cuts also seriously affect the intensity and stability of roadbed.

Siltation and erosion: The highway construction is very easy to cause the rivers, the drainage ditch, or the irrigation and drainage system to produce siltation and erosion, the deposit material is from embankment, borrowing area and the spoil of the new constructed road section. Before excavation and road surfacing, the siltation question is most serious. The water discharged from the road surface and the embankment and the redistributed surface water can urge the land and river erosion function in the neighboring area, produces the deposit which is led in the rivers, causes the river bed deposition, reduce the seepage coefficient of river bed; Also possibly causes the natural river course to change the direction, increases the flood disaster, and raises the sediment concentration of the water supply system. At the same time, if the highway design is unreasonable, the road will also suffer the corrosion from river or the influence from the unusual flood, and the new geological disaster is caused to occur.

3.2 The induced environment geology disasters from constructing the bridge and tunnel

Foundation excavation of bridge will cause the distortion destruction which is mainly the slope collapse, sometimes will result in the mountain massif's slipping. After the bridge has been finished, it inevitably has the hindrance function to the running water, causes the river deposit and the corrosion action change, aggravates side erosion action, further, the side erosion can pull out the embankment, causes the dike to collapse and to be in flood, and causes the massive sedimentation deposited river bed, and result in aggrading stream to destroy the farmland or the highway facilities.

The excavation of the tunnel must change original stress balance system of the mountain massif, change the mountain massif hydrogeological conditions, if the choice of tunnel location were not good, and design is unreasonable, the methods of construction is improper and so on, such environmental geological disasters as rock burst, roof collapse, landslide, ground settlement, water inflow, and poison gas leakage etc. come into existence. Moreover, if the massive waste residue produced by tunnel excavation is improperly piled up, such environmental geological disasters as slope failure, collapse, landslide, mud fluid, or soil erosion will produce, and result in silting up the river course, pollute the water source.

3.3 The environment geology disaster as a result of changing the river course

During the highway construction, sometimes, the river course is inevitably changed mainly for the improvement goal of road, the bridge. it is finished with deepening, broadening, bending improvement the river, getting rid of the vegetation and gravel, masonry dike and the protection project. After the river course is change, the new corrosion-depositional cycle starts, and strengthens stream trenching. The stream trenching causes the river bed to become deep, and directly influence stability and security of abutment, bridge piers and other highway structures, and if the vertical corrosion cause water level of river to drop, will result in failure of the irrigation, drainage, and supply system, causes the hydrology condition to change obviously and the side erosion will be strengthened, causes the river bed to swing in horizontal direction, cause the dike to collapse unceasingly and the rivers route will be changed, causes the highway structure and the farmland is threaten. The river siltation action will result in the channel sedimentation and the jamming irrigation and drainage and the water supply system, will produce the new environment geology question.

4 THE PREVENTION COUNTERMEASURES OF MOUNTAINOUS AREA ROAD ENVIRONMENTAL GEOLOGY DISASTER

The road geology disaster will not only create the enormous direct economic losses, but also the indirect

economic loss which is difficult to estimate and the bad social impact because of the disaster interrupting traffic. According to road geology disaster's present situation and the space-time distribution characteristic in China, the disasters induced by the natural factor or the human factor, become more serious year by year, therefore the prevention disaster's occurrence is also become more important.

4．1 The geological disaster prevention and controls countermeasure during highway construction process

4．1．1 insisting on geological selection line for construction the mountainous area road

While highway route is selected, the detailed survey of the engineering geology and the hydrology geology should be carries on. Regarding such serous geological disaster road section as the collapse, landslide, rock deposit, mud fluid, karst, soft soil, the mire, expansive soil earth and so on, engineers should insist on the geological route selection principle, in general, and should try to keep away from them. if the route must pass through them, according to the geological conditions engineers should choose appropriate position to reducing the scope, and takes the necessary engineering control measure. While selection the road route, we should protect the mountain massif balanced system as far as possible, and avoids excavating and filling in greatly.

