UNPREDICTABLE GROUND CONDITIONS AND FORESEEABLE LOSSES IN CONSTRUCTION ENGINEERING

1. INTRODUCTION

Construction engineering is a multifaceted discipline ranging from relatively simple civil engineering works up to large infrastructure projects such as motorways, power plants, harbors, airports, gas pipelines, railways, dams, water reservoirs, etc. Typically, such infrastructure projects display a significant degree of complexity as they comprises of a number of individual structures of great diversity such as large tunnels, earth cuts & deep excavations, embankments, retaining walls and bridges.

Following a number of disastrous events in the construction engineering practice, merely since the early '30s, it has become common knowledge that it is compulsory for the design and execution of such structures to be preceded by careful examination of their environment, particularly the foundation material on **or** in which these structures will be placed. However and despite the great technological advancements and sophisticated computational methods available in our times, there are still a significant number of accidents occurring that challenges not only the budget and the time schedule of the projects themselves, but in certain instances also the Insurer's ability to respond to the claims arising therefrom.

The scope of this paper is to discuss some interesting aspects related to the foreseeability of certain 'typical' insurance losses occurring during the implementation of complex infrastructure projects such as tunnel collapses, landslides and dam failures from the perspective of an international loss adjuster with geotechnical background. It will be demonstrated that the uncertainty arising from the widely insisted "unpredictability of the ground conditions" alone does not suffice to explain the relatively high frequency of these losses, but there are rather certain re-occurring man-made shortcomings rooted in the planning, design, execution and monitoring of the projects that contribute frequently to the occurrence of these typical losses.

So far, such shortcomings are dealt with in the insurance practice under the label *"faulty design and/or defective workmanship"*. However, the formulations used in the relevant exclusions, clauses and endorsements incorporated in today's policies, apart from lacking a precise definition of these terms, are also too vague, thus leaving space for subjective and also arbitrary interpretations. This is proven to be a weakness which, when taken together with certain other inconsistencies frequently appearing in the wording and/or the way some of the policies are being structured, may lead to significant problems in case of a dispute to be judged under a strict local jurisdiction or the legislation of certain emerging countries.

The points raised and views presented are closely tied to the particulars of the case studies elucidated further on in this paper.

2. WHAT DOES THE UNPREDICTABILITY OF THE GROUND BEHAVIOR DEPEND ON AND HOW DOES IT AFFECT THE FORESEEABILITY OF INSURANCE LOSSES?

2.1 The Challenge

The foundation material or ground on or in which the structures of a given construction project will be placed, is usually made of soil, semi-hard or hard rocky material of various geological composition and geotechnical characteristics.

These materials in nature, especially the deep ones, are affected by the weight of the overlying strata and by their own weight. Stresses develop in any soil or rock mass because of these factors, but also as a result of a precedent tectonic impact. In general, every stress produces a strain and displaces the individual particles of the ground. To be displaced, a particle needs freedom to do so; in other words it needs to have space available for movement. If the soil/rock mass is confined and its motion thus prevented, there will only be a partial displacement, if any. The stress that could not produce displacement because of the large scale confinement, still remains in the soil/rock mass and is said to be in storage.

This condition may change significantly in the event of a human intervention related to the execution of a structure regardless whether it is a deep excavation, the foundation for a large building or bridge or the construction of a dam, earth cut or tunnel. In this case and as soon as the confined mass or part thereof, acted upon by a stored stress, is freed and permitted to move, a displacement occurs, for the amount of movement relying upon the magnitude of this stress.

Depending on the geotechnical characteristics of the soil/rock mass, the magnitude of the stored stress and the approach applied for the intervention, the displacements may be very large and result in extreme deformations, differential settlements, instabilities, failures and/or collapses. Bearing in mind that ***"it is the engineer who has to comply with the requirements or restrictions set forth by the given ground in the area of his project and not the opposite"***, it is almost a prerequisite for the safe and economical execution of the project that all aspects of the design, including the ones related with the selection of the workmanship, materials and also the machinery & equipment to be involved are in strict compliance with these requirements. This in turn implies that at least the most essential geotechnical parameters governing the actual behavior of the ground have been reasonably assessed in advance and the validity of the assessed values confirmed by means of a scaled simulation of the changes expected to be imposed by the intended intervention on the original state of stresses prevailing in the ground.

This is indeed a very challenging but still sufficiently manageable task, provided that the following pre-requisites are being consistently fulfilled:-

a. Adequacy of the budget for the geological exploration of the area of the project.

b. Employment of a skilled and experienced geotechnical engineer, who will undertake not only to design and supervise the exploration campaign, but also to assess the most essential geotechnical parameters dictating the actual behavior of the ground during the execution of the project. Hereby, it is imperative that during these stages, the geotechnical engineer remains in close cooperation with the other designers involved in the project (i.e. structural, architectural, mechanical, etc.) as to ensure the proper understanding of their specific demands and hence also the compatibility of his assessments with their requirements.

c. Regular monitoring of the progress of excavations by the geotechnical engineer aiming in the confirmation of the predictions made in his geotechnical report and the provision of immediate consultancy services in case that unexpected and/or divergent ground conditions are being encountered.

d. Appointment of a qualified independent engineer (IE) in charge not only of the approval and compatibility of the various designs but also the coordination and supervision of their proper implementation during the execution of the project.

We will now take the above aspects in turn and reveal that it is not that much the widely supposed ‘unpredictability of the ground’, but rather the incomplete and inconsistent fulfillment of these pre-requisites which is the root cause in this issue.

2.2. Economic & Planning Aspects

Typically, all construction projects underlie a fixed budget and a strict time schedule, for the costing elements of the various activities being subject to certain limits. However and as revealed by experience, it is the sum made available for the geological & geotechnical exploration, which is usually kept to an absolute minimum compared to the other activities within a given construction project.

As a rule, the geological & geotechnical exploration is done in the very early stages of the project in which the various designs are fashioned on a conceptual basis only. Not being aware of the very specific requirements his investigations shall respond to, the geotechnical engineer in charge of the ground exploration is frequently faced with the dilemma of how to dimension his campaign without exceeding the limitations set forth in the budget.

