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Engineering Insurance Exposures related to the Construction of Roads

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1. Introduction

1.1 Goal and Scope of the Paper

Nowadays, roads are built at any time in almost every type of environment and serve many different purposes. Road structures range from a few hundred metres up to several hundred kilometres and are built across very different geological conditions. Construction time may last from less than a year up to several years. Due to these facts, road construction is naturally exposed to a wide variety of perils.

The goal of this paper is to help the Underwriter's understanding of road construction, to build up awareness for the wide variety of perils construction of roads is exposed to, to help to perform professional risk analysis and underwriting and to draw attention to possible loss scenarios by some illustrative loss examples.

The paper explains in the first part various types of roads and the technical aspects of road construction. In the second part, the paper describes a variety of exposures, individual underwriting considerations, typical loss scenarios as well as risk management, safety and security aspects. An integrated risk matrix illustrates the dependencies between types of roads and exposures. The paper closes with the description and illustration of typical losses and loss scenarios.

The risks involved in the construction of major bridges and tunnels – which quite often form part of large road construction projects – are not dealt with by this paper.

1.2 History of Road Construction

The first pathways were the trails made by migrating animals. By about 10,000 BC, these rough pathways were used by human hunter nomads following these herds. The development of roads, however, began with the invention of the wheel in Mesopotamia during the 5th Millenium BC. The oldest engineered road discovered is the Sweet Track Causeway in the Somerset levels, England, dating from 3800 BC. The Ancient Egyptians constructed a stone paved road to help move materials for the building of the Great Pyramid in about 3000 BC.

The ancient Chinese constructed an extensive system of roads, some paved, from about 1100 BC onwards. By 20 AD, the Chinese road network extended over 40,000km.
The Incas built fine highways for couriers through the Andes, and the Mayans built an extensive network of paved roads in Mexico before the European discovery of the New World.

From about 300 BC, the Roman Empire built straight strong stone Roman roads throughout Europe and North Africa, in support of its military campaigns.

Engineered roads in the age of horse drawn transport aimed for a maximum gradient of 1 in 30 on a macadamized surface since this was the steepest a horse could exert to pull a load uphill which it could manage easily on the flat. Notable road engineers from this period are Pierre Marie Jérôme Trésaguet (1716-1796) in France and John Loudon McAdam (1756-1836) in England.

During the industrial revolution, the railway developed as a solution to the problem of rutting of the road surface by heavy carts. Instead of trying to build a strong surface across the whole road the cart was constrained to run either on rails or grooves which could be made of much stronger, wear-resistant material.

Today, roads are almost exclusively built to enable travel by car and other wheeled vehicles. In most countries, road transport is the most utilized way to move goods. Also, in most developed countries, roads are formally divided into lanes to ensure the safe and smooth movement of traffic.

1.3 Economical Aspects

In earlier times, construction of road networks was of great strategic and economical importance. Huge investments were made in road construction e.g. by the Romans to expand and consolidate their empire. Roads had, however, not only strategic importance, they were of increasing importance for the rapid development of national and international trade.

At all times, road construction was only possible if the necessary resources – i.e. work force, materials and money – were made available. Nowadays, construction of roads is influenced by many different aspects. Still, financing is very important. In addition, road construction is often politically influenced. Ecological considerations and densely populated areas complicate construction substantially.

Whether privately financed or financed by the government, it becomes increasingly important to substantially protect these huge investments during construction and operation by proper risk management and insurance.

2. Understanding Road Construction

2.1 Introduction

The aim of this chapter is to give an overview on the technical aspects for the design and construction of roads. The information provided shall enable the reader to understand how road construction works. However it is important to note that the details vary depending on the road category and construction type.

3.1.1 Road Categories

There are various categorizations used for roads, defined along their location, function, capacity and other characteristics.

Depending on the main function, traffic load and design speed, the following road categories can be distinguished:

Motorways are routes for fast moving long distance traffic.

Strategic routes are trunk roads between primary destinations.

Distributor roads form the urban networks and are primary links for local traffic with junctions.

Link roads are linking distributor networks with frontage access and frequent junctions.

Access roads are serving limited numbers of properties and carry only access traffic.

3.1.2 Types of Road Construction

Depending on the original state of the road the following general types of construction can be distinguished.

- Construction of a new road
- Upgrading/extension of existing roads (e.g. adding two lanes)
- Rehabilitation of existing roads (e.g. replacing wearing course or drainage system)

Construction method as well as design may vary depending on the type of construction. Nevertheless, the technical aspects as described below generally remain.

2.2 Design of Roads

2.2.1 Determining Factors for the Design of Roads

The determination of the final route and the structure of a road are influenced by many different factors.

Expected traffic load:
Based on traffic models and the available figures on traffic flow (e.g. results from traffic census), a forecast of the future traffic load for the road to be built or upgraded is

established. This is also the basis for the definition of the size of the road (e.g. number of lanes) and the design of the pavement.

Maximum Speed:
The allowed maximum speed has a direct impact on the required stopping sight distance and therefore on the definition of the width of lanes, radii of curves, vertical alignment (radii of curvatures) and gradient.

Topography:
In flat areas, only minor structures like culverts, flyovers etc. are required, whereas in hilly areas with rivers and valleys the number of bridges and tunnels to be built is much higher and so is the quantum of earth to be moved (dams, cuts). In this case, the overall costs for the road can multiply.
It also has to be considered that the flood exposure in hilly areas with a lot of rain is high.

Geology / Soil Conditions:
Detailed knowledge of the geology and soil conditions along and adjacent to the planned road is crucial for the adequate design and construction of the road. The implied soil investigation program has preferably to be developed by an expert who is familiar with the local conditions.
A detailed geological survey report is the basis for the design of embankments, slopes, foundations and the road body.

Climate and Natural Perils:
Flood, storm and earthquake exposure are to be considered when designing a road. The possibility of frost is also a major issue for the durability.

International and Local Standards:
Roads have to be designed and built in line with internationally recognized standards like British Standards BSI, AASHTO (USA), Eurocode. In a number of countries, local standards taking the local conditions into account are used.

Local Regulations and Laws (safety, speed, etc.):
Parameters like design speed, safety measures and others are often specified by local regulations and laws.

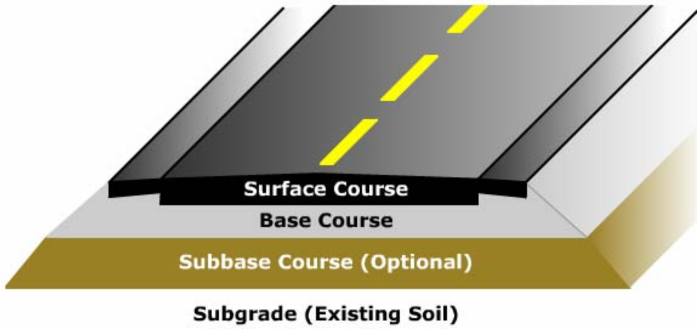
Existing / Third Party Property:
A road in 'greenfield' entails fewer restrictions for the design and construction than a new road or the upgrading of an existing road in an urban area.

2.2.2 Determination of the Route

In consideration of the above factors, the final route of the road can be evaluated. The connection of two points is usually made by adding up geometrical elements like straight line, circles with appropriate radii and clothoids as a transition from a straight line to a circle element.
The geometrical form of the road has to be aligned to the local topography. It is important to have a high comfort and security at any point of time even when driving at the maximum allowed speed.
In some cases, the optimal route must be adjusted in order to avoid bad soil conditions, negative impact on existing property or excessive noise emissions to existing settlements.

2.2.3 Road Structure

The cross section of a road consists of lanes for traffic like cars, trucks, buses, bicycles and pedestrians. Depending on the road category, further elements like hard shoulder, curbs and grass strips are added on both sides and/or in the middle of the road.
The purpose of the road structure is to carry the load of the traffic and to enable safe and comfortable driving.
A typical road pavement consists of several layers, consisting of different types of materials chosen for their particular properties, such as: Smooth ride, impervious to water, skid resistance, texture, load spreading ability/strength, drainage, etc.



Wearing Course (surface):
The wearing course is the top layer of the road pavement and is usually designed to be impervious to the ingress of water, have an even running surface, durable, have a high resistance to skidding and chosen so as not to deform under the weight of traffic the road is designed for. It is made of asphalt and laid on top of the base course.

Base Course (binder):
The base course is a load spreading layer, spreading the load imposed on the wearing course over a wider area of the road base.
Also, the base course is laid to tight tolerances with a good surface. The wearing course can then be laid accurately to "line and level" and will, therefore, produce a better ride quality. It consists most commonly of bituminous material, and can be either hot rolled asphalt or dense bitumen macadam.

Road Base:
The road base is the main load-bearing / load spreading layer of the road structure and is usually 100mm or thicker, depending on the traffic load the road is designed for. As the base course, the road base is made of bituminous material, i.e. dense bitumen macadam or hot rolled asphalt.

Road Base

Sub-Base:
This particular layer in road pavement construction is quite often used to refer - somewhat misleadingly - to the material granular sub-base (GSB). Granular sub-base is usually the material used in the sub-base layer, however, materials other than GSB can be used. Granular sub-base is a graded granular material, usually "hard rock". The sub-base can also be designed to act as a drainage layer, which in turn makes a drainage system necessary to remove the water from the sub-base.
The sub-base acts as a load spreading layer - also during construction, when it carries heavy site traffic and in addition protects to a certain extent the subgrade (as long as conditions are not too wet). Since the introduction of a capping layer material this role of GSB has become somewhat less important.

Finished Sub-Base

Capping Layer:
This is the material used in road construction as part of the earthworks at below sub-base level. The intent is to utilize cheap locally available material to reduce the use of more expensive sub-base material.
Crushed top rock, scalpings, as-dug sand & gravel are examples of material which may be suitable. The accent should be on simplicity of production in line with the low cost concept of the material. As an alternative, cement stabilization or lime stabilization are also permitted.

