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ÖNORM B 2203-1 as a Supplement to FIDIC Emerald Book in Conventional Tunnel Construction

Oleksandr Melnyk *, Jacqueline Raab and Frank Lulei

Institute of Construction Process and Construction Economics, TU Wien, Karlsplatz 13/235, 1040 Vienna, Austria
* Correspondence: oleksandr.melnyk@tuwien.ac.at

Abstract: This paper explores how the ÖNORM B 2203-1 model can complement the FIDIC Emerald Book contracts in conventional tunnel construction projects, specifically focusing on cooperation, project management, reimbursement, and dispute resolution. The complex technical nature of such projects requires collaborative stakeholder engagement, efficient project management, and effective dispute resolution mechanisms. This article enhances the current body of literature by undertaking a qualitative comparative analysis of the FIDIC Emerald Book and the ÖNORM B 2203-1 model within the specific context of conventional tunnel construction projects. The findings demonstrate that specific areas in the FIDIC Emerald Book exist where supplementary guidance is required. Compared to the FIDIC Emerald Book, the ÖNORM model offers a more extensive range of project management aspects, reimbursement guidelines, dispute resolution provisions, and comprehensive technical specifications, all supported by contractual provisions. The major limitation of this study is its focus on a literature review. Thus, including the qualitative analysis in an actual project and applying the study results would be advantageous for verifying the findings.

Keywords: conventional tunnelling; FIDIC; ÖNORM; contract forms; construction management

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1. Introduction

The objective of this study is to illustrate how the ÖNORM B 2203-1 can serve as a complementary tool towards Fédération Internationale des Ingénieurs Conseils (FIDIC) Emerald Book contracts, specifically focusing on areas such as cooperation, project management, reimbursement, and dispute resolution. Applying national civil law is often challenging in the context of large-scale international construction projects. Consequently, standardised contract models such as ÖNORM B 2110 in Austria, VOB/B in Germany, NEC in the United Kingdom, and SIA 118 in Switzerland are commonly used [1]. Considering the difficulty of predicting ground conditions, it is necessary to provide tunnelling contracts with a flexible contractual framework that can be easily adapted to local settings [2–4]. The present paper discusses the possibilities of developing such a contractual framework by applying the method of qualitative comparative analysis to the FIDIC and ÖNORM B 2203-1 models. This paper focuses on the similarities and differences between the two models and evaluates the potential applicability of the ÖNORM B 2203-1 as a supplementary tool to the FIDIC Emerald Book in the context of conventional tunnel construction projects.

This article is divided into four main sections. Section 1 briefly describes the research method. Section 2 provides an overview of the FIDIC Emerald Book and the ÖNORM B 2203-1 contract forms and examines the feasibility of using the latter to supplement tunnel construction contracts based on the former. Section 3 analyses the differences between the two contracts in project planning and management practices. Section 4 investigates the compatibility of reimbursement models. In contrast, Sections 5 and 6 examine the dispute resolution mechanisms and suggest how the ÖNORM B 2203-1 can effectively supplement the FIDIC Emerald Book in international tunnelling projects.

1.1. Status Quo

Previous literature on FIDIC application in civil engineering and infrastructure has extensively explored the use and impact of FIDIC contracts in various construction projects worldwide. Scholars and practitioners have recognised FIDIC as a leading standard for construction contracts, providing a comprehensive framework for governing contractual relationships, risk allocation, and project management [5]. Previous studies have examined the development of FIDIC contracts [5–8], highlighting their revisions over time to adapt to the changing needs and challenges of the construction industry. Researchers have also investigated the advantages and challenges associated with FIDIC contracts, addressing topics such as contract administration [9–12], risk allocation [13,14], dispute resolution mechanisms [15–20], and the role of FIDIC in promoting fair and equitable project outcomes. Additionally, some articles have examined case studies and real-world applications of FIDIC contracts [21–26], offering insights into their practical implementation, effectiveness, and potential areas for improvement. Previous literature on FIDIC application in civil engineering and infrastructure construction projects has contributed to a deeper understanding of the benefits and limitations of using FIDIC contracts in construction projects [27], fostering informed discussions and providing guidance for industry professionals and policymakers.