This in turn causes for the engineer to set certain priorities relying upon his experience, being mainly guided by routine. As revealed by the day to day practice, this instance leads frequently to the handicap that the type, number and spacing of the exploration means (i.e. field work, boreholes, laboratory and in situ tests, etc.) are either insufficient or even less relevant for the purpose. This is a serious shortcoming leaving no other choice to the geotechnical engineer than to take refuge to risky interpolations and unsupported interpretations, bearing in mind that the geological composition and hence the actual behavior of the ground may change dramatically even in very short distances.

The importance of the adequate assessment of the ground behavior remains unaltered regardless whether we are dealing with the design of the foundations of a dam, stability of an earthcut, a retaining wall, temporary support (in case of NATM), or even the selection of a TBM to be used for the excavation of a tunnel. What factually differs is only the relevance of the individual geotechnical parameters for each of the above mentioned tasks. However and because of the previously elucidated restrictions and/or shortcomings, inherent to the design and implementation of the ground exploration, it is frequently the case that the geotechnical report either fails to recognize the priorities set by the other designers, or even worse, the uncertainty arising from the interpolation and/or subjective judgment of a number of essential parameters by the geotechnical engineer may confuse or mislead the other designers participating in the project in making the proper assumptions for their own calculations.

2.3 Design and Workmanship

Per definition, the design shall inter alia contain detailed guidelines in respect of the method statement to be applied during the execution of the project. It is further expected that the designers will maintain close contact with the designated worksite managers and apart from their intervention in critical cases, they also carry out regular inspections of the site as to follow up and also monitor the smooth execution of the works in the field of their responsibility. In case that more than one designer is involved, as is usually the case in complex projects, regular meetings have to take place between the various designers as to ensure the proper coordination of their tasks and the elimination of any possible gaps or unnecessary overlaps in their respective duties.

However and as confirmed by experience, it is only in exceptional cases that the designers of a project upon receipt of the geotechnical report revert to their colleague in charge of the ground exploration asking for confirmation regarding the suitability of the assessed values for their specific purposes. There are also examples from the engineering practice where structural and other related designers, despite being in doubt about the credibility of the parameters suggested in the geotechnical report, simply preferred to ignore them and also base their own assumptions on arbitrarily chosen ones, instead of consulting with the geotechnical engineer and/or insist on the execution of additional ground investigation.

As it will be elucidated in the case studies presented further on in this paper, the implications arising therefrom may seriously compromise the safety of the works and also give rise to serious losses which in no case can be considered as being unforeseen and accidental.

In principal terms, every civil engineering structure is characterized by its safety margins determined on the basis of the anticipated behavior of the ground prevailing in the area of the project. Such margins take into account the tolerances for deformations, differential settlements, convergences etc., allowed for in the design of the structure which, when duly respected, will ensure not only the smooth implementation, but also the unhindered operability of the structure.

In the case of tunnels, it is the magnitude of the anticipated deformations and/or convergences, expected to be exerted by the surrounding ground, which is decisive not only for the selection of the excavation method (NATM or TBM), but also for the design of the appropriate temporary support (NATM) or the type of the TBM and the dimensioning of the segmental rings to be employed during the excavation. Apart from the economic aspects relevant to this selection, both methods differentiate also in their design requirements fundamentally. It is reminded that the NATM conceptually permits for a controlled relaxation of the ground to take place during the sectional excavation of the tunnel, for such relaxation being manifested in the form of a certain amount of deformations allowed to occur during the excavation. Typically, these deformations are successfully 'absorbed' by the temporary support and it is only after the achievement of the new equilibrium of stresses (ground consolidation) that the final lining will be placed in the tunnel. Thereby, is it essential that the various categories of the temporary support are suitably designed as to fit the intended purpose, which is to keep the deformations within the tolerances provided for in the design.

Other than in the NATM, the full face excavation with the TBM does not permit for any immediate relaxation of the ground to take place (i.e. allowable deformations are practically nil), and there are only the segmental rings, immediately placed after each excavation step, which are called upon to resist the pressure exerted by the ground pending its consolidation. This in turn requires not only that the type of the TBM chosen is the appropriate one as to avoid unnecessary over excavation (thus inducing further disturbances in the ground), but also that the design of the segmental rings (corresponding to the final lining of the tunnel) is sufficient to confront the relaxation stresses imposed during the excavation process without sustaining any damages which may affect their integrity.

In the case of artificial earth cuts or the re-shaping/notching of natural slopes in the immediate vicinity of ongoing construction projects, it is the stability margin of the new slope to be created following the intended intervention, which is of particular importance. It is the common engineering practice that in either case, all aspects that may affect the long term stability of the newly created slope will have to be carefully examined.
Typically, this examination focuses on the determination of the strength, coherence and friction angle of the materials comprising the ground, size/spacing and orientation of joints

and/or other discontinuities, identification of potential wedge failures, presence of groundwater etc., on the basis of detailed field mapping and sufficient laboratory and in-situ tests.

The stability margin of a slope is expressed by its safety factor. In case of naturally formed slopes advising very low to medium inclination, the factor of safety is equal to 1.0 or even slightly above, suggesting that the slope is in a marginal state of equilibrium. Hence, the investigation of potentially existing natural slopes in the immediate vicinity of a project, could deliver a reliable indicator as to the maximum allowable inclinations for free standing slopes in the specific area.

In principal terms, a free standing slope will definitely fail if the factor of safety falls below the unity, but also a safety factor between 1.1 – 1.3 for a permanent slope may be fairly insufficient depending on the environmental conditions prevailing in the area. As revealed by experience, a safety factor of 1.5 constitutes a sound value for the long term stability of a permanent slope. However, should this not be feasible for whatever reasons, then the implementation of additional measures, such as the creation of intermediate benches, execution of retaining/pile walls, anchoring, etc., at least in pre-defined focus areas or sections, may become necessary.

Certainly, the above principal considerations with regard to the safety aspects do not require any sophisticated knowledge as they are anyway self-evident in the daily engineering practice. However, it is the miscommunication and also the conscious deviation from the above rules from the part of the designers and/or project managers giving rise to a great number of losses, which would have otherwise easily been avoided. Here are two examples for such deliberate misconducts from the part of a designer and a project manager:-

- ✓ A designer of a TBM driven tunnel whilst being confronted with the persistent cracking of the segmental rings, instead of asking the geotechnical engineer for consultation, preferred to seek for temporary solutions experimenting with the desired strength of the rings by assuming arbitrary values for the earth pressure around the excavated hole. Moreover and as the problem continued to persist, he simply ordered the almost continuous placement of additional stiff support (i.e. steel ribs, anchors, etc.), in an effort to enable by all means the further driving of the TBM.

