RISK MANAGEMENT
LEADERSHIP & ANALYSIS

Tunnel and Underground Works: Managing insurance particulars in a well-structured and risk-averse environment

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ABSTRACT:

Insurance policies which are fundamental for a tunnel project to commence and finalize are managed primarily by the Insurer and the Insurance Broker (acting on behalf of the Insured) and are premised upon specific conditions and requirements.

Because of the extremely technical nature of tunnel projects, the placement of the appropriate insurance policy presupposes the availability of specific information to establish be-spoke policy wordings and clear terms & conditions. These can influence the level of the insurance premium and other critical elements (e.g. deductibles, sub limits, etc). A crucial role in this lengthy and (occasionally) attritional process is delegated to Risk Engineers, who can facilitate the entire process by delineating the project's overall "risk profile" through discernible services assisted by dedicated aids. These could create a healthy competition among Insurers, highlighting the Insurance Broker's invaluable role and finally satisfy the project's needs.

1. INTRODUCTION – GENERAL

Every civil engineering and in particular every underground & tunneling project, irrespective of its size, type, location, value, complexity, etc., requires as a prerequisite from Lenders the existence of a valid insurance policy for the construction activities to commence. The type and form of the insurance policy along with its stipulated particulars require a thorough investigation, a detailed presentation and cooperation between all incumbent parties, namely the Insured, the Insurance Broker and the Insurer in order to deliver the correct message, meet the project's requirements and fall into the Insurer's financial capacity and risk appetite.

For achieving the above objectives, there are specific and well-defined procedural steps to be followed, clear and explicit preconditions to be met, a diverse group of experts to be mobilized and involved, and various challenges and hurdles to be overcome in the context of a candid and truthful collaboration among all involved parties. This paper elaborates on the above features, providing the necessary explanations and guidance for a holistic and comprehensive approach, emphasizing the critical and most influential parameters. It describes the role each one of the three incumbents has to play and the actions to take in order to amicably and professionally manage the insurance particularities and mutually agree on the final product.

2. KEY RISK EXPOSURES & HAZARD SOURCES – PROMINENT IMPACT

Every underground project is exposed to many risks of varying nature and diverse consequences, which shall primarily and foremost be dealt with in the design and construction management practices. Nevertheless, the probability of a loss incident can never be annulled, always leaving a residual risk. In addition, the progress and maturity level of the project can create new risks and modify or alter the risks already identified. Hence, it is of primarily importance to review the most prominent hazards, common to almost all tunnel projects, as briefly presented hereinafter.

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2.1 *Natural environment – Ground conditions – Geology*

Ground conditions (including any distinct features, such as fault, bedding, etc.) and their physical and mechanical characteristics play a key role in the behavior of underground openings. Combined with other tunnel characteristics (e.g. depth, size, alignment, etc.), it could alter the likelihood and severeness of a loss and modify its manifestation (e.g. "chimney-like" failures).

2.2 *Construction Methods – Machinery – Plant & Equipment*

A diverse suite of construction methods and a broad spectrum of equipment and (sophisticated) machinery are available for tunneling, selected upon specific criteria (such as ground conditions, tunnel characteristics, logistics, etc.) The situation could become more complicated if any unproven (untested) technology or the adoption of innovations and novelties are proposed.

2.3 *Design Approach & Concept*

Design, although constituting the cornerstone of a successful project (Konstantis, 2020), is considered responsible for more than 40% of the underground failures (Reiner, 2011), whilst the most common and potentially shocking failure mode is the collapse of the tunnel face and support overstressing (Konstantis et al, 2016; Spyridis and Roske, 2021).

2.4 Construction Execution & Workmanship – Quality of finished product

A successfully executed project needs to meticulously adhere to the approved and scrutinized design, whilst concurrently adopting a robust inspection and supervision program. This will increase the possibilities of a quality product, minimizing defects, etc.

2.5 *Natural & Environmental Hazards – Third Party Liability*

A diverse set of natural hazards (mainly of an uncertain and unexpected nature) can affect the project, with the expected impact directly related to the location and project preparedness. Conversely, there are other man-made environmental hazards (such as noise, vibration, dust, etc.), which could affect third parties (especially in urban and densely populated areas). These need to be fully addressed in the design and construction concept and practices.