Subgrade (Soil):
The subgrade is the layer of naturally occurring material the road is built upon, or it can refer to the imported fill material that has been used to create an embankment upon which the road pavement is constructed. The strength of the subgrade or the material constituting the subgrade is commonly measured using the California Bearing Ratio (CBR) test. The strength of the subgrade is an important factor, influencing the thickness of the road pavement design. Where the subgrade is weak, i.e. carrying a low CBR, it will be necessary to have a capping on top of the subgrade to increase the strength before the actual road pavement thickness is designed.
In some cases, the soil is further improved by sand-drains or even replacement of the soil in order to achieve the required bearing capacity.

California Bearing Ratio (CBR) test

Various materials are used for the different layers. Naturally occurring material like hoggin (mixture of sand and gravel), crushed rock from quarries, limestone, marine aggregates, bitumen or the previously excavated material on the site have been used for road construction for decades. In the course of the past years, some of these materials are occasionally replaced by residual materials from the heavy industry like slag from blast furnaces or incinerator bottom ash which have proven to be suitable for the purpose.
Whichever material is used for the specific layer it is of utmost importance that it fulfils the requirements like grading, density, binder content and strength as defined in the specifications (see also quality assurance, chapter 3.5).

2.2.4 Structures

Depending on the topography, existing roads, railways and the density of residential and industrial buildings, a large number of structures may form part of the project. Ancillary structures would include

Culverts:
Existing streams and rivers need to be channelled and diverted underneath the road. In case of small streams and creeks this is usually done by means of pre-cast concrete pipes of different diameters. In some cases, culverts are cast in situ with rectangular cross sections. Depending on the soil conditions, adequate foundation like piling must be applied.
Similar structures are used for existing services like pipelines and cables which have to be lowered or diverted as well as for new pipelines which have to be drilled using directional drilling or micro-tunnelling below existing roads.

Underpasses:
In order to avoid interference with existing roads, railways or pedestrian ways underpasses are often being built. Normally these are simple structures cast in situ with minor spans of max 8 metres and a height of around 5 metres. Again foundation like piling is required in case of difficult soil conditions.

Overpasses:
Like underpasses, overpasses are built in order to keep a steady traffic flow in all directions. They are simple bridge constructions with usually one main span of up to 20 metres and a standardized design. Depending on the soil conditions the foundation has to be adapted.

There are, of course, also major structures like tunnels, bridges and flyovers. However, as mentioned before, these shall not be further described in this paper.

2.2.5 Cuts / Slopes:

In order to fulfil the requirements regarding maximum inclination and minimum radius of curvature, hills have to be partly removed which, in some cases, result in large cuts with high slopes. Such slopes have to be designed and constructed considering the soil conditions and using appropriate measures like shotcrete, rock bolts, anchors, stabilization by adequate vegetation and many others in order to prevent the collapse and erosion of the slopes.
It should be also mentioned that focus should not only be on the final stage of the slope but also on the different stages during construction.
Retaining walls are required in narrow conditions with limited space for slopes.

2.2.6 Embankments:

The purpose of embankments is similar to the one of cuts. As opposed to cuts, embankments are built by compaction of several layers of aggregates of up to 1 metre thickness each, which then carry the road. It is important that the compaction is done properly and that the individual layers are not too thick in order to get the required compaction strength. On the other hand, the bearing capacity of the subsoil must be sufficient to carry the load of the embankment and some time – usually in the order of weeks up to several months - is necessary to let the subsoil consolidate.
In areas with frequent inundations, embankments are also used to protect roads from flooding.

2.2.7 Drainage System:

Part of the drainage system is used to drain the ground in the area of the road in order to maintain stability of the subsoil and road structure (Including slopes and fills). As the water is not contaminated, it is collected and transferred into existing local water courses such as rivers and lakes.
The surface water drainage system is close to the surface and must on one hand be designed to carry a maximum flow of water resulting from heavy rain and on the other hand to collect dangerous fluids like oil or chemicals spilling out of a tanker truck after an accident. The maximum design flow of water is usually determined on the basis of the relevant return period for rain (e.g. 20-25 years). As the surface water is usually contaminated with residues of rubber tyres, oil, grease and fuel, such water must be collected and properly treated prior to discharge into local water courses.

2.2.8 Technical Installations:

In order to maintain high safety standards, roads are equipped with adequate signalling and lighting installations. The signalization is usually determined by local regulations and standards.
For protection against damage, cables are laid in buried pipes running along the road or in the sub-base. Quite often telecommunication companies, power and gas utilities as well as other parties take advantage of the ongoing works and put their pipes and cables along the road or in the road body. Early consideration of all interests of the various parties involved makes the coordinated and uninterrupted execution of the works much easier.

2.2.9 Buildings:

Along with the construction of the main road a few buildings are sometimes included in the project. Maintenance buildings are used by the operator of the road. They include offices as well as storage areas for materials, spare parts and maintenance equipment and also parking facilities for heavy vehicles. Depending on the length and the road category, service stations are included. For concession roads, toll stations have to be built.
These buildings are usually standard structures which have to withstand wind and snow loads.

2.3 Construction Costs

The average total construction costs vary between 250,000 and 750,000 USD per lane and kilometre (excluding land acquisition costs). This estimate applies for roads in average geological and topographical conditions and excludes costs for large structures like tunnels and bridges. The level of construction cost is also highly dependent on the cost level in different countries.
Where tunnels and bridges form a major part of a road project, the average costs can be much higher.

In general, total construction costs can be split as per the following breakdown:

Earthworks	15 – 30%
Sub-base, road base and base course	15%
Wearing course	15%
Drainage	15%
Signalling and lighting	5 – 10%
Structures (e.g. underpasses, flyovers, etc.)	5 – 10%
Incidental costs (site clearing, transportation, landscaping, etc.)	20 – 30%

2.4 Site Organisation

Road constructions are typically linear construction sites with all the different works going on at the same time on different stretches.

After the site setup (camps, offices, etc.) the works usually start with the earth movements at several locations, using heavy equipment like bulldozers, earth moving trucks, scrapers and graders. This also includes the cuts and embankments. The slope protection has to be applied according to the design. The compacting for the embankments is done by means of large vibrating rollers.

Earth Works

The subsoil is improved to the required condition. Trenches are excavated and the cables and pipes are laid.
As a next step the road structure is built up layer by layer. Finally, the signalization and lighting is installed.
Buildings and structures are usually built by separate teams or subcontractors at the same time as the main construction works on the road are ongoing.

In order to minimize the construction time, the contractor will usually choose to start the works at several locations at the same time. This also leaves more possibilities to expedite the works in case of a delay on one stretch.
Another advantage of this approach is that the material which is excavated in one stretch can be used e.g. for embankments in another stretch in case the quality of the excavated material proves to be adequate.

A much higher degree of complexity involves the upgrading of existing roads in urban areas where the traffic flow needs to be maintained during the whole construction period. In these cases the emphasis is on the planning of the construction sequences and the minimization of disturbances on the ongoing traffic and existing property.

2.5 Quality Assurance

2.5.1 Testing

In order to achieve the quality of road construction defined in the specifications, a detailed testing programme must be in place and complied with by all parties involved. The testing plan should entail predefined tests on site as well as in workshops, quarries, gravel pits and other material deposits.
The used material has to be tested with regard to their suitability for the construction. All the requirements like grading and strength have to be met in line with the design specifications.
Samples must be taken with a predefined frequency from the finished road and tested (e.g. drilling cores).
Additionally, the bearing capacity of the subsoil (subgrade) and the compacted layers must be tested using e.g. the CBR test or plate test, and have to be reported to the design engineer and the geologist. Parameters which form the basis for the design must be reconfirmed by these tests. If the specifications cannot be met by the results achieved, the design must be adapted to the new parameters.

Plate Test

2.5.2 Monitoring

A lot of damage can be avoided or diminished by applying a suitable monitoring system on the site. Preferably, the monitoring system should be designed and maintained by an independent engineer in order to avoid conflicts of interest.
By monitoring deformations (e.g. using slope indicators), cracks (e.g. visually) and subsidence (e.g. geodesic surveys), potential failures can be detected at an early stage and the appropriate mitigation actions can be applied, hence avoiding further damage.
In areas with groundwater and especially if lowering of the water table is planned, the level of the ground water table must be constantly monitored (e.g. by means of piezometers).
The monitoring system shall entail the frequency of measuring, definition of the measuring points, allowable limits and possible mitigation actions in case the limits are exceeded.

If existing or third party property can potentially be affected by the construction works it is vital to take evidence of all existing damages like cracks etc., prior to the start of works in order to avoid future confusion about the cause should new damage be reported.

3. Typical Exposures

The following exposures will be analysed in the paper according to the following structure:
- Definition of Exposure
- Typical Loss Scenarios
- Underwriting Considerations (Scope of cover, typical endorsements, etc.)
- Risk Management / Mitigation during Construction
- Safety and Security Aspects

3.1 Natural Catastrophes

Typical Loss Scenarios of Natural Disasters:

As land use gradually increases, flat areas which are safe for construction works decrease in number and thus underground works such as shield tunnelling and cut-and-cover tunnelling increases in flat areas. Even for road construction on the surface, construction tends to increase in areas where the ground conditions are poor, such as reclaimed land. Furthermore, since high standard roads are being built in all areas of the country, the chances increase where road construction is carried out on steep slopes such as the shoreline or mountainous regions, which increases the effect of natural disasters to road constructions.

Various natural disasters such as earthquakes, windstorm and flooding, tidal waves and volcanic activity affect road construction, similar to completed roads. The most prominent natural disaster, both from the standpoint of frequency and damageability, is the water hazard. Although exposed to a lesser degree than tunnel or dam construction, road construction is also affected by water hazards. Other than tunnels and bridges, road construction on slopes tends to be affected most by natural disasters. When constructing roads on slopes, the upper side of the slope is shovelled out (Cut) and shifted to the lower side of the slope (Fill). As this process makes the slope less stable than a natural slope, it may collapse and create a landslide disaster. Especially during the construction phase, the soil is in a very weak condition since the protection works to stabilize the slope is not completed, and the underground water level is in a shifting state.
Types of losses are the burying of the road construction due to the landslide of the upper side of the slope, or the road and lower side of the slope collapsing causing subsidence or washing away of the road surface.
Factors that increase the moisture of the soil which in turn causes the collapse of the slope are rainfall or snow thaw, and changes in water levels of nearby rivers and lakes.