While previous research on FIDIC contracts has significantly contributed to understanding construction project management, several questions remain to be addressed in the context of conventional tunnelling projects. One major limitation is the scarcity of studies focusing exclusively on FIDIC contracts for such projects. Most existing research addresses the general application of FIDIC contracts, such as comparing national and international construction contracts, e.g., ÖNORM B 2110 and previous FIDIC standards [6]. Furthermore, the predominant emphasis of research in tunnel construction has been on risk management [28–32] and dispute adjudication [20,28,33], overlooking the need for a comprehensive overview of contracts and the specificities of conventional tunnelling. For instance, ref. [34] conducted an analysis of international contracts and digital data management in mechanised tunnelling, yet the examination of the FIDIC Emerald Book was not included in the study. Research [35] focused on contract models in tunnelling, explicitly emphasising the risks and security of payment for Contractors in mechanised tunnelling. Although these studies contribute substantially to the research field, their limitations underscore the need for a more comprehensive analysis to address the gaps and challenges in understanding FIDIC contracts and their application in conventional tunnelling projects.

1.2. Research Gaps and Questions

Research to be explored includes conducting an in-depth literature review of the FIDIC Emerald Book and its supplements, focusing on its application in conventional tunnel construction projects. The specific research questions that will be addressed are as follows: Which similarities and differences between the ÖNORM B 2203-1 model and the FIDIC Emerald Book concerning conventional tunnel construction projects can be determined? What potential does the ÖNORM B 2203-1 have to enhance project execution based on FIDIC contracts, particularly regarding cooperation, project management, reimbursement, and dispute resolution?

Additionally, it is essential to examine the effectiveness of the ÖNORM B 2203-1 in providing documentation, internal controlling, invoicing procedures, and facilitating dispute adjudication. Addressing these research questions can develop a comprehensive understanding, identify gaps in the existing literature, and provide information for future studies in this field.

1.3. Materials and Methodological Approach

As stated before, the objective of this study is to compare construction contracts and identify their similarities and differences. Following [36], the paper applies a qualitative

comparative approach to two contractual documents: the ÖNORM B 2203-1 and the FIDIC Emerald Book. The research approach involves identifying the scientific relevance and the need for research on the topic, as well as the definition of the research questions, as seen in Figure 1. The following literature research is conducted on the subject areas and contents of the research questions. Relevant data on the ÖNORM B 2203-1 and the FIDIC Emerald Book is collected and extracted, which forms the foundation for the subsequent thematic and comparative analysis. The themes, such as contract characteristics, reimbursement models, and dispute resolution models, are explored to identify patterns and trends across different contracts. Finally, the collected relevant key data are presented, interpreted, and evaluated, focusing on the two contract models and their applicability to tunnelling projects in international and local contexts [4,37]. The findings provide an overview of the similarities and differences between the two contract frameworks and portray how the two frameworks can complement and contribute to each other.

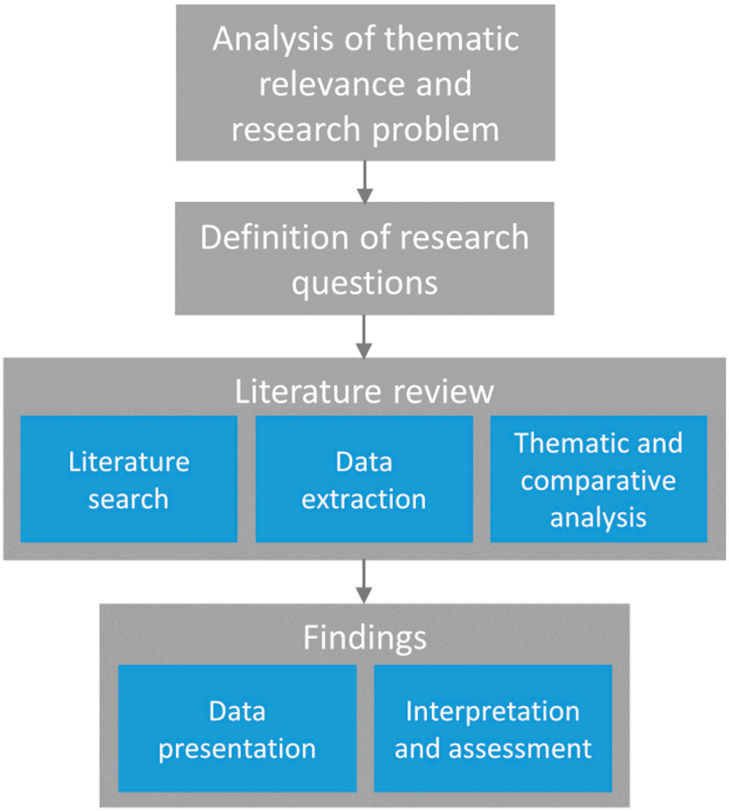

Figure 1. Methodology of the research.

The review does not focus on specific contract clauses but describes the overall structure and approach of the Austrian and FIDIC contract forms and remuneration models for conventional tunnelling. The model contracts' essential aspects, approaches, and relevant standards are emphasised. The section below provides their general overview before discussing and comparing such main relevant patterns of the ÖNORM B 2203-1 and FIDIC construction contracts.