2.6 *Prominent Tunnel Failures & Losses*

Under specific conditions and circumstances, the above-mentioned hazards could be proven highly impactful and potentially catastrophic, especially in more complex projects. The consequential and collateral damage could also be emphatic, both in financial (costs) and time-related (delays) terms (with the latter also translating into financial damages), as presented on Figure 1.

Date	Project	Cause	Insured Loss (USD)	Delay
1994	Great Belt Link	Fire and flood	33m	12
1994	Munich Metro	Collapse	4m	14
1994	Heathrow Express	NATM collapse	141m	14
1994	Taipei Metro	Retaining wall collapse	12m	12
1995	Los Angeles Metro	Collapse	9m	15
2000	Taegu Metro	Retaining wall collapse	24m	9
2003	Shanghai Metro	Cross passage collapse	80m	47
2004	Singapore Metro	Retaining wall collapse	80m	36
2006	Kaohsiung Metro	Cross passage collapse	10m	24
2007	Sao Paolo Metro	NATM collapse	10m	10
2009	Cologne Metro	Retaining wall collapse	400m	??

Figure 1. Prominent historical tunnel failures and insurance losses (compilation of publicly available data)

3. MATERIAL INFORMATION – UNDERWRITING CONSIDERATIONS

Tunnel projects come in many shapes and forms and the following is a non-exhaustive list of tunnel projects, generally considered as major civil construction projects:

- Hydroelectric schemes – headrace tunnels, tail race tunnels.
- Underground metro projects.
- Tunnels constructed using:
  - Conventional Excavation
  - Tunnel Boring Machine
  - Cut & cover methods

For insurance companies to understand a project and be in a position to provide the best insurance coverage that fulfills project requirements, accurate and full information relating to the project must be provided (Towers and Scott, 2015). It should be remembered that insurance transfers risk from the owner and contractor's balance sheet to that of the insurance company. If the insurer does not have the information to fully understand the risk exposure presented, they will err on the side of caution, be it with restricted coverage or increased premium and deductibles. This financially could result in the contractor or owner being required to retain more of the risk than may be necessary.

Experienced insurance brokers generally know what is required. However, market conditions, timing and inexperienced brokers

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who do not fully understand the impacts of providing inadequate information to the insurers may contribute to less risk being transferred to the insurer. It should not be overlooked that brokers as well as insurers have in-house engineers with civil engineering backgrounds who are able to review and understand the technical information presented. Additionally, insurance risk engineers are often exposed to numerous projects throughout each year and can add value to the risk management process through shared experiences from a plethora of other tunnel projects.

The type of information generally required for a full project review includes but is not limited to:

- Detailed project description – Scope of Work
- Ground Condition reports
- Design details
- Complete set of project drawings
- Contractual information (budget and baseline schedule, etc.)
- Construction data (Method Statements, plant & machinery, etc.)
- Quality data (e.g. QA/QC plans, third party properties management, etc.)
- Health & Safety data
- Risk Management data (Risk Management plan, risk registers, etc.)

It should be noted that all this information should be readily available and is not a special requirement. Additionally, there is a duty to disclose information to the Insurers which the Broker can advise on. Failure to disclose relevant information could lead to significant repercussions.

4. KEY FACTORS OF SUCCESS – INVOLVEMENT ROADMAP

4.1 *General*

Despite the above difficult situation, there are specific and targeted actions to be implemented towards a proper and effective risk management program. These initiatives should ideally cover all stages of a project's lifecycle and be founded on a solid and robust interaction between the Insured, the Insurance Broker and the Insurers. The critical linkage among them is risk engineering, which could effectively and amicably reinforce / substantiate the trilateral negotiations, address underwriters' considerations and key requests and satisfy the project's requirements.

The main responsibility for developing a well-structured and proactively implemented action plan falls to the Risk Engineer, whose critical role and responsibilities are explained below.