4．1．2 Strengthening geological prospecting and optimization engineering design

The road environment geology disaster is closely related to the engineering geology and the hydrogeological conditions. The bad area of the engineering geology and the hydrogeological conditions is where the geological disaster occurs mostly. Geological environment directly influence the stability, construction cost, benefit of highway engineering. We must strengthen the engineering investigation and cooperate mutually with roadbed designer, and combining the profile section design the roadbed agreeing to the reality. According to the geological situation, we design synthesis draining water measure in a corresponding way. Makes use of local materials and construct protection project, and combine the reality and establish environmental protection facility. In the area of more geological disaster, we should insist on the policy of prevention primary and treatment auxiliary, combination the prevention and treatment, take such control measures as the prevention, unblocking, blocks off and so on, proposed the scientific reasonable technology countermeasure of reduction disaster after the more side comparison, optimize engineering design and achieves economic efficiency, social efficiency and environment benefit of highway.

4．1．3 Positive Monitors and prevention, scientific and reasonable construction

In the highway construction, engineers should utilize fully the modern science and technology method, studies positively the environment geology disaster's synthesis reconnaissance, appraisal, prevention, and other project countermeasures, carries on a comprehensive environment geology disaster general survey to all skeleton lines and the branch road, carries on the monitor and forecast to geologic body ambushed the danger and each kind of high-risk slope which is in the key road section or project spot. Only establishment road geology disaster information & analysis system and strengthening the road environment geology disasters forecast system and against disaster reduction system, can people enhance the environment geology disaster's protection ability to the highway engineering.

In the highway construction, many environmental geology disasters are caused by the methods, equipment, quality of construction, and so on. Therefore, in highway construction period, workers should take the positive preventive measures, and uses the scientific reasonable construction methods. In the construction process, people should avoid the rivers, the canal and the dike receiving the corrosion and the siltation; when excavating the gravel material in the river course, people should prevent the rivers condition to change; In rock mass loose or structure disruption section, people must not use large-scale blast to work, in order to avoid the mountain massif becoming loose and the destroying stability of slope, and result in the rock mass collapse and the soil erosion; After the borrow pit excavated, people must avoid hindering drainage system and water supply system around local area; When piling up the waste, people should prevent the periphery irrigation and drainage channel, the drainage and river course to be polluted and clogged with silt; In the construction process, people must consummate the temporary drainage engineering and prevents the surface water washout and infiltrates massively under soil; we should reduced occupying land area, pay more attention soil erosion, reduce destruction of the vegetation and the natural ecology.

4．2 Natural environment geology disaster's prevention

4．2．1 collapse's prevention

In the mountainous area highway construction and the operation process, to the section of easily collapse, people should do regular monitor, and make the judgment about the possibility, intensity and the scale that collapse occurs, and takes the suitable prevention measures. The danger stone which is easy to tumble

and the loose deposit at the collapse section should be cleaned up promptly, at the same time, people should establish the safe warning signal to guarantee the driving and the personal safety; For the high and steep bedrock slope where the rock is breaking and easy to crash, should eliminate dangerous rock and wipe the seam with the cement, and add piling up stone to support or combined bolting and shotcrete to reinforce; For the steep slope which is mainly surface flakes off primarily and whose integrity is strong and is lower than 30m high, people generally uses brushes the slope and constructs the protecting wall. If the slope is excessively high or below is the bedrock and above is the loose deposit, people may establish the stave platform, brush the gradational slope. Regarding the big scale earth, and stone pile while harm roadbed, people should use suitably mortar rubble retaining wall to obstruct; To the collapse section where difficulty in brushing slope, people should adopt such protective measures as establishment steel wool to block stone, and so on. In highway construction, people should avoid as far as possible the collapse because of hand excavation or the demolition.

4．2．2 Prevention of Mud fluid

Governing mud fluid mainly adopts such prevention principles as drainage project primarily, drainage and obstruction project union, the mechanical control measures and the biological control measures union.

The first method is the drainage projects which include three types such as trough, dike and dam. This method is most widely used to prevent mud fluid because the drainage project is simple and its effect is good. V shape reinforcement bed trough is mostly used in the mud fluid formative region, and V shape trough play such roles as fixing ditch bed, stabilizing mountain massif, reducing collapse, the landslide and deposit of river bed to participate mud fluid activity. Constructing training levee and diversion dam for drainage flood is mostly used in the mud fluid deposition area, and play such parts as improvement speed of flow, the guidance flow, prevention the mud fluid the sheet flood to change course and result in siltation harm, in order to protect road, railroad, bridge, culvert and other buildings.