2. Basics on Examined Contractual Frameworks

As discussed in the Introduction (Section 1), despite the similarities between the ÖNORM B 2203-1 and the FIDIC Emerald Book, there is a notable difference in their suitability for local and global legal contexts. Consequently, the question arises as to whether and to what extent the two frameworks can contribute to each other. This paper addresses this question by applying a qualitative comparative approach to analysing the two contractual models. This section describes the research methodology and provides a

preliminary overview of the ÖNORM B 2203-1 and the FIDIC Emerald Book. It summarises the main similarities and differences between project management in the two contractual documents and shows how they can supplement each other.

2.1. Overview of FIDIC Emerald Book

FIDIC is an international standards organisation for consulting engineering and construction technology, which has been publishing sample contracts for global construction since 1957. The first version was mainly based on the "General Conditions of Contract and Form of Tender" published by the Institution of Civil Engineers in Great Britain in 1945 [38]. Since then, the sample texts have been revised several times, and various contract templates have been developed for different applications. The FIDIC Conditions of Contract have been part of the World Bank's standard contracts since 1995 and have been recommended by the World Bank and other development banks since 2005 in the "Pink Book" version. The use of the FIDIC Standard Terms and Conditions is generally mandatory for funding programmes of the European Union. In the past, the traditional FIDIC contract forms were adapted for tunnelling projects [2]. However, certain specificities of these projects required a separate template with new tunnel-specific provisions. For example, the New Austrian Tunnelling Method (NATM) contractual practice was applied to previously published FIDIC contracts, as described in [39].

In 2019, FIDIC and the International Tunnelling and Underground Space Association (ITA), a joint task group, published the Emerald Book to extend the applicability of contract models for tunnelling [40]. It was drafted explicitly for underground works based on international best practices and the ITA Contractual Framework Checklist [22,32]. It draws on the Second Edition of the Conditions of Contract for Plant and Design-Build (Yellow Book 2017) [31,33,41] as its foundation, incorporating new concepts to address the unique risks associated with underground works, particularly subsurface conditions. This is the first contract form to address international underground and tunnelling projects.

The FIDIC Emerald Book is a guide for drafting contracts. It is an independent book containing general contractual conditions and information on special provisions and is used for preparing tender documents [42]. It is specifically applicable to tunnelling projects due to the possibility of adapting individual parts of the contract to the different project-specific distribution of tasks between the Employer and the Contractor (e.g., design and build or pure execution services). Essential elements from other FIDIC contracts, such as the consulting Engineer [43] and the three-stage dispute resolution procedure [44], are incorporated into the FIDIC Emerald Book [45,46]. The Geotechnical Baseline Report (GBR) [47], which defines the expected ground conditions [48,49], is intended to serve as the basis for the contractual agreements of the precise FIDIC contract model. The other two key documents besides GBR are the completion and the baseline schedules. Due to the project-specific variations based on the FIDIC contract model, hardly any contract components are consistently applied in the same way. A detailed contract review during bid processing is necessary to understand the contract.

The joint task group of FIDIC and ITA representatives identified several issues that the new standard form of contract aims to address in order to promote equitable risk allocation and effective dealing with unforeseeable conditions in tunnelling projects [50]. The key areas addressed explicitly in the new contract include the allocation of risk [51], a contractual geotechnical baseline, and the complete disclosure of available geological and geotechnical information [41]. Further, the contract contains a tailored "Unforeseeable Physical Conditions" clause and provides a flexible mechanism for remuneration depending on the ground conditions [45]. Since the time for completion is mainly influenced by ground conditions, the contract implements a ground classification system and supports conditions that must adequately reflect the effort of excavation and stabilisation.

It is important to note that FIDIC does not provide specific provisions for all project-specific conditions, as they are inherently tailored to each project. For this, FIDIC provides a guide in the "Guidance for the Preparation of Particular Conditions" section, which

helps in approaching the specific contractual provisions. This highlights the importance of thoroughly considering and reviewing the contract terms before entering into an agreement to ensure that the parties fully understand their obligations and responsibilities.

2.2. Overview of ÖNORM B 2203-1 Works Contract Form

The works contract form drafts ÖNORM B 2203-1:2022 for conventional tunnelling and B 2203-2:2022 for mechanised tunnelling developed by the Austrian Standards Institute adopt the general risk allocation of ÖNORM 2110 [52] and provide a detailed mechanism for adjusting reimbursement and construction periods in accordance with the actual ground conditions within a given set of parameters of subsurface physical conditions [42]. Further, the ÖNORM B 2203 contract models contain supplementary regulations based on Austrian national law, hardly making their application in international construction projects an option [21]. Additional challenges arise in coordinating international project partners, primarily if the construction services or building components are supplied from other countries. The issue concerning the ÖNORM B 2110 model contract and the ÖNORM B 2203 works contracts in the context of international construction projects resides in their incompatibility with national laws and their application across diverse legal systems [53].