4.2 *Timeline of Involvement – Cooperation among all parties – Project Lifecycle*

Due attention ought to be given not only to the involvement of an experienced Risk Engineer but also at the timeline of his involvement, as the level and magnitude of "effort" and "benefit – return" heavily depend on it. Figure 2 presents an indicative and characteristic graphical illustration of the variation of risk engineering involvement at the different project realization phases.

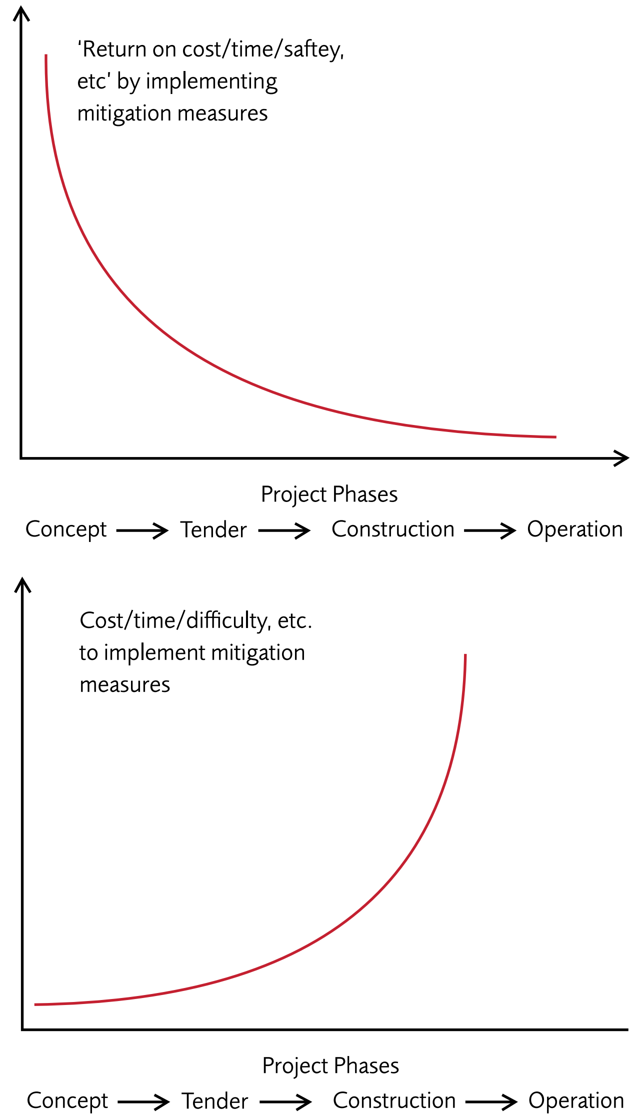

Figure 2. Project Phases & risk engineering (indicative generic illustration)

4.2.1 *Project Development Stage*

This is a critical period, with feasibility studies playing a crucial role on forming and shaping the project and its contextual 'risk profile'. Moreover, actions such as third party surveys and dilapidation studies, development of the technical viability of the project, the preparation of a design of the upcoming procurement stage, the selection of the preferred form of procurement contract, etc., can facilitate a smooth placement of the necessary insurance policy.

From a risk management perspective, the project owner's role is pivotal in setting up the risk policy encompassing the risk acceptance criteria, a qualitative risk assessment and a detailed analysis of areas of special interest or concern.

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4.2.2 *Construction Contract & Procurement – Tendering & Negotiation Stage*

This stage is important both for the project contractual particulars (such as pre-qualification process, contract models and documentation, tender assessment and contract award) as well as the insurance aspects. Clear guidance and directions can positively affect the terms and conditions of the insurance policy, addressing the main concerns and reservations from the underwriters.

4.2.3 *Project Design Stage – Project Formation and Structuring*

The element of design is present throughout the project's entire lifecycle (in the form of scheduled designs and / or field changes) and unfortunately (as seen from publicly available data) has a role to play in every major loss incident. Hence, due care and attention ought to be given in order to address all aspects and especially achieve the fundamental objective of managing the remote risks ("high impact low probability") during construction and throughout the design life of the project. Critical elements (such as temporary vs permanent works) need to be scrutinized, whilst the existence of risk registers is considered best-practice in the context of risk management perspective. A commonly used approach is the ALARP ("As Low As Reasonably Practical") principle, which balances between the upper "unacceptable region" of intolerable risks that should be reduced regardless of cost and the lower "broadly acceptable region" where there is no need to consider risk reduction.