As outlined above, insurance damage caused by water accounts for the majority of losses in road construction. Most of them are caused by lack of experience, inadequate design and carelessness. The most essential risks are outlined below.

Rain:
Heavy or long-lasting rain can wash away (erosion) unprotected, incomplete or inadequately stabilized road sections. Inadequately designed or missing drainage systems (culverts, ditches and other facilities) of the road under construction may result in flooding. The infiltration ability of the soil as such plays an important role for the design of appropriate drainage systems. It is of paramount importance that the contractor maintains draining systems well during construction and that unprotected road sections are kept at a minimal length.

Flood and Inundation:
Roads along nearby rivers, lakes or other water bodies are exposed to flooding. During rainy seasons the water level can rise significantly, even beyond river banks, causing extensive flooding of the construction area. In particular rivers running parallel to roads over long distances may heavily damage the construction works, especially if culverts are under-designed or obstructed by debris.
For unprotected, incomplete and inadequately stabilized road sections the same hazard of washing away (erosion) applies.

Snow and Ice:
Snow will normally cause losses to road construction only if it appears in the form of avalanches, in particular if sizeable quantities of debris are carried along. This risk is extremely important to consider for roads in mountainous regions.
Ice or rather frost may, however, cause considerable damage to large sections due to frost weight and settlement, surface roughness, damage to surface treatments, loss of compaction and loss of strength during thaw. Retaining walls may be damaged by this effect too.

Other natural perils to be considered are the following:

Earthquake:
Depending on the construction area, earthquake is an important risk factor. The following points should be considered to assess the extent of the risk:
-Probability of the earthquake exposure in the area of the construction works
-Whether or not the construction location is on or near any known active faults
-Whether or not the construction location is near hypocenters of previous earthquakes
An earthquake of a certain magnitude can cause severe damage to the works under construction. The probability of such losses is lower than in the case of water damage, the severity, however, is usually very high. The exposure area with its return periods as well as topography and geology must be adequately considered not only in the design of the road as such, but also for its infrastructure like technical installations and buildings. Particular exposures exist in hilly and mountainous areas with steep slopes, where sections of roads under construction can collapse or can be buried by landslides and rockfalls. In addition, sections under construction or already completed as well as underground services can be ruptured as a result of an earthquake. In soils with high water content (e.g. reclaimed areas), the phenomenon of soil liquefaction can cause extensive damage to the road and its infrastructure.

Windstorm:
Road construction works are less exposed to windstorm as such. A certain exposure does exist for structures and buildings under construction, where strong winds can affect the stability of formworks and scaffoldings.
In deserts or desert-like areas, on-site filling material deposits or the already completed sub-base or basecourse can be contaminated by drifting sand during sand storms. The contamination may lead to a too high content of fine and finest materials in the sub-base and basecourse material. This usually makes the complete replacement of the contaminated material necessary if the composition of the material does not fulfil the given standards anymore.

Underwriting Considerations and Risk Assessment Points:

Underwriters must have evidence that the contractor has gathered sufficient statistical data with respect to hydrology, meteorology, earthquake and windstorm and - most important - that those have been considered in the design of the project.

It is important that underwriters require information relating to existing water bodies in the region and their proximity to the site, the flood history, the return period applied for designing culverts, ditches and other protection facilities as well as for the road works as such. The time schedule should be arranged in such a way that the most exposed works can be carried outside of flood seasons. The number of open works sections has to be taken into consideration, as if more than one section is worked upon, the possibility of expediting the works after a claim, increases.
In areas with substantial earthquake exposure the local and international earthquake building codes must be considered in the design of the road construction as well as for the road infrastructure, buildings and structures.
In respect of windstorm, the local seasonal wind speeds must be considered with a reasonable return period (e.g. 25 years).

The following insurance clauses are worthy of consideration:

- Warranty concerning sections (max. indemnifiable length/section) – (MRe Endorsement. 106)
- Warranty concerning safety measures with respect to precipitation, flood and inundation (MRe End. 110)
- Warranty concerning construction material (MRe End. 109)
- Special conditions concerning the erection/construction time Schedule (MRe End. 005)
- Warranty concerning structures in Earthquake Zones (MRe End. 008)

Slopes of cuts and fills are particularly sensitive to the influence of natural catastrophes. The following measures are necessary to prevent the collapse of slopes as a result of natural disasters:
-Conducting a full soil investigation prior to the construction works
-Gradient pitch of the slope is correctly determined
-Slope protection works are appropriately scheduled
-All phases of the construction schedule give due consideration to climate conditions of the worksite

Soil conditions:
When conducting a soil investigation (which includes prior investigation history and any existing documentation), it is preferable to investigate the soil condition of the general surrounding area and the slope area, and not only the road surface area.
Of the factors related to soil conditions, the main factors affecting the construction are the particle distribution of the soil, the inclusion of gravel and cobblestones in the soil, moisture content of the soil, whether or not special substances such as volcanic ash are included, and manoeuvrability of construction machinery on the soil. For rock surfaces, the hardness of the rock, degree of cracking and weathering, and condition of the adjoining strata layers should be taken into consideration.
The soil condition of the worksite should be determined from the rock and soil categorization obtained from the seismic prospecting and boring investigations. Especially in cases where the soil investigations reveal special soil which is vulnerable to slope erosion during rainfall such as volcanic ash type cohesive soil, sandy soil, weathered granite and highly organic soil, slope protection must be carried out carefully. Extra care is also necessary if there are landslide areas and steep slopes at or in the vicinity of the worksite.

Gradient pitch of the slope:
In determining the gradient pitch of the slope, investigation reports about the geological surroundings, soil conditions, subsurface water and climate conditions of the worksite, should be taken into account. For the following cases, careful analysis regarding ground stability should be carried out to reflect the reports of the soil investigation:

-Cutting out large scale slopes
-Areas consisting of talus cones, debris flow, heavily weathered slopes and

subsidence areas where the gradient pitch of the natural slope itself has reached a critical condition
-When cutting out soil such as ash strata or decomposed granite, which is extremely vulnerable to erosion by surface water
-When cutting out rock that quickly deteriorates after cutting out such as mudstone; similarly when cutting out rock with various cracks or weaknesses in fault patterns
-Filling of sloping grounds or weak grounds (such as paddy fields)
-Slope works adjacent to roads, railroads or housing areas
-When filling material is not appropriate
-etc.

Slope protection works:
The types of slope protection works are earth anchoring, concrete/mortar spraying, rock/block covering and vegetation growth.
Slope protection works by structures are carried out to protect the slope in cases where protection by vegetation is not sufficient to stabilize the slope due to the steep angle, slopes consist of rock with poor soil accumulation where vegetation cannot grow, slopes with a possibility of falling rock, and economic concerns or the land condition does not permit a mild sloping. In such cases, rock, concrete or metal is made into artificial structures to protect the slope. Furthermore, retaining walls are introduced where it is not possible to construct slopes with standard gradient pitch due to the structures and land condition, or to avoid the construction of a large slope which is more advantageous in terms of stability.
Vegetation works cover the slope with vegetation and prevents surface layer sliding and erosion by rainfall, prevents blowing away of surface soil, reproduces the natural environment by means of seed dispersion and laying pieces of turf, which is the most economical and visually attractive means of construction. However, this is not possible in steep slopes.

Risk Management of the Risk Assessment Points mentioned above:

One of the contractor’s prime duties is to gather hydrological and meteorological data of the region going back to an observation period of at least 25 years. For earthquake, even longer observation periods are necessary to get a somehow reliable picture of the possible exposure. The longer the observation period is the more reliable the statistics are. However, these data alone have little value unless they are used as design factors.

Weather conditions on the other hand ought to be observed daily and the project schedule should allow certain flexibility for adaptation in case of particularly adverse weather conditions like in typhoon or cyclone exposed areas. Good risk management practise also requests the contractor to study and work out possible worst case scenarios with respect to natural catastrophes and to have adequate counter measures planned and prepared in advance.

When conducting the monitoring, it is important not only to monitor short term rainfall such as hourly and daily rainfall to get an idea of rainfall at the worksite, but also to monitor the accumulation of rainfall by the week or month to estimate the moisture content of the soil, and if necessary to suspend any cutting or filling works if the moisture content is considered at a dangerous level. In particular in typhoon and hurricane exposed areas it is highly recommended to maintain contact with a nearby meteorological station and to have an emergency plan established in case of a typhoon or hurricane approaching the project site.

3.2 Faulty Design, Material and Workmanship

Definition of Exposure:

Road Construction consists of different types of structures. It is a complicated puzzle where a number of different design aspects play an important role. As mentioned in various parts of this paper, important design factors to be considered are

- Traffic load
- Design speed
- Geology
- Topography
- Exposures to natural perils like
    - Earthquake
    - Water
    - Possibly storm,

just to mention a few of them.

Incorrect consideration or even non-consideration of these parameters in the road design may lead to serious losses during construction or during the maintenance period.

Faulty material often involves the use of materials not classified for the construction, e.g. sub-base or base course materials of faulty composition or wearing course material which does not fulfil the specifications.

Faulty workmanship may, for example, result in insufficient compaction of the various layers of the road structure.

Typical Loss Scenarios and Underwriting Considerations:

As with the design, faulty material as well as faulty workmanship can produce severe losses. A portion of the road, of an embankment or of a slope may suddenly collapse during the course of the construction works as a consequence. In the majority of the cases, however, the consequences show only at a later stage, i.e. after some months of operation under traffic loads. In these cases, the question will arise whether the loss is covered under the maintenance cover of the construction policy, if applicable, or under the operational policy, if such a policy does exist.
Particular attention must be drawn if sections of the road are taken into use and remain covered – often for periods of up to one year or more - until the whole of the construction works can be handed over. Such operational cover within the construction policy constitutes a substantial risk aggravation, in particular in the light of cover for faulty design, material and workmanship.
If it comes to a loss under the cover for faulty design, material and workmanship, the question about what will be the faulty part will immediately be raised. No doubt – depending on the interests involved by the various parties the definition will vary between the faulty grain of sand in the filling material and the road body as a whole. Underwriters are well advised to define the faulty part in the policy wording in advance.
Roads are vertically built up structures with one layer directly built on top of another. With the exception of the wearing course, no other layer or the dewatering system or cable canals can be replaced without destroying the good parts of the structure. Therefore, a definition commonly used is that the road body as a whole is faulty if one of its elements suffers from faulty design, material and workmanship.
A Clause to reflect the above could read as follows:

"It is understood and agreed that in relation with the different layers (subbase and granular base, capping layer, wearing course, soil improvements, curbstones, etc.), which constitute the different types of road surfaces and pavements for roads, pedestrian zones and large areas, are seen as a whole in respect of the application of the coverages and exclusions of the policy, i.e. they are treated as one entity of the works."