- ✓ A project manager in charge of the construction of a hydroelectric power plant, being in delay with the completion of the upstream cofferdam, ultimately requested his designers to seek for urgent alternative solutions that would enable the anchoring of the dam abutments on the soil layers left in place instead of on the underlying hard rock stratum, as provided for in the original design.

The above examples from the actual loss adjusting practice resulted in significant damages to the works, which were throughout avoidable. It is though obvious that the approaches adopted in either case had more in common with a poker game rather than with the widely accepted engineering practice and there cannot be an argument pointing to unforeseen ground conditions having initiated the captioned losses.

A further interesting point, which is common in the above examples, is that the adverse circumstances leading to the curious approaches adopted by the designer and the project manager evidently did not arise over night, but were well known to the respective parties several months ahead. However and as in other similar cases, these circumstances, despite being associated with material changes in the risk, were never reported to Insurers nor were the substantial deviations from the designs and the workmanships ever approved by them.

2.4 Summarized Comments

Like any other scientific branch, geotechnical engineering has also made significant progress in the recent years, being benefited from the great technological advancements in the machinery & equipment used for field exploration, the instrumentation and methods adopted for the laboratory examinations and sophisticated computational methods for the data processing available in our times. Also the academic background and skillfulness of today's geotechnical engineers has in the meantime considerably improved, therefore the number of the full professional and also qualified engineers in this field is significantly greater than it was a few years ago.

There are many examples from the engineering practice confirming that, provided the above recourses are used in a proper and well-coordinated manner, the margin for 'surprises', as far as the accuracy of the prediction of the anticipated behavior of the ground is concerned, is significantly lower than it was in the recent past. This is also supported by the re-occurring experience that "post-loss" investigations as a rule though manage to bring to light most of the mysteries originally believed to be hidden in the ground.

It is because of these reasons that we believe that the terms 'unpredictable' or 'unforeseen' ground conditions appears having lost in the meantime their actuality and/or validity both in the engineering and also in the insurance practice. Instead, it seems that there are rather the previously outlined human related shortcomings and omissions giving rise to the vast majority of the so-called unforeseeable losses.

3. HOW DOES THE INSURANCE COMMUNITY RESPOND?

For the Insurers sitting several thousands of miles away from the scene, it is not practicable to actively follow up all developments and also obtain inside information on what is going on 'behind the curtains'. Hence, they have no other choice than to (a) draft in first instance the insurance policy on "utmost good faith", by reasonably assuming that the insurance proposal and any other supplementary information eventually provided by the Insured and their Broker at inception is complete and accurate, and (b) also insist on the fulfillment of a number of pre-requisites or provisions including but not limited to the

- submission of regular progress reports advising the actual status of the project
- timely notification of any circumstances which may give rise to a claim
- entitlement of the Insures and/or their representatives to carry out site inspections at their choice aiming at the monitoring of the risk.

Despite that the above approach in theory is fair and reasonable; it is its implementation in the daily practice which significantly impacts the efficiency of the whole exercise for the following main reasons.

3.1 The Insurance Proposal and its reflection in the Policy

Per definition, the insurance proposal, prepared and submitted by the Broker in consultation with the Insured, is the main instrument supposed to contain true, complete and sufficiently specified information which would enable the Underwriter to properly assess the risk and also express his conditions for its acceptance. However and as revealed by experience, the completeness and accuracy of such proposals is not always what it should be. This in turn results in seriously compromising the Underwriter's ability to properly assess the risk.

There are many instances in which the description of the 'risk details' and more especially of the insured 'interest', provided for in the proposal, are either incomplete or too general whereas it is only in the appendixes that some of the missing details are only fragmentarily presented. This is certainly a crucial shortcoming which, when adopted in the same disordered fashion in the policy, may give rise to serious legal implications in the event of a loss, more specifically in case of a CPM policy.

Let's take for example a CPM policy insuring an excavation machine or equipment such as TBM, road header, heavy dragliner, etc. As is generally known, there are many types of such machines or equipment differentiating substantially in their specifications and overall characteristics, depending on the requirements of the ground they shall be deployed.

Typically, such differentiation is expressed by the denotation of the type given by the manufacturer such as *"single shield hard rock", "slurry" or "earth pressure balance" TBM*, etc., for this denotation also specifying the categories of the ground each of these types are compliant to.

These being the circumstances, it is essential that the description of the insured interest both in the proposal form and also in the policy is complete and accurate, as to also include the type of the machine or equipment denoting its suitability with the ground conditions prevailing in the area of the project. Generalized expressions such as *"a TBM to be used in the project…."* shall be strictly avoided as they impose the risk for the policy cover to be legally interpreted as granted in the case of a loss or damage to the TBM itself, say, resulting from a tunnel collapse, even in the instance that it becomes evident that it was just the incompatibility of the type of the TBM chosen which in fact provoked the loss.

It is not quite uncommon in the international insurance practice that the Underwriter being pressured by the Broker to respond within very strict deadlines fails to recognize such and other similar apparently innocent shortcomings contained in the proposal form made available for his assessment and/or acceptance of the risk. It is only when it comes to a multimillion loss that such shortcomings becomes evident, leaving no other choice for the Insurers than to seek for a compromise settlement as to avoid an imminent litigation, more especially in the event that the policy is governed by the law and jurisdiction of a strict nationally oriented emerging country.

3.2 Risk Monitoring

The adverse circumstances giving rise to the uncommon approaches in the two exemplary cases previously described in Chapter 2.3, certainly did not arise over night, but were rather well known to the respective contractors and their designers several months before. As in other similar cases in the practice, these adverse circumstances were never reported to the Insurers nor have the associated deviations from the original designs ever been approved by them.

As a rule, the Insurers insist on the submission of monthly progress reports from their Insured and also delegate from time to time their own risk engineers to visit the worksite(s) in order to obtain a more accurate picture of what is happening on the spot, but as frequently confirmed by the daily practice, this seems not to be enough.

The progress reports delivered to Insurers are identical with the ones drafted for the consideration of the owner and/or the lenders of the project. For obvious reasons, no detailed information is contained in these reports in respect of any adverse circumstances or technically driven problems possibly encountered.