4.2.4 *Project Construction Stage*

Following the above stages, the next step is the actual construction of the project. It is critical that the project is developed with no deviations from the approved project design or from the framework of a well-structured and project-specific Construction Management Plan (CPM). Other essential elements relate to the Instrumentation and Monitoring (I&M) schedule, the skills and qualification level of the construction team, the workmanship and quality level of the final product, etc. Nevertheless, for the seamless transition from theory (plans and procedures) to tangible outcome (actual structures), the primary role of supervision and inspection has to be acknowledged and recognized, both by the Contractor and the Project Owner.

4.2.5 *Project Owner's Role & Responsibilities*

The Project Owner holds the ultimate ownership and business case. He dictates the particulars and details of the contract and other transaction documents and specifies the critical project requirements and performance outcomes. Through a careful and robust selection of his partners / representatives he can gauge the project delivery process and the desirable quality level of the final product. The above actions should receive elevated attention in the case of an Owner Controlled Insurance Policy (OCIP), where the management and administration of multiple construction contracts and interfaces (both external and internal) is of fundamental importance.

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5. INSURANCE POLICY PARTICULARS & KEY ITEMS

5.1 *Optimum Timescale – Best Practice*

The establishment of an insurance policy and its mutual agreement and consent may be a lengthy process and (occasionally) attritional, hence requiring a pro-active and meticulous approach. Time is essential in achieving the best possible outcome for all stakeholders and avoiding pitfalls and omissions, especially in complex tunneling projects. As a rule of thumb, a period between 2 to 6 months may be needed for the Insurance Broker (with the assistance of his Risk Engineer) to digest the information, submit it to the Insurers in a structured way ('Construction Risk Report') for their information and review, to negotiate lead terms and gather support from the insurance market before finally placing the insurance policy.

5.2 *Insurance Premiums*

Setting insurance premiums is difficult as no two tunnel risks are the same. This makes benchmarking premiums from one project to another impractical. However, premiums are affected by the level of information and confidence an insurer has about a particular project. If insurers have to make conservative assumptions in relation to the project and its risk management framework, this can adversely affect the insurance premium from the project owner / contractor's perspective.

As previously noted, factors that affect premiums include type of tunnel construction, contractors experience, length and depth of tunnel, ground conditions, location (susceptibility to Natural Catastrophe), deductibles or excess, policy terms and conditions, adherence to the Tunneling Code of Practice and finally insurance market conditions.

5.2.1 *Effects of rating tools on Insurance Premiums*

Nowadays most insurance companies have sophisticated rating tools which are based on historical data that is then analyzed and analyzed using the insurer's models. Input parameters in these tools will affect the perceived risk quality and thus the premium. There are several different rating tools available to insurance companies, with the use of a particular rating tool over another determined by company preference.

The rating tools themselves are sensitive to parameters such as:

- Ground conditions (unknown or limited information will also result in insurers making conservative assumptions)
- Contractor experience (personal)
- Length, depth, diameter and tunnel alignment
- Tunnel construction (drill and blast, Conventional Excavation, TBM, etc.)
- Fire protection and detection (during construction)
- Construction costs for particular elements of work
- Project timeline and timeline for individual aspects of work (Tunnelling, mechanical and electrical, as well as other fit out works)

The quality of the information supplied by the project team / contractor directly determines the output from the rating tool. The experience and judgement of the underwriter assisted by the in-house engineers determines the data inputted. As the input to the rating tool can be varied, the sensitivity of the output can also vary. Using the extreme ranges of each input field the output can differ significantly.

With all parameters leaning towards a well-managed risk, these judgements can lead to significant discounts on the final premium. If information is unknown, a cautious approach is adopted resulting in a higher insurance premium. This is an undesirable situation for both the insurance company (who wants to be competitive) and the insured who seeks a competitive premium.