Risk Management and Mitigation:

Due consideration of all elements necessary for the sound design and execution of the road project is the basis to eliminate most of such losses. As outlined in the next chapter, this can only be achieved if experienced and qualified parties are involved in the design and execution of the road project. In addition, it is most important that a broad and structured testing and monitoring programme is in place (see 2.5 Quality Assurance). Insurers and reinsurers can add by frequent risk surveys, where these points are carefully observed and discussed with the insured parties.

3.3 Contractors and other Parties involved

Definition of Exposure:

Any kind of civil engineering or building project – ranging from a detached house to a high-rise building or a hydro-electric power plant is born as an idea to satisfy private needs or to realise business opportunities. Whether initiated by a private party or a public body, needs and objectives of the project must be carefully evaluated and clearly defined. To achieve the defined objectives of a project, a number of different parties are involved from the first idea on the drawing board to the actual completion and entry into service.

Even in a very small project at least two parties are usually involved. This becomes much more complicated in large scale projects. Many different parties – quite often even from different cultures – need to communicate and to interact with one aim in mind: To successfully complete given tasks and objectives within specifications and budget.

Parties to a project:
- Principal (public or private)
- Contractor and sub-contractors
- Suppliers and sub-suppliers
- Engineering consultant
- Architect
- Financial institutions
- Authorities
- Insurers and reinsurers
- Independent Engineer

The successful completion of a project highly depends on the competence of the individual parties and the communication amongst them. All of those involved in the planning and execution of the project must be qualified for the particular type and scope of works.

Another important element is the communication between the parties involved. This applies not only for large-scale projects, it is equally important for small projects. Missing communication often results in misunderstandings with severe consequences for the project and the insurers.

Typical Loss Scenarios:

A very important element is the experience of the contractor in a particular environment. Soil conditions, exposure to natural perils, political environment etc., varies greatly from country to country or even from region to region. Contractors and consultants must be aware of the environment they are exposed to and take all the necessary steps to adequately consider the local factors during planning and execution of the works. Difficult conditions must also be taken into consideration in the budget. The result for insurers can be disastrous if these factors are not properly checked in the underwriting process. This is illustrated by the following example:

A contractor in the Middle East was assigned with the construction of a road through the desert. In order to take advantage of a relative flat and easily accessible construction area, the road was built in and along a “wadi” (dry river bed). The project was almost completed when a flash flood caused by heavy rainfall far away completely destroyed several kilometres of the road. This major loss happened because the local circumstances were totally neglected in planning as well as in execution of the road.

Underwriting Considerations:

In particular with complicated projects the underwriter is well advised to carefully check the qualifications and experience of the parties insured. In addition, the “loss history” of a contractor provides an important element in the risk assessment process.
The successful completion of the works highly depends on the number and qualification of the contractor’s workers and supervisory staff. This is for insurers one of the very important points to be observed. Well trained – also in site safety matters - and dedicated staff is one of the key factors for a successful and loss-free project. The necessary information can be gathered in a structured and standardized way by using the construction insurance questionnaire.

Risk Management:

Experienced and well-trained staff, familiarity with the environment as well as good relations between the parties involved are key factors for a successful project. Insurers play insofar an important role as they need – in particular in large-scale projects – to stay in regular contact with the parties insured and contribute with their experience to the risk management process. Insurers must also check that communication channels and schedules for regular meetings are established and executed.

3.4 Third Party Liability aspects

Definition of Exposure:

With this cover extension (wording based on Munich Re English Standard CAR/EAR Wording Section II) Insurers agree to indemnify the Insured against such sums which the Insured shall become **legally liable to pay** as damages consequent upon:

a) accidental bodily injury to or illness of third parties (whether fatal or not)
b) accidental loss of or damage to property belonging to third parties

occurring in **direct connection with the erection, construction or testing** of the items insured under the Material Damage section and happening on or in the immediate vicinity of the site during the Period of Cover.

In respect of an indemnifiable TPL claim the Insurers undertake to indemnify the Insured against the following additional costs and expenses:

a) of litigation recovered by any claimant from the Insured, and
b) incurred with the written consent of the Insurers,

Especially for road constructions extension of coverage to include TPL cover is very common and the amounts usually required **per event** tend to be moderate to large, i.e. between US$ 5 Mio and 20 Mio.

Underwriting Considerations incl. typical Loss Scenarios:

For assessing the TPL exposure one should make the distinction between:

- **roads in rural areas** where the possibility of concurrent traffic during construction is rather low unless the project relates to the expansion of existing highways etc., e.g. addition of new lanes, re-pavement works. For such projects however, in no case should the underwriter underestimate TPL exposures relating to neighbouring farms, neighbouring industries that can be damaged by the execution of the insured works (blasting works), concurrent construction works by another contractor, etc.

- **road in urban areas,** where concurrent traffic is in most of the times allowed during construction, the TPL exposure aggravates significantly. Loss or damage to surrounding constructions is not insignificant either.

The **country factor** should be considered in the following manner:
For projects situated in litigious countries like USA, the underwriter has to take into account the aggravated exposure. In developing areas as well, the public is gradually becoming aware of their rights and frequency of TPL claims increase rapidly as well as the amount claimed.

Roads in mountainous areas certainly increase the potential of TPL losses by high probability of landslides (major excavation / anchoring works / retaining walls change the soil stability).

Intense **weather influences** such as heavy or longstanding rain may result in flooding of the surrounding crops and farms.

Surrounding structures (buildings, bridges, etc.) adjacent to the road under construction can be severely damaged by construction machinery/traffic, by vibration, overloading, piling & underpinning works.

Road construction causes frequently a considerable amount of dust and this may result in sizeable claims from farmers, factories, etc.

The financial impact (loss of revenue, land devaluation, etc.) on existing facilities (hotels, industries, etc.) in the vicinity of the road project must not be underestimated either.
Some **typical loss scenarios** help to better understand the impact:
- Decrease of number of guests in an adjacent hotel, which as a consequence loses anticipated income.
- Landslide affecting a nearby railway track that has to be closed down for a number of days resulting in loss of revenue for the railway company.

Usually, insurance contracts for road projects suffer from smaller and frequent TPL losses rather than large ones. Administration costs and loss adjusting fees as well as extra costs for appointing external experts must be taken into account, as in some cases these may reflect a significant (up to 50%) amount of the claim.

TPL during Maintenance Period:
The probability for claims increases tremendously by virtue of the fact that the road is already given for public use. The underwriter must carefully analyse and evaluate the exposure and apply adequate pricing. A good level of deductibles is recommended in order to avoid smaller and frequent claims.

Losses or damages caused by Third Parties:
It is not unusual for a road project to have parallel construction works for building of bridges, tunnelling, parallel roads or railways, other sections of the same road, interchanges, underpasses, etc. These works constitute separate projects and are executed by independent contractors, which subsequently must be considered as “Third Parties” towards the insured project. Although not with high probability, considerable material damages, such as deformations, landslides, cracking and subsidence, can originate by the “Third Party” projects.

Surrounding industries such as a quarry in the neighbourhood of a road construction in a mountainous area involve interval blasting that unless properly coordinated and executed may cause severe damages to the insured project.

The underwriting information available shall cover these aspects too and cautious analysis of the related exposures must be included in the underwriting process.

Risk Management during Construction:

Insurers ought to be in regular contact with the project manager who is taking care of proper risk management. The underwriter must have a certain degree of comfort about the loss prevention measures applicable on the site. A sound risk management plan on site shall address the following elements:

- Identification of above exposures should already start before the construction works begin.
- Awareness of surrounding structures, farms, etc. should be the prime concern of the contractor.
- Inspection of structural condition of existing structures and liaison with the owners of the surrounding buildings helps to eliminate claims arising out of pre-existing structural deficiencies.
- The project manager should do his utmost to synchronize construction time schedule with agricultural demands of the area.
- Works signalization and safety measures should comply with applicable road code of practice and state of art, e.g. fencing of construction site, evident maximum speed limit, flagging, assign personnel that takes care/regularly controls/maintains of safety and security measures.
- An advance communication should be sent to the inhabitants to advise of planned works that may disturb day to day activities.
- Awareness of other projects running simultaneously in the immediate vicinity of the insured project is required. The insured contractor shall liaise with the “Third Party” contractor(s) and coordinate works that may affect his project in order to avoid unpleasant surprises.

Remark: For further general TPL related issues, please also refer to IMIA WGP 40 (05) EAR&CAR – Third Party Liability – Existing and Surrounding Property

3.5 Topographical Exposures

Definition of Exposure and typical Loss Scenarios:

a) Projects in rural areas:

Roads through hills and/or mountains can suffer from rockfalls, landslides, adverse weather conditions (snow, avalanche, ice, low temperatures, etc).
Also, projects through mountainous landscapes require extensive blasting works which subsequently increase the probability of landslides (unstable slopes affected by blasting) with potential soil deformation. Damages to surrounding structures (TPL claims) should not be excluded either.

Roads in flat areas which are prone to flooding because of neighbouring water bodies, inundation or sandstorms.

b) Projects in semi-rural areas (housing/industrial sites, air fields):

It is essentially the same type of exposures as outlined for category a), however, an escalated TPL exposure must be taken into account because of higher intensity of population and traffic demand.

c) Projects in towns or villages:

The TPL exposure is predominant with emphasis on maintained traffic, underground pipelines, cables, etc., and existing structures.
A special warranty relating to underground pipes, cables and other facilities has to be considered when underwriting the risk.

d) Projects in high value agricultural areas:

The following exposures have an increased probability:
- generation of dust during construction
- flooding due to inadequate drainage system of the road under construction or excavation material dumped on adjoining land disturbing regular water flow.