On the other hand, the Insurer's own risk engineers usually assigned for this purpose either do not have sufficient worksite & claims experience or even lack the necessary in depth knowledge of the crucial technical aspects inherent with the subject matter of their inspection.

It is because of such shortcomings that the risk engineer's reports, not quite infrequently, misses to recognize key issues of concern and also to suggest the timely execution of reasonable recommendations. It is worth mentioning that in the two exemplary cases in Chapter 2.3, both worksites were indeed visited by the Insurer's own risk engineers only a few weeks prior to the dates of the imminent losses, however without having noted anything unusual or being briefed by the respective worksite managers of the adverse circumstances, they were evidently confronted with at that time.

For such inadequacies not being quite uncommon, it frequently happens that such periodical site inspections and reports are used by the Insured in turn as argument for the sudden and accidental nature of a loss coincidentally occurring shortly after the site visit of the risk engineer.

3.3 Policy Exclusions – Limitations & Applicability

Some 20 years ago, a global Insurer in an effort to increase their market share in certain emerging markets, invented in their CAR policies the additional cover for damages due to "Unforeseen Ground Conditions". It needed for them only a few years and some millions of USD on undue indemnifications to withdraw this cover and return to normal business. Was the lesson learnt? Obviously yes! But how does it stand with this issue in our days?

Whilst dealing with the interpretation of an insurance policy, there is the widespread view that everything which is not expressively excluded is though considered as being covered and this appears to apply also with regard to the "Unforeseen Ground Conditions", which as such are never expressively excluded in the CAR policies. Does this mean that "Unforeseen Ground Conditions" shall be seen as a rather 'sweeping' circumstance which is *per se* covered by the CAR policies? If not, how come this term is still frequently used, with some success, by insured contractors and their brokers as an argument in support of the accidental nature of their claims?

It seems that there is still no direct approach in addressing this matter other than by means of a number of special exclusions, additional clauses or endorsements, invented in the insurance practice many years ago whose wording, apart from being to a large extent outdated also leaves much space for arbitrary interpretations.

Let's take for example the MR 115 Clause referring to the designer's risks. The wording used

"...loss of or damage to items due to defective material and/or workmanship and/or faulty design, but this exclusion shall be limited to the items immediately affected and shall not be deemed to exclude loss of or damage to correctly executed items resulting from an accident due to such defective material and/or workmanship and/or faulty design" (our underlining),

clearly implies that the terms "*correctly executed items", "faulty"* and *"accident due"*, are unmistakably defined and also interpreted the same by all parties, which is by far not the case. As long as no widely accepted criteria for the definition and interpretation of these termini have been introduced, not only will the application of this clause remain ambiguous but any attempted differentiation between "foreseeable" and "unforeseeable" loss or damage will also remain standing on tipsy legs.

As confirmed by experience, in case of "manmade losses", any suspicions or even conclusions pointing to the circumstance of a faulty design or workmanship are usually raised only after the occurrence of the loss itself, for the most frequent of these faults or defects being attributed to one or more of the following main reasons:-

i. Inadequate exploration of the ground due to issues related to the budget or due to any error, omission, negligence or even incapability from the part of the geotechnical engineer in charge of the exploration and/or the other designers in charge of the design of the various items or parts of the project (**most frequent reason**).

ii. Objectively restricted ability to sufficiently explore the ground and/or access the geotechnical parameters, which are essential for the prediction of its actual behavior during the execution of the works. Typically such restricted ability is given only in areas with limited access or even in case of exceptionally complicated geological conditions or processes having taken place, resulting to significant changes in the composition and behavior of the ground in very short scale (**less frequent**).

From the engineering point of view, there are certain criteria allowing for a reasonable distinction between the above main categories to be made. It would be advisable for some of these criteria to be also adopted in the insurance practice.

3.4 Legal Aspects

The recognition that the most frequent reasons for the faulty design/workmanship are commercially driven decisions and/or human negligence or omission, implies that the definition and applicability of the terms "accidental", "unexpected" and "unforeseen", widely used in the insurance practice for the characterization of losses, needs to be fine-tuned if not entirely revised. This would certainly assist in eliminating beforehand most of the frequent complications arising therefrom in case of legal disputes.

It is not quite uncommon that when it comes for the issues of the misrepresentation of the risk, the non-disclosure of material facts and the foreseeability of an event to be decided by the courts and more especially the ones of an emerging country, there may be some surprises as to the interpretations made by the judge, depending on the local jurisdiction and the particulars of the case.

As a rule and apart from any distinctive provisions possibly stipulated in the local legislation in force, such unexpected decisions arise also from the fact that sometimes the judge and/or the lawyers attending the case are overextended in dealing with fairly complicated and highly specialized technical matters. This is certainly an incalculable risk whose reasonable confrontation to a large extent depends on the intenseness and the quality of the cooperation between the Insurer and their appointed loss adjusters and legal advisors.

3.5 Damaging Event(s) vs. Policy Deductible

The most common definition of the event is an incident or situation caused by an insured peril, occurring in a particular place or area during a particular interval of time, giving rise to a loss or damage to the insured property or part thereof. Thereby, it will be distinguished between damages caused by natural hazards and so-called accidental ones as a result of defective material/workmanship and/or faulty design. With regard to the damages caused by natural hazards, the most common criteria in use for their consideration under the policy and application of the deductibles are the re-occurrence or return period and the duration of the event, being unanimously specified to 15-20 years and 72hrs, respectively.

Aside from the cases due to natural hazards, occurring in a rather unpredictable and isolated manner, the vast majority of the losses due to defective design/workmanship/material very often start manifesting themselves in an earlier time in the form of persisting extraordinary deformations, over excavations, displacements, partial collapses etc. In many occasions, such events, giving rise to minor up to medium sized damages falling within the policy deductible, are dealt with by the contractors on the basis of improvisations and/or short term remedial works without being notified to Insurers. However, when after a period of several weeks or even months it becomes a large scale loss due to the same root cause, the contractor frequently decides to include the costing elements associated herewith in their final claim as constituting one occurrence or event for which one policy deductible would have to be applied.

The main argument presented in such cases is that the preceding similar incidents regardless whether timely reported or not are due to the same root cause, for the times of their manifestation not differentiating substantially from each other.