5.2.2 *Other Factors Affecting Price*

It is worth noting that the focus on premium discussed thus far has been attributable to the level of information provided to the insurance company for review, and owner's and / or contractor's adherence to a robust risk management framework. However, all else being equal there are other factors that can dramatically affect premium.

5.2.2.1 *Loss Estimates*

The standard way in which most insurance companies operate is to review the available technical information presented by the project owner and / or contractor and to determine the worst probable disaster scenario and to estimate a monetary value for this scenario. This is known as the Estimated Maximum Loss (EML) or the Probable Maximum Loss (PML) and the accuracy is determined by the extent and quality of the information supplied.

By doing this, the insurance company can determine the amount of potential financial exposure it will have from a particular event, which is one factor considered in determining how much premium it will need to charge to cover potential claims.

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5.2.2.2 Deductibles

The level of self-retention or deductible or excess will also affect the insurance premium. This is the part of the insurance claim that the insured must bear, usually on a per event or per occurrence basis. The higher this figure, the lower the insurance premium, as the insured is bearing more of the risk. A difference of one to two times in the deductible level might incur a substantial saving in the premium under specific conditions and circumstances.

5.2.2.3 Policy Coverage

Policy coverage will also have a profound effect on the premium charged. As an example, full defects coverage with guarantee maintenance could attract upwards of a 25% loading on premium compared to a traditional coverage of consequential physical damage loss resulting from said defects and extended maintenance.

5.2.2.4 Tunnel Sub Limits

Realistic tunnel sub-limits based on calculated assessments by engineers can be used to limit the exposure of insurance companies. Therefore, if full reinstatement coverage for a project is not actually required and it is more appropriate that a lower loss limit can be accepted, then the insurance premium will be lower. The in-house risk engineers from the insurers and brokers can help to determine an appropriate limit.

6 RISK ENGINEERING MANAGEMENT

6.1 Risk Engineering Management Tools

There are several well-established and globally recognized tools that can assist the Risk Engineer in accomplishing his/her goals to reach an optimum outcome. Two of the most commonly used ones are the "Code of Practice for Risk Management of Tunnel Works – TCoP" (ITIG 2012) and "ITA – AITES Guidelines for Tunneling Risk Assessment, 2006", which can significantly improve the project's marketability with insurers.

6.1.1 Tunnelling Code of Practice (TCoP)

The TCoP is a very powerful and extremely useful document in managing risks in a tunnel project. It is the most frequently used and recommended document in the insurance industry when structuring an insurance policy. Since its publication in 2003, the document has a proven and sustained track record in contributing to the reduction in frequency of tunnel failures and consequences (both in cost and time). Like other documents, it has to be used carefully, with any conclusions drawn aligned with the business model and particularities of each individual project.

The TCoP is an excellent tool in streamlining and benchmarking project plans and procedures and managing the anticipated expectations. The approach equally beneficial to all parties, is a "pro-active" one based on compliance with the "spirit of the code", rather than a "passive approach" (compliance to the 'letter of the Code') which is more onerous and cumbersome.

6.1.2 ITA – AITES WG2 Guidelines

This document is a powerful asset when dealing with risk management. It provides indications on recommended industry best-practices for risk management combined with guidelines to designers as to the preparation and implementation of a comprehensive risk management system for tunneling works. The main objectives of this document are to give guidance for the identification and management of risks in tunneling and underground projects, whilst clearly describing the transition of risk management from the initial design stages up to construction.

6.2 Risk Engineer – Tasks, Activities & Services Provided by Risk Engineers

6.2.1 Benchmarking exercise against the TCoP – Baseline Results

The benchmarking exercise is carried out against the TCoP to determine the compliance level and manner of the project with the requirements and guidelines of the TCoP. As already explained, there are two ways of undertaking this task, namely the "proactive – to the spirit" and "passive – to the letter" approach.

The former requires a robust engineering judgement of an experienced Risk Engineer based upon a thorough use of engineering skills. The latter could be described as merely a "simplified and rigid procedural route" that lacks flexibility, ignores the technical particularities and overlooks the distinct operational characteristics of the incumbent parties.