Underwriting Considerations:

In general, the underwriter must receive comprehensive information about the situation of the project so that the related exposures can be identified and evaluated in the underwriting process.

The time bar chart of the project is surely a useful tool for the underwriter in order to identify exposed sections (e.g. works in rainy season) and recommend precautionary measures or exclude highly exposed works which might produce foreseeable losses.

Time permitting, a site inspection on behalf of the insurance company can be arranged, which would surely give a more precise picture of the topography and the relating exposures.

It is wise to complete such site visit with a report with findings and improvement suggestions and a meeting with the project manager to discuss the way forward.

Depending on the topography in consideration, the introduction of the following special warranties and clauses might be considered:

- Exclusion of loss or damage to Crops, Forests and Cultures.
- Removal of Debris from Landslides (MRe 111) to eliminate the effect of possible soil deformations
- Application of safety measures relating to precipitation, flooding and inundation (Mre 110)

Risk Monitoring:

In some extreme case where it becomes evident that the topography of the region would create severe problems in works execution for some sections or would lead to uneconomical solutions, the contractor must be reasonable enough to consider an alternative route for the particular sections.

3.6 Geology / Hydrology and Soil Conditions

Definition of Exposure:

Geology/hydrology and soil conditions are decisive factors for the route of the road and moreover for its design specifications as well as for its financial design. The project must not be either over-designed resulting in waste of money or under-designed leading into endless troubles during construction and later on during operation.

Soil quality can vary from stable such as rock or gravel to soft/unstable such as clay and sand. Roads often extend over several kilometres and subsequently involve various types of soil. It is the contractor's/principals' responsibility to adequately investigate the subsoil conditions by means of soil sampling as well as field and laboratory testing. Professional contractors/principals usually cooperate with experienced geologists, which can perform sound soil investigations. Local know-how of geologists is as well required to understand long term pattern of soil development/movement. The number of bore-holes drilled, and their depth, depends on the geology of the area, the size of the road and the complexity of the construction. Hydrological investigations are done in the same course of actions. Trying to save money on this preliminary soil analysis may prove to be very costly later on during the construction phase.

Roads are susceptible to Earthquake. The subsequent damage may not only be rupturing of the surface but vertical dislocation of one side as well. Such displacements can be significant. As roads extend over several kilometres, the EQ exposure can vary from low to medium or even high. Existence of geological faults nearby the construction area aggravates the exposure. The fault direction relative to the route of the road and the density of faults will have to be taken into consideration in design.

Changes in ground water level (drought, rise of level) can have adverse influence on the stability of the underlying material with subsequent damage during excavations for foundations, to retaining walls as well as the road works as such.

Typical Loss Scenarios:

Some typical loss scenarios are shown below for better understanding of the exposure:

- Soil settlement may be the result of inadequate design (not allowing for the weights and loads to be transferred properly in soil) or of faulty workmanship (inadequate compacting), or of seismological activity or hydrological factors.

- Instability problems such as shear failure of the embankment on soft subsoil, slopes sliding (inadequate underpinning/anchoring)

- Intense changes in temperature including freezing of water in the road embankment can cause extensive cracking.

Underwriting Considerations:

An important piece of information for underwriting is whether the contractor has a comprehensive geological report in his possession, carried out by experienced soil engineers. The underwriter shall request and receive a copy of the findings/conclusions of the soil investigation, which is the basis for road design. If the underwriter does not have the required background to evaluate the available information, he is advised to seek assistance from risk engineering/consulting experts.

Unavailability of geological reports or use of existing reports for other similar projects in the neighbourhood should be alarming for the underwriter and cautious underwriting must be exercised.

As stated elsewhere in the text, the frequency and the chosen location of bore holes drilled is decisive for the reliability of the results. Nevertheless, the economical design of a project imposes restrictions with regard to the extent of such investigation. Thus, the underwriter shall not underestimate the possibilities of unexpected soil conditions, e.g. undiscovered faults or even new faults developing, unexpected high water table in rainy season, undiscovered strata of soft soil, etc.

Recommended special clauses are outlined below:
- The special warranty for projects in regions with medium or high EQ exposure (MRE 008)
- Exclusion of loss of damage arising out of unforeseen soil conditions

Risk Management:

Contractor’s own risk management initiatives shall be evident to the insurers. He should make available to the insurers the following information:
- Are there soil engineers specifically appointed for the project?
- Are they going to be on a 24hour basis on site? If not, when will they be on site?
- Is there a regular monitoring system of earth movements established on site?
- Is there a regular and standardized communication between the soil engineer(s) and the design engineer(s) established?

Depending on the size and the complexity of the project, insurers may consider appointing an independent expert, who would undertake to visit the project regularly, i.e. it is recommended twice a year but it could also be quarterly, especially if Advance Loss of Profit cover is attached to the CAR coverage. This expert shall be capable to identify the risks, classify them depending on the relevance to the project as well as recommend improvements for mitigating the impact, if the risk occurs. Moreover, he should monitor implementation of his recommendations.

3.7 Other Environmental Impacts

Definition of Exposure:

There is a growing awareness that road development has major environmental impacts. Some of the major environmental impacts of road projects include damage to sensitive ecosystems, loss of productive agricultural lands, resettlement of large numbers of people, permanent disruption of local economic activities, demographic change, accelerated urbanization and introduction of disease.

Since environmental impacts from road developments are quite common, such projects usually call for comprehensive environmental assessment studies carried out by professionals, who work closely and support the main engineering team.

In relation to the impacts they generate, road projects are commonly classified into one of these five categories:

- New;
- Existing (rehabilitation/upgrade);
- Rural;
- Urban; and
- Mixed

New versus Existing projects:
The key difference is that, for new projects, the focus is on preventing impacts, whereas for existing or upgrade projects, the focus is on rehabilitating and mitigating further impact.

Rural versus Urban projects:
In the rural setting the key impacts usually revolve around removal of productive agricultural lands and the opening up of previously inaccessible, territory to in-migration and large scale resource harvesting. Introduction of new sources of noise is often an issue in rural settings where ambient noise levels are usually low. Furthermore, because rural life is so closely integrated with the biophysical aspects of the environment, issues such as water quality and biodiversity conservation deserve special consideration. On the other hand in urban setting, where population density is higher the dominant impacts have to do with displacement of people and their homes, general neighbourhood disruption, local air-shed contamination and noise. In those urban areas where the mode of travel is dominated by non-motorized vehicle, access and movement restrictions become major factors to consider when planning facilities for motorized vehicles.

In reality most road projects are a mixture of rural and urban sections, since rural roads do not simply stop in the countryside but traverse, or end in, urban areas.

Typical Loss Scenarios:

The main road activities associated with road construction and their likely impacts are presented below:

- Construction Camp Establishment:

Careless construction camp design and management can lead to serious environmental degradation including sewage and garbage pollution, infrastructure loading, etc.

- Equipment Servicing and Fuelling:
  Experience shows that without a fuelling and servicing protocol as part of the project's Environmental Management Plan chronic oil product pollution often takes place
- Site Preparation and Clearing:
  These activities may involve demolition of buildings, clearing of brushwood, tree removal, temporary rerouting of utilities, topsoil stripping and diversion or re-channelling of waterways, which brings risks of erosion of exposed ground or stored topsoil, and increased water runoff and siltation of watercourses.
- Earthworks:
  The removal and placement of earth can bring further risks of soil erosion.
- Quarries and Borrow Sites:
  Significant environmental problems can develop if these sites are not rehabilitated. Impacts range from chronic erosion and siltation to air quality and noise impacts during their use as well as permanent visual and aesthetic intrusion, if rehabilitation is neglected.
- Asphalt plant siting and operation:
  On larger projects a temporary bitumen production plant or concrete batch plant is often constructed along the road right-of-way.
- Drainage Works:
  Roads often modify water flow and drainage patterns over wide areas, causing rising water levels, excessive drying, and erosion and vegetation die-off.
- Waste Management
  Construction crews, which on larger projects can exceed 1,000 people at any one time, may generate significant amounts of solid & liquid waste per day. Uncontrolled and untreated, these wastes are major sources of pollution, disrupting the ecosystem and contributing to local health problems.

Underwriting Considerations:

It is of utmost importance that the underwriter excludes from the TPL coverage environmental liability (this should be treated separately by specialized underwriters), seepage and gradual pollution.

TPL coverage must be restricted to accidental pollution only.

Risk Management:

Direct impacts of road projects can be significantly reduced and sometimes eliminated through the application of environmentally sound construction and operations management practices. For such actions to occur, the following two basic conditions need to be in place:

- a knowledgeable construction and operations management team, which is sensitive to environmental issues; and
- an enabling environment where regulatory agencies and government planners look for and encourage sound resource use.

(References: World Bank web site: www.worldbank.org/transport/publicat/reh/toc.htm)

3.8 Camps and Stores

Definition of Exposure and typical Loss Scenarios:

Depending on size of the road several camps & stores facilities along the road may be required.
These units are temporary facilities used during the construction period and are usually covered with the same insurance programme purchased for the project as such.

These temporary facilities are usually low cost constructions, e.g. containers, wooden structures, etc. and are exposed to the following perils:

- Flood:
  Careless situation of camps and storage units, e.g. nearby a water body, increases the flood exposure significantly.
- Fire:
  The temporary scope of these facilities limits the fire-fighting facilities to the use of some fire extinguishers only. Bearing also in mind that in road projects outside city limits such facilities remain unattended after the working hours, it is easy to understand why the risk aggravates. One should not underestimate the risk of arson especially for projects opposed by the public.
- Theft:
  The content of these units (tools and tackles, computers, fax machines, etc.) is surely very attractive and relatively easy to steal.