This point of view is not quite uncommon by contractors, who fail to recognize that it is not only the uniqueness of the root cause but also the difference in the point of time in which these individual incidents became manifested, which is essential for the justification of the number of the policy deductibles to be applied. In addition, in the vast majority of these cases, the contractors are not willing even to accept that the preceded similar incidents as such contradict their assertion that the ultimate loss, giving rise to the claim, was by far not unexpected, unforeseen and accidental.

The frequency with which such disputes are encountered in the international loss adjusting practice makes it advisable for Insurers to consider refining the wording used in the definition of the term event or occurrence by also inserting time limits or intervals, when it comes to deciding the number of the policy deductibles to be applied in case of a series of multiple 'man-made' incidents due to the same root cause.

CASE STUDIES

3.5 TUNNELS

The tunnel under consideration is a 6.4km long, single tube traffic tunnel incorporated in the construction of a new 533km long high speed railway project. The underground section has a length of 6.1km and a net diameter of 13.4m being the largest structure within this project.

Background

The route passes through a mountainous area with steep inclinations and small valleys. During the geological exploration, 4 boreholes were executed along this section revealing that some 78% of the tunnel length would have to be excavated through weak to very week graphite schist, for the remaining 22% passing through weak to medium strong chlorite schist. The graphite schist, dominating the area of the project was classified in the report as *"granular and soft being mainly in a loose condition, advising a low stability with inherent tendency to squeeze and/or collapse when excavated"*. The maximum overburden along the route was given to 205m.

As per the original design, the tunnel would be excavated according to the so-called 'New Austrian Tunneling Method' (NATM). Whilst dealing with the preparation works in the area of the northern portal, a landslide which occurred nearby during the construction of a new motorway project necessitated the realignment of the tunnel for safety reasons.

It was because of this instance that the geotechnical engineer in charge requested for another 8 boreholes to be executed along the realigned section of the route, which reportedly confirmed the findings of the original boreholes. On the basis of these findings, the engineer proceeded with his assessment of the geotechnical parameters of the ground and also the design of the temporary support to be applied during the NATM excavation.

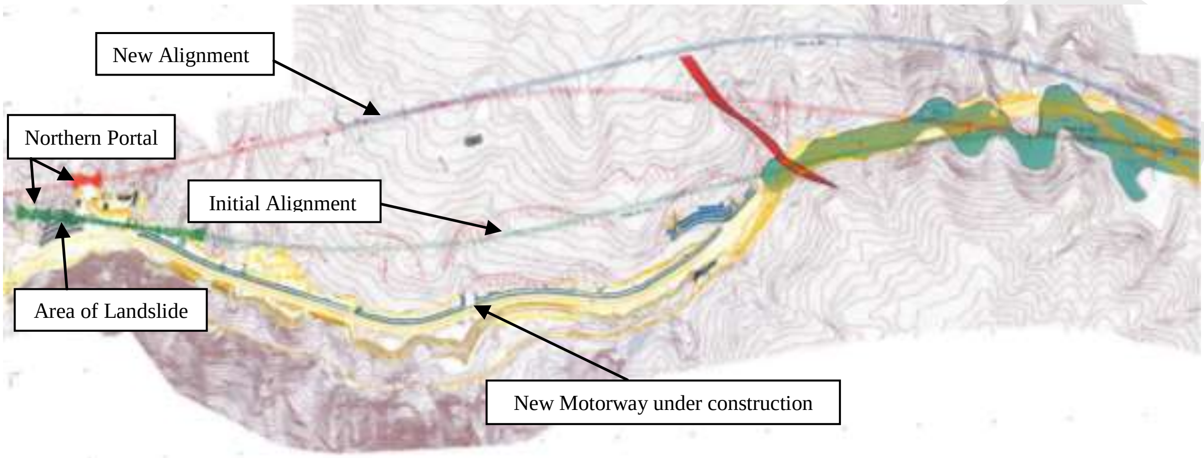

Fig.1: Layout of the original and new tunnel alignments following the landslide in the adjacent motorway

The excavation commenced on the northern portal in September 2009, i.e. one year after the scheduled date. However and given the very slow progress of the excavation, caused by the extreme squeezing behavior of the graphite schist, in March 2010, with the consensus of the owner the contractor decided to abandon the NATM and instead to continue the excavation with a TBM. The overall length of the excavated section up to that time was 297m.

Being under time pressure to continue the works, the contractor started searching for a second-hand TBM, possibly available in the market. The basis for the selection of the type of TBM to be purchased was the geotechnical report at hand. A reputable European manufacturer, who previously inspected and also assessed the geological conditions of the site, confirmed the suitability of a second-hand “hard rock single shield” TBM kept in their yard. Given the time required for the refurbishment, it was agreed for the captioned TBM to be delivered in May 2011.

Pending delivery of same, the contractor proceeded with the re-profiling of the horseshoe cross section of the 297m previously excavated with the NATM to the required circular one, as to enable the passage of the TBM through it. Following the arrival of the parts and completion of the erection of the TBM on the spot by the end of May, the TBM commenced its operation on 1 June 2011.

Insurance

Whereas the previously existing CAR cover was retained in force, it was only in July 2012, when the contractor applied for the provision of an All Risks CPM cover for the TBM. During the intervening period of nearly 13 months, the uninsured TBM had managed to excavate only a length of 610m in the *"virgin"* ground. The placement of the CPM policy was made via a separate Broker, for the Insurer and Reinsurers involved being almost different from the ones attending the CAR cover. The terms and conditions of both policies were according to the standard MR wording.

In the application form submitted to Insurers/Reinsurers it was erroneously stated that the TBM (a) despite being from its origin a "hard rock single shield" TBM, was modified and now working in an "earth pressure balance" (EPB) mode, and (b) in the almost one year of its uninsured operation was 'loss free'. Based on these declarations the risk was unconditionally accepted by the interested Underwriters.

Events preceding the Loss and Circumstances

Having completed its passage through the re-profiled section that was previously excavated with the NATM, in October 2011, the TBM already upon entering into the 'virgin' ground started encountering serious steering problems accompanied by premature wearing of the components of its cutterhead. This adverse situation was further aggravated through the occurrence of frequent over excavations, sinkholes ranging up to the surface of the overburden and partial collapses both in the excavation face as well as in the crown of the tunnel, leading to repeated shield jams and blockages of the TBM.

Despite the continuous efforts of the contractor and the manufacturer, attending the excavation, to manage the situation by means of extended repair and modification work on the TBM itself, the problems remained factually not only unresolved but became even worse given that as from March 2012 severe cracking of the segmental rings, forming the final lining of the tunnel, started to occur.