The second method is obstruction project. Dam against stone is mainly used in the middle reaches circulation area, and plays such roles as retaining the silt stone of laminar motion, raising the river bed to enhance the erosion base level, slowing down river bed slope the of dam upstream, reducing the speed and scale of mud fluid, preventing the lateral erosion and undercuts of mud fluid. Dreg arresting dam which has multistage water permeability may obstruct different particle size block, reduce impact force of stone to the construction structure, railroad, road and so on.

The third method is bio-engineering. It takes the vegetation as the method to build a series of flora which have different combinations, structure and function, like the forest for water conservation, the forest for conservation of water and soil, the forest reinforcing ditch, stabilizing slope and against flush, the forest for shore and beach protection, the economic forest, the biological granary forest, the biological fence and so on. All of above can strengthen the steady ability of loose material from the mud fluid ditch and slow down binding time the surface runoff and so on, thus control the basic condition on which mud fluid form, achieve the goal of suppressing the mud fluid occurrence. At the same time, we should strengthen the mud fluid geology disaster's surveying work, carry on a detailed investigation to the latent mud fluid disaster spot and section, establish the dynamic observation mesh point, study its origin mechanism and the trend of development, work out the practical and feasible control program.

4．2．3 Landslide prevention

In the highway construction and transport business, the sector where landslide easily occurs should be carried on the monitor. The sector which becomes to wriggle and distort should take the prevention measure promptly, simultaneously, people must reduce the influence of human factor as far as possible. The landslide prevention measures mainly include draining water, supporting, reducing loads and so on.

First measure is to eliminate surface water and deplete ground water in order to increase the skid-resisting capacity. To establish the ring-like drain gutter and carry on the slope face protection around the slope where the landslide slope possibly occur or have occurred, in order to intercept the surface water outside the landslide, prevent surface water permeating landside mass, simultaneously pad the crack and eliminates the slope water puddle, and plant big transpiration quantity tree and so on. For the ground water, we should adopt desludging and not obstructing, the main measures include that the establishing intercepting blind drain in order to intercept the ground water periphery the landslide, that establishing the support blind drain which have double-acting function of draining water and the support, and that establishing the drill hole group nearly level to discharge the ground water, furthermore, including such measures as the blind hole, dry well, leaching pipe, and the vertical drill hole and so on.

The second measure is to take the earth above the landslide for deloading reducing downlside force. People may adopt excavating earth for unloading in the main sector of slideslope, may adopt pile earth for increasing for resisting slide sector, when the slip mass have the downslide trend of development, people should drain water promptly and adopt supporting structure and other anti-slippery measures in order to prevents the slip mass to relax and lose stability.

he third measure is establishment supporting

structure to prevent the soil body to slide. According to the project need and the landslide scale, hazardness and so on, people should construct the anti-slide retaining wall, ragged rubbled wall,slide-resistant pile and so on to support slip mass or to anchor the slip mass on the good ground.

The fourth measure is to reinforce slope body and enhance the skid-resisting capacity. In addition, for the big scale or the landslide which will produce the big harm once it is induced, people must establish promptly the strict monitor mechanism and take the suitable prevention measure.

5 CONCLUSIONS

When highway route selected, people should avoid the above inciden geological disaster area as far as possible, and should reduce destructing mountain massif for the human factor as far as possible to, simultaneously must pay attention to the spoil's processing in order not to provide the physical conditions for the geological disaster's production. The reasonable development and exploiting resources is to guarante the local natural landscape where the road passes through. Fully using the modern science and technology methods, people should study positively the highway engineering geology disaster's integrated survey, the appraisal and the prevention countermeasure, and establish highway geology disaster's forecast system and the disaster reduction system, enhance the highway system to the geological disaster's reaction capacity and disaster reduction capacity [9,10].

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山岳ハイウェイの環境地質学的災害の予防対策に関する研究

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概要

本論文では，最初に山岳ハイウェイの環境地質学的災害について詳述し，崩落，地滑り，泥流，カルスト，洪水，特異土壌，地震などの環境地質学的な災害の発生源について分析した。また，山岳ハイウェイの建設中に発生するこのような災害は，人為的な路盤の土盛り，開削，橋梁建設やトンネル工事，水路変更などにより簡単に発生することについて記述した。人工的あるいは人為的な環境地質学的な災害に直面している山岳ハイウェイ建設や施工の観点から，災害の予知，予防や効果的な環境保護対策について提案した。

Keywords : Mountainous area highway, Environmental geological disasters, Environmental protection, Protection countermeasures