Underwriting Considerations:

The underwriter shall obtain information regarding the exact location and value of the facilities insured.
It is recommended to incorporate the following special clauses:

- Special warranty for camps & stores (MRe 107)
- Special warranty for fire-fighting facilities (MRe 112)
- Special warranty regarding Theft pre-requiring fencing of the areas where camps and stores are placed as well as 24 hour guarding of the project with emphasis on these facilities.

Risk Monitoring:

As part of a general risk monitoring plan for the entire project, emphasis shall also be given on regular inspection of the camps and stores insured with subsequent improvement suggestions, when required.

3.9 Contractors' Plant and Machinery

Definition of Exposure and typical Loss Scenarios:

As in almost all types of construction projects, construction machinery used in a road construction project represents a considerable capital investment.

Mobile construction machinery (self-propelled or not), stationary units (like processing plants, conveyor belts, crushers, etc.), mobile or stationary producing and powering equipment and machinery (e.g. for generating energy or compressed air), additional equipment like unit parts not permanently fixed to the basic equipment and spare parts are the main headings under the construction machinery.

In general, the causes of losses and damages to construction machinery can be divided into three main categories:

a) Acts of God (natural hazards)
b) Operating errors
c) Material failure

Acts of God are certainly unforeseeable for the contractor as long as he has taken the appropriate normal precautions. Typical Acts of God are flood and inundation, storm, rockslide, landslide, earthquake, lightning.

Loss or damage resulting from human error and negligence can in principle be reduced by adequate training of personnel. For the contractor, however, the possibility of an unskilled employee making a mistake cannot be avoided. Damage resulting from such causes is covered by construction machinery insurance. Typical examples here are collision of vehicles on the construction site and tipping of cranes.

The risk of theft or vandalism can be reduced by appropriate precautions such as locking up equipment, fencing the machinery park site or patrolling the construction site. But as the contractor cannot avert the danger completely and is also dependent on his employees' care in this respect, this peril is covered by construction machinery insurance in most countries.

Construction machinery is mostly subject to excessive and hard use and often operates under difficult conditions. One indication of the intensive strain and wear of such machinery is the brief average period of use, which is only around 4 years e.g. for bulldozers. As a result, construction machinery is rapidly written off.

Underwriting Considerations and Risk Assessment:

When construction machinery is to be insured, the insurer has to get an exact idea of the risk and be personally aware of the peculiarities of that particular risk. When a road construction project is under consideration, the insurer has to take into account the nature of the work to be carried out, i.e. the type of structures to be constructed (tunnels, viaducts, bridges, etc.), the amount of cut and fill works and in particular also to the topographical situation and the exposure to natural perils. Contractors' machinery is exposed to risk at a greater extent in underground works and works on steep slopes. Special care must be taken for the construction of temporary access roads.

Contrary to the project works as such, Contractors' Plant and Machinery is usually insured on an annual basis with annual premium (Munich Re or Swiss Re Endorsement for Contractors' Plant and Equipment). It is important for insurers to insist on a complete list of all items used on the site with their respective new replacement values.

The underwriters should try to introduce MRe 108 Construction Plant, Equipment and Machinery endorsement where applicable.

The location of the machinery park is of importance, however, in a road project the insurer must be aware that the machinery may just be left along the road unattended most of the time, which aggravates the theft and malicious acts risks, and underwriting has to be done accordingly.

4. Probable Maximum Loss (PML) Considerations

As experience shows – and this is impressively demonstrated by the loss examples in the following chapter – roads may suffer for various reasons severe losses during the period of construction. In order to verify what share of a road construction project a company can accept within its underwriting and acceptance guidelines, the underwriter is obliged to carefully consider the various risk scenarios and to come up with realistic estimates of potential losses.

Roads are “linear” risks which spread out over long distances. Due to this fact, it is actually unlikely that a road project can suffer a total loss. However, a “high severity / low probability” scenario is earthquake. In exposed zones and depending on the construction sequences, losses of very high magnitudes can occur, in particular if also tunnels and bridges form part of a road project.
More relevant for accumulated losses in road projects are, however, medium-sized frequency losses as a result of flood, inundation, landslides and faulty design, material and workmanship. It must be taken into account in the assessment that the single loss as such does not threaten an insurance company in its existence, but that frequent medium-sized losses can add up to very high total amounts during the construction and maintenance period.
Total loss scenarios need to be taken into consideration in the case of smaller local roads in very flood-exposed (heavy rainfall within very short periods of time) areas. It must be noted that such scenarios can occur almost everywhere – during a typhoon in Southeast Asia as good as during a short summer thunderstorm in central Europe. Roads built along “dry” riverbeds in deserts or semi-desert areas have also a good chance to be totally washed away during a flash flood.

Underwriters can minimize the loss potential by limiting the length of open work faces and the length of all work faces combined in the policy conditions (Warranty concerning Sections – Mre Endorsement 106).

IMIA describes the PML as follows:

“The Probable Maximum Loss (PML) is an estimate of the maximum loss which could be sustained by the Insurers as a result of any one occurrence considered by the underwriter to be within the realms of probability. This ignores such coincidences and catastrophes as may be possibilities, but which remain highly improbable.”

The Underwriter may also refer to the IMIA Paper WGP 19 (02) “PML Assessment of Civil Engineering Projects”.

5. Typical Loss Examples

5.1 Introduction

Most losses involving road construction, with the exception of earthquake or other natural catastrophic losses are related to subsidence and or landslide.

As with all contract works, good road construction is governed by two main aspects:
1) Adequate and appropriate design, including specification of work and material
2) Economy of design, work and material.

In addition to fulfilling its function to provide a useable and sustainable surface for the various types of vehicles designed for road travel, road design must take into consideration the topography, ground availability of borrow material and climate in which it is to be located.

In this respect, given that most international contractors are familiar with the ground conditions and climate in the regions in which they work, economy of design, work and material, can be of crucial importance in determining the contract bid price; clearly the contractor will be aiming to submit his bid as competitive as possible. This aspect of the risk should be considered by insurers in determining the level of deductible to be applied. Examination of the ground conditions and proposed slope angles and stabilization measures by an experienced engineer, can provide valuable information to enable underwriters to have a better understanding of the risk to be insured.

Whereas considerable design detail in the structure of the road is considered by the owner or his consultants, other aspects of the design are often left to the discretion of the contractor. This is particularly evident when the road route is obliged to traverse mountainous or hilly regions where ‘cut’ and ‘fill’ forms a major part of the contract works.

Where possible, the construction of the road in hilly or mountainous regions is carried out in the dry season, and if possible the contract should be completed before the rains/flood can cause damage.

In other cases however the project may contemplate the road construction to take place entirely in mountainous regions. In this case underwriters need to give close attention to the adequacy of the design particularly the type of ground on which the road is to be built, the angle of finished cuttings, the superficial drainage of the ground above the excavated cutting and the deep drainage of the aquifer. It is this aspect of the design that, unfortunately, the owners leave to the discretion of the contractor, stipulating in the contract: *‘due attention should be given to adequacy of the slope stability and drainage’*. In certain parts of the world special attention must be given to understand and to prevent potential erosion of roads to be constructed adjacent to and parallel to rivers in steep terrain such as in the Andes mountains in South America.
As these loss prevention measures are often not specified in detail in the contract, *adequacy of slope stability and drainage* becomes subjective and is one of the areas of the works where ‘economy of design’ takes on a different dimension to that envisioned by the road designers. In the interest of economy, damage to the works due to the lack of or ineffectual ground stabilization and drainage, is often transferred to a *‘Bona fide’* insurance claim.

We will now look at an example of such claims.

5.2 Derivation Channel Project "Apacheta Choccorro", Peru

The project was for the construction of a road and canal in the Peruvian Andes, at heights reaching 5.000 masl. for the collection of rainwater from the mountains which was to be used for the irrigation of agricultural land at lower levels. By the nature of projects such as this (construction of road and canal on steep mountain slopes) one of the highest risks is damage to contract works due to flood and or landslide. The design must contemplate:

1) construction programme to be carried out in the dry season
2) cut and fill sections to be of a suitable angle to avoid subsidence due to natural slips or due to inadequate drainage.

Failure to comply with these requirements can result in very important losses. As can be seen from the photos below, the angle of the slopes cut in the mountain to accommodate the road were approaching vertical in many locations, which following heavy rain resulted in large landslides causing important damage to completed works.

Photo No.1: Road and canal construction prior to loss

Photo No. 2: Debris deposited on works, after loss

How can these claims be avoided?
Irrespective of the disturbances of the natural terrain caused by construction works, the Andes Mountains are known to be subject to natural slips and erosion, simply because of the characteristics of the geology. It is imperative therefore that, in addition to adequate angles of cut and fill, protection measures must be introduced in order to avoid slips and the resultant damage to the contract works.

Examples of protection /stabilization measures are:

1) The installation of Gabions, (rock filled wire boxes) and/or retaining walls, to maintain slope stability.
2) Benching of slopes where the angle of cut results in exceptionally high slopes.
3) Adequate drainage of the slopes against natural water courses and/or rain.
4) Shotcrete (liquid concrete) sprayed onto slope surface, in conjunction with anchors (anchors located at the end of tensioned cables extending various metres into the cutting or fill)
5) Adequate slope angles in accordance with the type of material being excavated/filled.

Many road construction contracts leave important aspects of the design of the road up to the contractor. Often the contract will only provide guidelines and set conditions on the contractor, which relieves the owner of all responsibility for loss or damage to the works. The contract usually stipulates that the design and specification must be in accordance with international engineering practice. Unfortunately, however, there is not a standard or norm to which the contract can refer and an example of this is given in the following diagram that illustrates the variance in slope angles from country to country.