The ring designer, who was called in for assistance, attributed the cracking of the segments to the overestimation of the parameters of the ground presented in the geotechnical report, used as input for the design of the segments. However and instead of insisting on the execution of additional ground investigations, he decided to upgrade the strength of the segments based on arbitrarily postulated values for the parameters of the ground. Having repeated this improvised exercise twice in vain, as from the early July 2012, the ring designer ordered the almost continuous application of additional stiff support to the rings, comprising of steel ribs, anchors and shotcrete, as to enable the continuation of the TBM drive at any price.

Fig. 2: Continuous application of stiff support as to enable excavation with the TBM

None of the above circumstances were ever notified to the CAR Insurers nor even mentioned in the proposal form submitted to Insurers at the end of July 2012 for the provision of the separate CPM cover.

On 1 August 2012, and whilst the TBM was once again still stand due a further blockage of its cutterhead, with immediate effect the owner of the project ordered the

- ✓ exclusion of the captioned tunnel from the scope of the project
- ✓ suspension of all construction activities including the excavation with the captioned TBM upon reaching the nearest possible safe location
- ✓ preparation and submission of a new design for the construction of a bypass tunnel in replacement of the abandoned one, to be constructed according to the NATM.

In addition, the Owner advised the Contractor of their decision to proceed with the re-tendering of the outstanding works on the abandoned tunnel sometime in the near future. It is noted that at the time of receipt of these orders from the Owner, the

- ➢ additional length excavated by the TBM since the issue of the CPM policy was only 14m
- ➢ location where the TBM was standing was in fact the safest one ever reached in the duration of its drive, given the extensive additional stiff support implemented in the specific location in the meantime, as per the previously mentioned instruction of the segment designer.

Notwithstanding the above instructions from the owner, the contractor decided to continue the excavation with the TBM at his own risk under the continuous application of the additional stiff support, whilst working in parallel also on the excavation of the bypass tunnel with the NATM. Again, none of these interim developments were ever reported to the Insurers attending the CAR and CPM policies.

Loss

In the morning of the 16 November 2012, i.e. some 3.5 months after the exclusion of the tunnel from the scope of the insured project and also the instruction of the owner to immediately suspend the excavation, the extreme squeezing of the ground caused another, this time severe, blockage of the TBM encompassing its shield/cutterhead, tail and the subsequent first gantry resulting in significant material damages. At that time and since the 1st August, the 85m long TBM had excavated another 98m, under the continuous application of additional stiff support, corresponding to an average excavation rate of only 0.9m/day.

Photos 2 & 3: *Partial collapse of the tunnel benches amongst stiff support resulting to the squeezing and damaging of the TBM*

As a result of the damages sustained by the TBM and also by the works (partial collapse of the side and crown areas and destruction of the segmental rings over a length of 12m), the excavation of the tunnel was ultimately abandoned by the contractor.

Claim

In June 2013, the Insured submitted two separate claims under the CAR & CPM policies in excess of € 25 million. Included in these claims were also the costs related to the previous similar incidents since March 2012. However, the documentary evidence provided in support of these submissions was entirely unspecified, comprising mainly of long lists of man-hours allegedly spent and materials purchased. No elucidation whatsoever was contained therein confirming the causal relationship between the individual amounts claimed having been spent over the entire period and the incident of the 16 November 2012, forming the subject matter of the claim.

The adjuster's request to be provided with the outstanding elucidations and also to be given the opportunity to inspect and validate the nature and extent of the reinstatement works allegedly done in the meantime was never responded to by the Insured.

Cause

As clearly demonstrated in the detailed Root Cause Analysis (RCA) report, elaborated by the appointed loss adjusters under the CAR & CPM policies, the principal causes that contributed to the numerous but similar incidents since the commencement of the excavation of the TBM in June 2011 until its final blockage on the 16 November 2012, were due to the

(a) significant underestimation of the extreme squeezing behaviour of the ground and the Insured's and their designer's insistence to rely on the unrealistic values for the geotechnical parameters suggested in the geotechnical report, despite the numerous warnings for the opposite since the commencement of the works

(b) incompatibility of the type of the TBM chosen for the excavation (i.e. single shield hard rock instead of EPB), despite the efforts of the Insured and the TBM manufacturer to overcome this problem on the spot by means of repeated improvisation work done on the TBM over the entire period. The continuous over excavations imposed by the unsuitability of the TBM, in fact provoked the further de-stabilization of the anyway unstable (squeezing) ground

(c) insufficient grouting of the annular gaps behind the rings in conjunction with the defective design of the segmental rings

(d) Insured's conscious decision, despite the numerous interim incidents and also the instruction of the owner to abandon the works, to continue the excavation at any price by instructing their designers to seek for fragmentary solutions to the original design (i.e. arbitrary upgrades of the ring's strength and almost continuous application of various types of additional stiff support).

Summarized Assessment of Cover

From the above elucidations and in terms of the principal conditions and provisions stipulated in the CAR & CPM policies, the actions of the Insured since commencement of the works up to the date of the incident in November 2012, constitute a continuous and severe breach of these provisions in at least four separate aspects as follows:-

1. **Misrepresentation of the Risk**: Despite the Insured's declaration to the contrary, the TBM never managed to operate in EPB mode.

2. **Non-Disclosure of Crucial Facts**: None of the interim partial collapses, repeated jams and blockages of the TBM were ever reported to Insurers, nor were the Insurers ever advised of the owner's instruction regarding the immediate suspension of the construction activities and exclusion of the tunnel from the scope of works, some 3.5 months prior to the loss.

3. **Change in Risk**: The almost continuous application of additional temporary support (forming in fact an integral part of the NATM) in the TBM drive, as a pre-requisite for the continuation of the excavation, constitutes a materially different risk to that originally accepted by Insurers.

4. **Fortuity**: The repeated incidents as per item 2 above, which also necessitated the Owner of the project already in August 2012 to order the suspension of the works and the exclusion of the tunnel from the scope of the project, clearly suggests that the incident of the 16 November 2012 can in no case be considered as being accidental, unexpected and unforeseen.

Conclusion

The circumstances and cause of this loss does not fall within the basic requirements of the CAR & TBM policies. Hence and also in the light of the exclusions provided for in the additional relevant clauses of these policies, the Insurers are relieved from the duty to respond to the claims submitted by the Insured.