The benchmarking exercise and the effort to delineate the compliance level are following the same essential and non-negotiable fundamental principles, as briefly presented below:

- The TCoP complements rather than supplanting any local standards and statutory duties
- It stipulates the hazard identification process for all distinct four project stages
- It encompasses a set of formalized procedures, clearly structured

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- It recognizes the need and importance of risk registers at each project stage, concurrently considering them to be "live" documents
- Risk is managed to the ALARP level, avoiding any exaggerations and onerous directions
- It recognizes the need to 'cascade' risk registers through all project stages in a seamless and continuous procedure
- There is a clear and obvious allocation of risk and responsibility at every stage, avoiding any ambiguities and generalities that could jeopardize the project's integrity and safety

The designated route and process of the benchmarking exercise presupposes the evaluation and assessment of various topics, including a detailed list of project information deliverables. Indicatively, it can be said that topics around work method statements, QA/QC, project and risk management plans, plant selection criteria, value engineering and constructability reviews, etc., all form part of the key evaluated areas. In conclusion, the benchmarking task is extremely useful during the insurance policy pre-placement (negotiation) period and should be ideally combined with the underwriting submission.

6.2.2 *Broker PML Studies – Insurable Limits Delineation*

PML studies are a critical tool in the endeavour to approximate the correct (and sufficient) level of insurable limits, ensuring the right balance is struck between coverage and premium. The main reason for this approach is that the "traditional" concept was based on correlating the indemnification provided following a loss with the original construction cost, usually capped at 125% or 150%. However, this approach could substantially underestimate the provided indemnity and hence leave the project significantly underinsured.

The assessment of the PML needs to be realistic and properly substantiated in order to prevent extremes that could compromise the validity and applicability of the insurance product (Konstantis, 2017 and 2018). The actual process of calculating the PML has to clarify what is actually at risk, what the value at risk is, and what portion of it is likely to be damaged and to what extent. In order to facilitate the entire process and reach a realistic outcome, there is a suite of information required to be provided. A non-exhaustive list could include the following:

- Overall plan of the project, including its relative location to all other adjacent properties
- Plans and sections of key structures of the structures of the project, in order to identify construction material, layouts, construction sequences, temporary works, etc.
- Construction cost details for all major components of the project
- Construction program / timeline of the project

In brief, the procedure to be followed commences with the review of the relevant project information in an effort to understand the project. The process continues with the identification of the hazard sources that have the potential to cause a loss incident, albeit consideration is given only at the "major" loss scenarios with highest envisaged impact. These scenarios are then quantified and assessed on the basis of the likely cost impact and time delay. The above steps, although seemingly generic, have to be adjusted in line with the conditions and particularities of each individual project that is examined. The use of any previously acquired experience and robust engineering judgement is acknowledged with the identification of the "major" loss scenarios and also the evaluation of the extent of the credible damage to be caused (both cost and time).

7. CONCLUSIONS

This paper attempts to show the benefits and merits of a professional and amicable collaboration between the Insurers, the Insurance Broker and the Insured with the established level of confidence and trust reflected with competitive premiums (subject of course to the current insurance market conditions). This confidence is gained by the demonstration of the use of risk management techniques, since the more insurers understand about a project, the likelihood of the insurance company participating in a project increases. This creates competition between the Insurance companies and elevates their construction risk appetite, which in turn leads to broader coverage and reduced premiums and lower project costs.

It should be remembered that insurance is not purely a financial mechanism to restore projects to the same pre-loss position, but its interest in other aspects of a project (such as safety, quality, risk, etc.) can be proven equally assistive and favorable to the project. It is in the interest of the Insured, the Insurance Broker and Insurers that the project is completed free of any claims and disputes. In order to achieve this, the experience and knowledge gained by the in-house risk engineers of Insurance companies and Insurance Brokers who visit numerous tunnel projects annually, can facilitate a dissemination of lessons learnt and best -practices that should not be overlooked by any project team, Contractor or Employer.

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