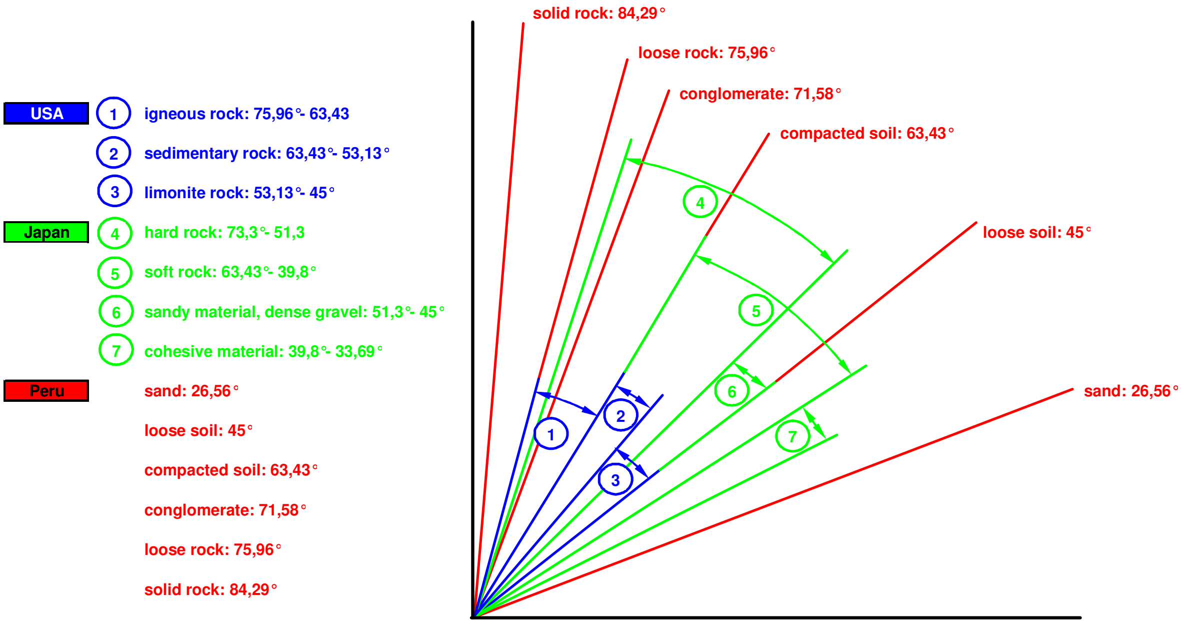


Diagram No. 1: Illustrating slope angle variance

The road construction contract is often awarded based on a lump sum bid for the complete works. As mentioned earlier, having secured the contract, the contractor will seek to execute the works in the most economical method possible. The implementation of expensive loss prevention measures will be minimised, attention being focused on completing the project within the bid price, hopefully before the start of the rainy season. If heavy rain does cause landslide which, in turn, causes damage to the works because of lack of adequate slope stabilization measures, the damage is often claimed under the CAR policy.
In the Middle East and other exceptionally dry locations, very severe erosion can cause significant damage to roads under construction in dry or desert areas due to 'Flash Flooding' and in this respect large 'Wadis' should be avoided for construction as well as for storage areas or site installations.

Policy liability:

The Munich Re *Endorsement 111 Special Conditions Concerning Removal of Landslides, Detritus and Discharge,* is often and effectively used to limit insurers liability in respect of landslide causing damage to the Contract Works.

Endorsement: Special conditions relative to landslides, subsidence
It is the intention of this endorsement that in addition to the terms, exclusions, clauses and conditions contained in the policy or its endorsements, the company will not indemnify the insured with respect to expenses in relation to debris removal, for whatever the cause, whose origin volume is outside of the limits of the construction area.

With respect to slopes cut into mountains or hills, these limits are given by the vertical projection of the line that intersects the limit of the contract works (top of slope) with the natural ground.

If a landslide or subsidence has its origin partially outside of the area described by this vertical line, indemnity will be restricted to that part of the slide material whose origin is within the described limits (see diagram No.2 below).

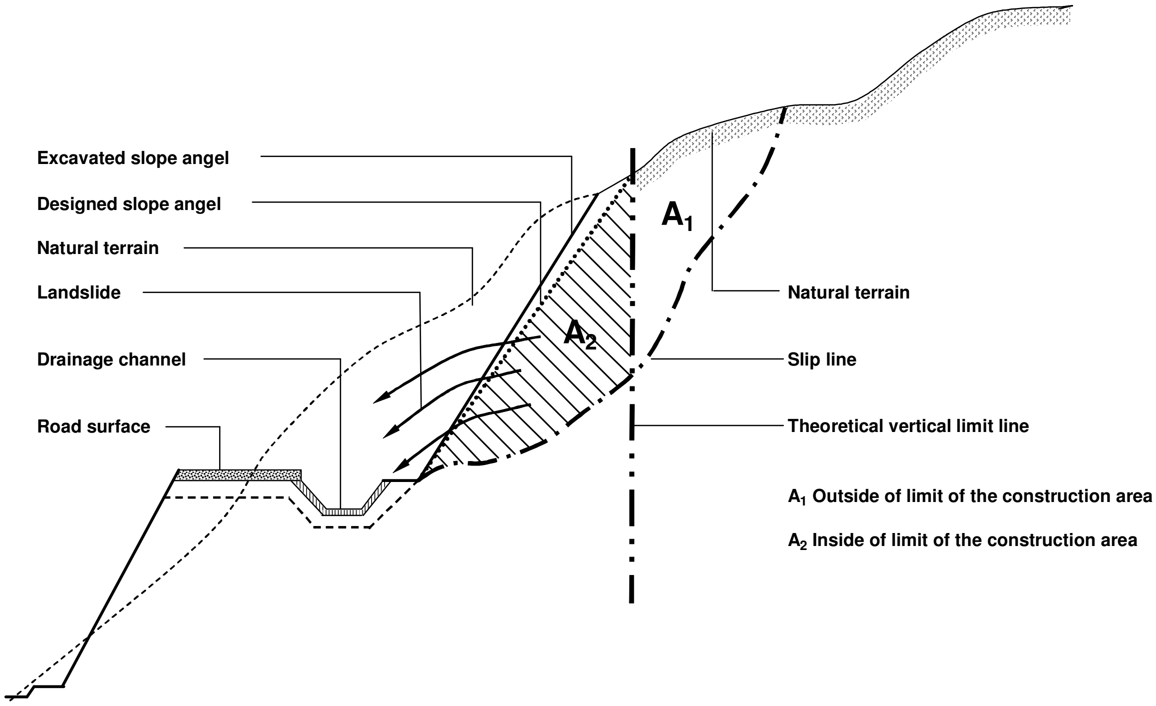


Diagram No. 2: Removal of debris

Often the insured will claim for the removal of all of the material that forms part of the slide, that is in diagram No.2 the volume of material represented by A_1 + A_2. However, in accordance with MRe Endorsement 111, the policy will only respond for the volume of material whose origin is restricted by the intersection of the vertical line with the profile of the natural ground that is the volume of material represented by A_2.

Care needs to be taken in the construction of the wording of this clause:

"…If a landslide has its origin partially outside the aforementioned limits, the indemnity shall be restricted to that part of the landslide which has its origin within these limits…."

The use of the word *"Origin"* in this context refers to the location of the material prior to the landslide, not to the cause of the slide.

With reference to diagram No.2 it can be appreciated that the origin of the material forming the landslide can be either:

a) within the area delimited by the vertical line, or
b) outside of this line.

The intention of the restriction is (in the event where a slip or subsidence displaces material both inside and outside the site boundary limit), to limit indemnity exclusively to the costs of removing material which prior to the slide, was inside of the limit of the contract works.

In calculating the volume of this material and the cost of its removal, account must be taken of loss of compaction. Material which forms part of a landslide has a larger volume than it had in its compacted natural condition. Thus the original contract prices for excavation and transport cannot be used in relation to the claim. The removal of this class of material is much easier than the excavation of the material in its natural compacted condition and therefore the unit cost per m3 must be less than that given in the contract. On the other hand, due to the increase in volume, transport could be more expensive due to the required number of journeys to the deposit.

5.3 Examples of typical Losses

Frequency Losses:

The most frequent losses usually occur in connection with inclement weather. In the event of a claim therefore it is important that the loss adjuster is conversant with the project design parameters and is aware of the necessity to check the nearest meteorological station to compare measured rainfall /storm data for return periods and to compare with those contemplated in the design for the period during which the road is to be built. An example of Frequency Losses is given in Appendix No. 1.

Insurers' liability for frequency losses can be further limited by planned site inspections. When the location of the construction site is in an area in which rainfall is seasonal, an inspection shortly before the start of the rainy season can reveal situations which unless changed will give rise to serious losses in the event of heavy or sustained rainfall which is not necessarily exceptional for the location. At locations where part of the works, have been completed, gullies and drains can be blocked by construction debris resulting in predicable flooding to the works and or damage to third parties. Following inspection of the works, Insurers or their representatives, have the opportunity to notify the insured in writing making cover under the policy conditional upon the introduction of adequate stabilization or other loss prevention measures at specific locations.
This procedure was successful in limiting Insurers liability for claims where extensive landslides occurred after the start of the rainy season during the road construction connected with the Jarra Dam project in Morocco (see details in Appendix No. 2).

Severity Losses:

Severe losses can occur when inadequate attention has been given by the designer to road stability in conjunction with heavy rain or storm. An example of this type of loss is the collapse of the Anchienta Highway section between Sao Paulo and Santos in Brazil (see details in Appendix No. 3).
At this location heavy rainfall over a three day period caused important damage to contract works and to third party property located further down the slope. The works that were necessary to reinstate the slope and support the road were complicated and extremely expensive in relation to the original costs of the road construction at this location.

Nat Cat Losses:

In considering a road construction project, attention must be given by underwriters as to the nature of the contract works (number and location of viaducts / bridges / tunnels etc.) and in particular the climate in which the risk is placed as well as the corresponding construction programme in relation to critical construction phases. Consideration of proximity of rivers, dams, height above sea level and seismological activity are important aspects that can give rise to important losses if the risk is not properly controlled. Exclusion of flood losses for plant, material storage areas and camps etc. which have been constructed or placed below a 20 year high water return period can limit insurer's liability for flooding risk.

As indicated under 'Frequency Losses', Insurer's liability can be limited by carrying out risk inspections prior to the start of tropical storm and cyclone seasons and modifying cover to be conditional upon the introduction of measures to avoid predictable losses.