4.2 LANDSLIDES

The case in reference concerns a landslide which occurred during the execution of an earthcut along the footing of a hill side in the course of the implementation of a new motorway concession project.

Background

For the alignment of the new motorway passing through a rough topography, the design provided for at a specific chainage the execution of a 21m high and 125m long earthcut on the lower part of a hill as to create sufficient space for the new route. The captioned hillside was naturally formed advising a flat inclination of 18° (footing) and 23° (top) for the upwards length measuring some 300m. The top of the hill was bordered by a narrow asphalted rural road, running almost parallel to the alignment of the new motorway. The hill side was planted with olive and various fruit trees belonging to third parties.

According to the design, the excavation for the earthcut would have to be executed by means of heavy machinery without explosives. The new slope in the area of the 21m high earthcut was designed to include three benches, each 8m in height with an average inclination of 45°.

Incident

During the last week of June 2011, the excavation of the fractured schist comprising the area had reached a depth of 15m for the excavation of the remaining 6m being scheduled to be completed within the following few days.

Whereas the excavation work was still in progress, a landslide took place encompassing several parts of the hill side within the area bordered by the length of the earth cut and the some 300m upwards positioned rural road. Besides from moving several meters downhill, the hill side was also vertically settled between 1.5m to 2.0m giving rise to the manifestation of a transitional crack running along the border of the rural road, measuring some 2m in width and 3m in depth.

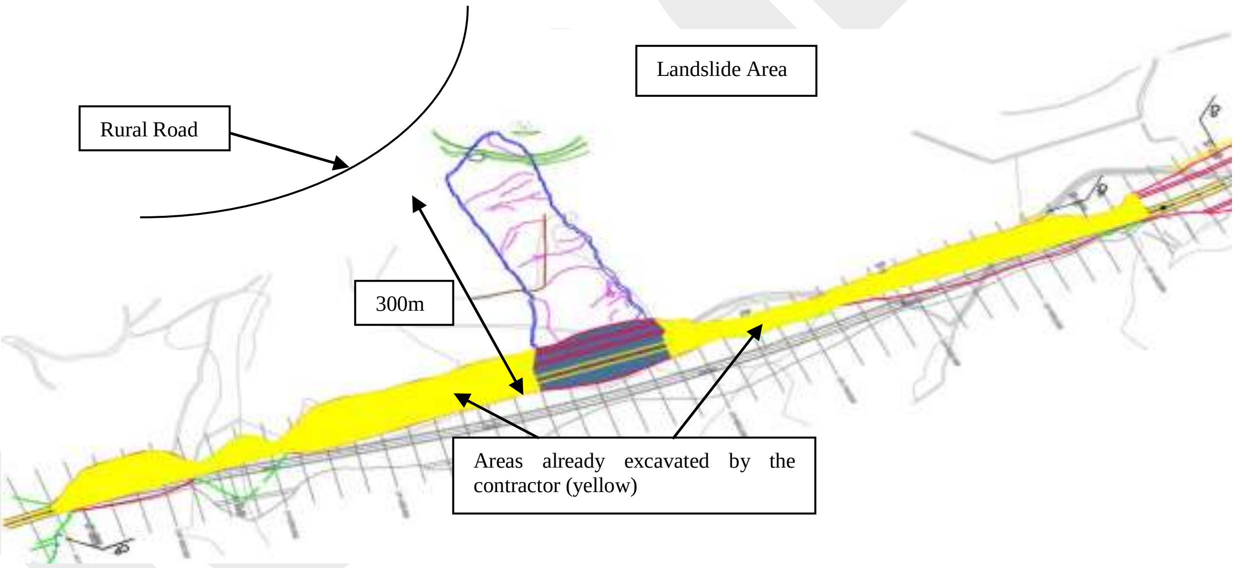

Fig. 1: Layout of the area of the works

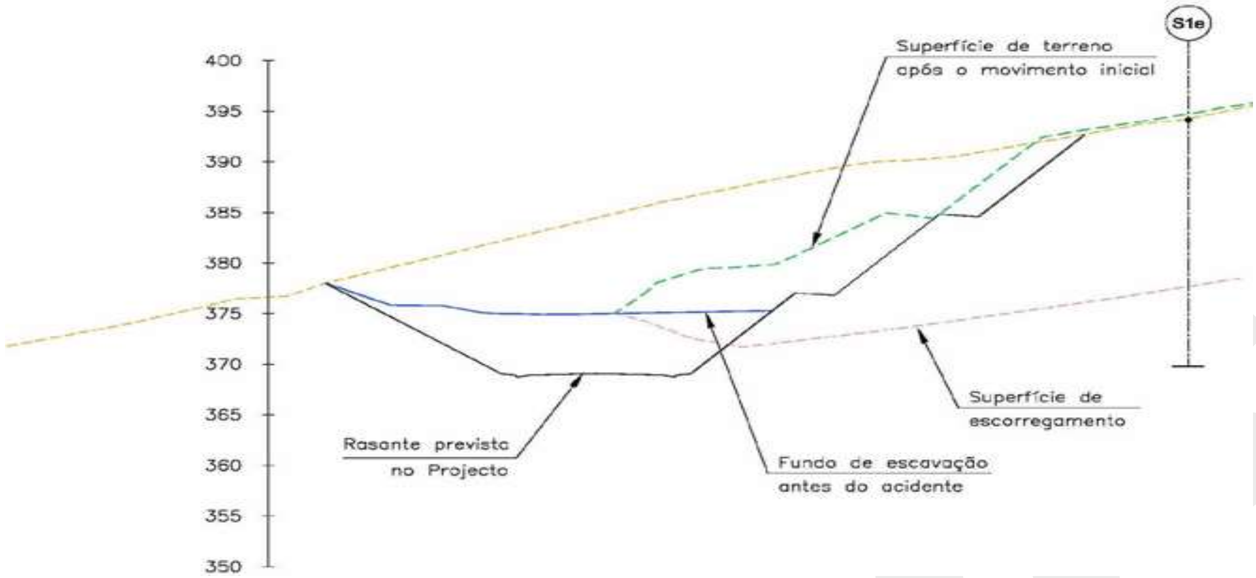

Fig. 2: Cross section of the landslide

Photos 1&2: Views of the slipped area

Photos 3 & 4: (a) earth mass fell on the already completed sub base of the motorway under construction, (b) works for re-routing the affected stretch of the motorway.

As a precautionary measure, the excavated area along the footing of the hillside was immediately backfilled and a detailed investigation of the ground conditions prevailing in the specific area was carried out. Being uncertain of the residual stability condition of the natural slope after the incident, the Insured decided to temporarily suspend the works and look for alternative solutions.

Cause

As it was obvious even to the naked, but skilled eye, the earth movement occurred in an area in which the hill side forms a natural 'amphitheater' whose topography is dominated by steep and flatter sections. This type of geological terrain is indicative of a relatively loose soil material of variable thickness, overlying a rocky stratum with changeable composition and hardness, prone to locally restricted slide activity depending on the thickness of the overlying soil and also the stiffness and inclination of the underlying rocky stratum.

The original investigation of the site reportedly comprised only of a standard penetration test (SPT) ranging up to 15m, and a seismic profile of the lower part of the hill side. Following the incident, the contractor proceeded with the execution of additional 21 SPT and 11 dynamic penetration tests (DPT), ranging between 13m-24m, as well as 19 exploration trenches up to 1.5m. It is noted that no ordinary boreholes were carried out in any of these stages of investigations.
As revealed by these examinations, the ground conditions in the specific area comprised of heavily fractured schist advising thin bedding with spatial orientation, being prone to weathering processes. This schist was covered by a soil-like material comprising of a matrix of clayed components with medium to high plasticity, originating from the decomposition of the schist. The "sliding surface" was identified along the transition zone between the soil like overburden and the schist lying underneath in a depth varying between 5.5m and 16.5m. Due to its changeable stiffness, the surface of the underlying fractured schist advised an irregular configuration comprising of randomly distributed cavities or lenses with varying inclinations, filled with saturated soil from the overburden. It was because of these numerous lenses encapsulated in the transition zone that the hill side, being anyway in a condition of marginal equilibrium, was prone to locally restricted downward movements.

In view of these ascertainments, it was reasonably concluded that the recent landslide was due to the reactivation of older displacements caused by the excavation and removal of a huge portion of the footing of the hill side, previously acting as a counterweight.

Claim

Being uncertain about the residual stability of the hill side following the captioned incident, the contractor decided to abandon the excavation in this area and instead to re-align one km long section of the route of the new motorway some 40m downstream as indicated in photo 3b. This solution provided also for the removal of the displaced earthmass and also the execution of stabilization works, comprising of the installation of 3 subsequent retaining walls made of anchored micro piles to be placed along the hillside as indicated in Fig. 3, below.

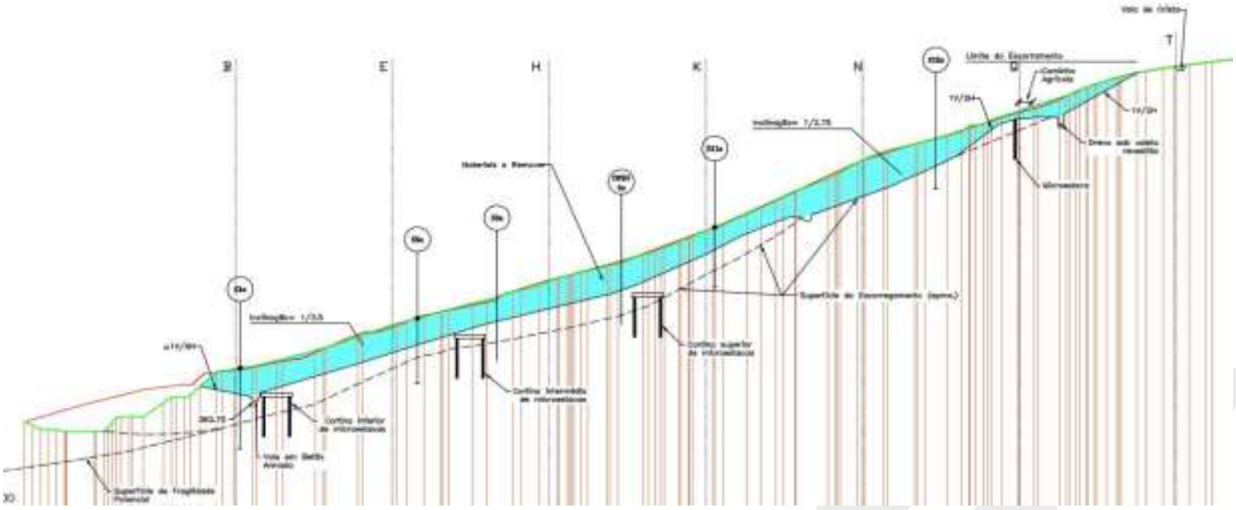

Fig. 3: Cross section depicting the concept of the stabilization works.

The net claim submitted by the contractor was in the amount of € 2,822,880 including the value of the already executed contractual works in the specific area and also the amount of € 200,000 to be paid to the third parties as indemnification for the damages sustained by their cultivations.

Summarized Assessment of Cover

The project was covered under a CAR policy based on the standard MR wording. The main argument of the Insured in support of their claim was that the cause of the loss was due to the unfavorable and also unforeseen geological conditions prevailing in the area of the hillside. It was further argued that these conditions could not be predicted in the course of the initial exploration forming the basis for the design for the earthcut.

The argument regarding the unpredictability of the ground conditions provided by the Insured as the root cause of this incident is lacking any substantiation. It was though evidenced that the initial ground exploration consisted in fact of the execution of only one standard penetration test, which is by far insufficient to obtain a clear picture of the geological conditions prevailing in the almost 30ha measuring hillside. If the contractor had instead carried out the most extensive post loss examinations beforehand, then they would have certainly acquired the accurate picture timely, thereby avoiding the loss in terms of having implemented the necessary stabilization works they are claiming for, prior to the commencement of the excavation for the earthcut.

Furthermore, the conscious decision of the contractor to keep the costs for the initial geological exploration to the lowest possible limit also caused for the dimensioning of and the method statement adopted for the execution of the earthcut to be based on entirely arbitrary criteria and assumptions without even for any slope stability analysis having ever been carried out as to even check beforehand the validity of these assumptions.

In the light of the above circumstances and also the lack of any approved design as a prerequisite for the execution of the works, the Insurers denied acceptance of liability for this loss.