Faulty Design Material Workmanship:

Prior to acceptance of the risk insurers must give attention to the characteristics of the road location climate and other aspects of the risk discussed earlier. It is not practical for insurers to have a full understanding of the road design and all of its connected aspects (geological investigations, geological and structural calculations etc.) however, a broad appreciation of the basic road design parameters and the identification of critical construction phases (such as the excavation of slopes and placement of fill) can easily be obtained by Insurers or their representatives. The objective of the risk inspections is to identify aspects of the risk or situations that can 'predictably' give rise to a loss and to notify this to the insured. It is critical for Insurers to differentiate between losses claimed under; Faulty or Defective design, Material or Workmanship and those which are in effect, the result of intentional transfer of 'savings' in the contract works, to that of an insurance claim (such as the failure to adequately protect or stabilize slopes).

An aspect of Faulty or Defective Design that remains ambiguous is the relevance of the soils or geological investigation of the area in which the road is to be built and whether or not this forms part of the design. It is usually left undefined in the policy, whether or not the design is 'Defective' if, during the course of the road construction, a Geological Fault (which has not been identified in the soils investigation or geological survey and on which the road design has been based), is encountered and gives rise to damage to the works.

The extent to which the damage to the works will be covered will depend on which Design cover/exclusion the policy provides. The importance in defining cover for 'Defective Design' will be appreciated however, by reference to outright exclusions for defective design such as DE1 or LEG 1. If part of the works failed because the design did not consider a particular ground condition which was not identified in the soils investigation report (such as a Geological Fault) then the design could be considered 'defective' and by virtue of LEG 1 and DE 1. the entire loss would be excluded from cover. An example of this type of loss is the collapse of the Anchienta Highway road section in Brazil (see Appendix No. 3).
Other design covers vary from the exclusion of the defective part or works, but covering the resultant damage occurred to correctly completed works - to that of covering all damage including the defective part or works, but excluding the costs of improvements to the original contract works insured.

Third Party Liability:

Third party claims resulting from road construction are varied and exposure will depend on the location of the risk. The highest TPL exposure is usually for roads constructed in towns where existing underground utilities such as water, gas and electricity and telephone lines are hazards to this type of risk. Whereas it is incumbent on the contractor to identify the location of these installations, often they have not been installed in accordance with the official records and drawings resulting in damage that can be extremely expensive to repair particularly where power supply has been affected or where damage to water pipes causes flooding. For road construction in urban areas, prior to the inception of cover, it is highly recommended that insurers carry out a 'Dilapidations Survey' that records both in written form and photographically the condition of third party structures and the possible damage that could occur to structures due to the road construction and that require special treatment prior to the commencement of the works at that location.

A common TPL claim is for the loss of water supply claimed to be due to a loss covered under Section I of the policy. In this case it is necessary to establish whether the loss of water supply to the third party is the result of a covered loss or whether it is related to the nature of the contract and has occurred in consequence of the normal execution of the works and should have been contemplated in the project design.

Losses can also arise from when landslide of part of the works causes damage to existing roads located at lower levels of the road works. Adequate posting of hazard signs such as 'Danger of falling rock' to traffic, installation of protective barriers and temporary shelters and or special diversion works, are important in managing this type of risk during construction. Insurer's interests can be protected by regular site inspections informing on the status of the risk at critical phases.

Third party liability is an important aspect of road construction insurance with a high exposure. Large Third Party claims can be minimised by the intervention of Loss Adjusters in conjunction with insurer's legal representatives in promptly settling claims that have the potential of escalating beyond control.

For additional interesting claims examples please also refer to
www.imia.com/claims_examples_car.htm

5.4 Appendix No. 1

Derivation Channel Project "Apacheta Choccorro", Peru

Photo No.1: Construction of road and canal of 40km length on slope of the Peruvian Andes, at heights reaching 5.000m asl. The project is for collection and routing of rain water for irrigation of agricultural land at lower levels.

Claimed amount: USD 3.860.000

Adjusted amount: USD 754.000 (net of deductible)

Cause: Defective design of cut slope angle

Risk description: Excavation of material on side of slope on which the road is to be built and fill in of slope below in order to accommodate road structure.

Comments: Investigation revealed the following:

- Cut slope angles were not adequately adapted to ground conditions.
- Insufficient installations of gabions to protect canal and road structure.
- Insufficient Benching of exceptionally high slopes.
- Drainage of slopes against water courses and/or rainfall inadequate.

Conclusion: Insured did not follow international engineering practice. According to the policy condition debris removal, for whatever the cause, whose origin volume is outside of the vertical limits of the construction area, is not indemnifiable.

Photo No. 2: Completed road and canal section after landslide.

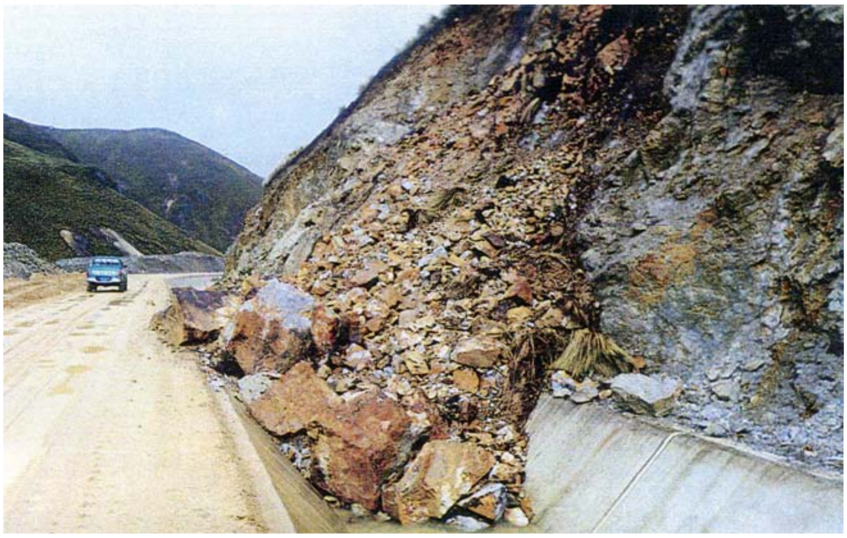


Photo No. 3: Damaged concrete canal by fallen rock. Slope angle too steep, insufficient drainage.

Photo No. 4: Landslide road structure slope stability not adequately secured.

5.5 Appendix No. 2

Al Wahda M'Jaara Dam, Morocco; Construction of Road Network

Photo No.1: Construction of 60km new road network as due to the dam construction existing roads below 168m asl located within water reservoir of the dam. Slides due to inadequate drainage above slopes.

Claimed amount: EUR 380.000

Adjusted amount: EUR 256.450 (net of deductible)

Cause: Extraordinary heavy and continuous rainfall

Risk description: Following the M'Jaara Dam closure the catchment area of the dam included flooding of some access roads connecting surrounding villages. Therefore, new road network was constructed on the route between the towns Rafsai and Tafran with a total length of 60km. The route leads through hilly terrain and following intensive and continuous precipitation (380mm/m²), particularly in January 1996 several important landslides occurred causing damage to road sections under construction.

Comments: The soil prevailing in this region is of marl and susceptible to ingress of humidity. The accumulated water volume could not be absorbed by the ground above the road and landslide occurred affecting road works and ditches under construction.
Weather conditions at the time of loss exceeded those normally expected at this time of the year.

Conclusion: The Insured applied adequate measures and standards of slope protection. Following our investigation landslides also occurred at areas where road construction was not yet commenced and even higher standards of slope protection could not prevent landsides.
Repair works and removal of debris were only accepted at sections where the insured already had started road construction activities.

Note: Further losses were excluded from cover by restricting cover for damage to works only for those locations where adequate slope angles, benching and drainage, had been implemented prior to loss event.

Photo No. 2: Landslide occurred at locations with shallow cut angles.

Photo No. 3: Benched slopes and gabions damaged by slides

Photo No. 4: Damage to filled road structure after heavy rainfall.

5.6 Appendix No. 3

Anchienta Highway Project between Sao Paulo and Santos

Photo No.1: View of Via Anchieta Highway south lane at km 42 prior to loss, located 900m asl close to crest of Serra do Mar scarp.

Loss amount: USD 1.250.000

Cause: Extraordinary heavy and continuous rainfall/defective design: inadequate drainage.

Risk description: The Anchieta Highway was built in the 1950's through the national park Serra do Mar, at an average height between 750m to 800m connecting Sao Paulo and Santos. Yearly rainfall more than 3.000mm with maximum values reaching 5.900mm is standard for this region.
During 10.12.1999 and 12.12.1999 a local rainstorm occurred with 274 mm precipitation over a three days period causing landslide 100m downhill of south lane highway: 20m depth, 100m width and 200m length. Cracks occurred on road surface. On 16.02.2000 precipitation of 111mm within 8 hours caused additional subsidence of the slope below the highway.

Comments: The Failure was caused by transient water flow through the joint system of the rock strata, which opened the joints and caused landslide. Immediately stabilisation measures by installation of a concrete piling with pre-tensioned anchors and horizontal drainage prevented further collapse.

Conclusion: The Insured was not aware of the instability of the rock strata. Loss occurred due to insufficient monitoring of possible soil movement and installation of suitable drainage and stabilisation measures.

Photo No. 2: Landslide after heavy rainfall

Photo No. 3 Stabilisation measures included a grouted pile wall and pre-tensioned anchors

Photo No. 4: View of Via Anchieta Highway after repair completion

6. References and Internet Links

6.1 Literature

Contractors’ Plant and Equipment Insurance in International Markets
Swiss Reinsurance Company, Zurich – 1998

Contractors’ All Risk Insurance
Swiss Reinsurance Company, Zurich – 1998

Engineering Insurance and Reinsurance
Swiss Reinsurance Company, Zurich – 1997

PML Assessment of Civil Engineering Risks
IMIA Working Group Paper WGP 19 (02) – 2002 on www.imia.com

6.2 Illustrations

2. Understanding Road Construction:
Kindly provided by VCE Consult ZT GmbH, Vienna / Austria

5. Claims Examples:
Kindly provided by Advanta Global Services GmbH, Munich / Germany

6.3 Internet Links

www.worldbank.org/transport/publicat/reh/toc.htm

www.imia.com/claims_examples_car.htm