As shown by [34,42], the ÖNORM B 2203-1 standard attempts to create a transparent distribution of risk spheres, leaving the reimbursement of costs with the contractual partner responsible for it. Using a unit price contract, the ÖNORM model offers high-cost security for the Employer [54]. The standard differentiates between general construction site costs (one-off and time-related construction site overheads) and costs of service provision. Further, performance-based construction timetables are used for settling payment of time-related costs. An advantage of the ÖNORM B 2203-1 contract and remuneration model lies in the flexibility of the model, which is given by a clear definition of the excavation classes and their adaptation to the rock conditions encountered during construction. Accurately describing the services in the tender documents ensures fair competition and comparability of the offers. Although the standard does not provide explicit guidance on allocating subsoil risks among project stakeholders, these risks are commonly addressed in the contractual agreement between the Employer and the Contractor [55]. A contract following ÖNORM B 2203-1 can, if used correctly, support the contract partners in the execution of the project.

One of Austria's main tunnel planning guidelines is described in the Austrian Society for Geomechanics (ÖGG) guideline for the geotechnical planning of underground structures with conventional tunnelling [56]. The main phases of the ÖGG guideline [56] comprise the design and construction phases. The design phase includes the specification of the expected ground conditions, the classification into ground types, the assessment of the ground behaviour and its categorisation into ground behaviour types, and the definition of construction measures based on the project-specific boundary conditions [57]. Finally, the system of expected ground behaviour is predicted, and tunnelling classes for a bill of quantities are determined according to ÖNORM B 2203-1 [54]. The construction phase includes a definition of the current rock types and short-term forecast of rock conditions, specification of excavation, support measures, and forecast of system behaviour. Then the tunnel expert verifies the system behaviour by confirming the structural engineering measures and approving the interior work [58].

The following main body of this paper compares contract characteristics, reimbursement procedures, and resolution models of the two frameworks. It discusses the possibilities of using ÖNORM B 2203-1 to supplement project execution based on FIDIC contracts in greater detail.

3. Comparison of Contract Characteristics

Project management is essential for any construction project, including tunnel construction projects. The success of a tunnel construction project largely depends on how well the project is managed and how efficiently the project participants work together. This

section compares contract characteristics of the FIDIC Emerald Book and ÖNORM B 2203-1. It highlights their similarities and differences and the extent to which the two contract models can supplement each other.

3.1. Geotechnical Baseline Report in FIDIC Emerald Book

The FIDIC Emerald Book focuses on the previously mentioned GBR (Section 2.2) as the basis for project planning to prevent possible disruptions of construction and delays caused by unpredictable ground conditions. The GBR is intended to be the single source and contractual document describing the anticipated subsurface conditions encountered during project implementation [47]. The GBR must also define the risk allocation of subsoil conditions or ground hazards between the Employer and the Contractor. Appendix A of the Emerald Book explains what the GBR should contain [45]. The Contractor suggests the rate of construction and the duration of the excavation and lining work corresponding to each excavation and work area [59]. To determine the necessary duration of construction, the Contractor should consider the economies of scale, the learning curve, the resource availability and deployment, the safety requirements, the work area, the accessibility, and working hours [60].

According to the GBR, physical conditions include natural physical conditions, physical obstructions (natural or manufactured), and pollution, as well as the reaction of soil to excavation. Thus, the excavation work must continuously be monitored, and the Contractor must submit his interpretation of the subsoil and surface monitoring results to the Engineer daily. Under Sub-Clause 13.8.3 of the FIDIC Emerald Book, the Engineer may reassess the conceded excavation and construction work time in the schedule and construction plan, providing a flexible compensation mechanism for both predictable and unforeseen field conditions. As stated by [49], the GBR is a multi-step procedure that starts at the project's initial planning stage and is completed once construction is finished. During the design phase, the risks should be identified and viable engineering solutions developed to cover the full range of expected physical conditions [48]. During construction, the relevant geotechnical parameters and properties should be collected, recorded, and evaluated on site to validate subsoil classification, design assumptions, and safety margins regularly.

Specific geotechnical information collected during the construction phase generally includes the visual classification of subsoil through fracture mapping and results of probe drilling or sample testing [49]. Further information contains geophysical measurements, groundwater measurements, monitoring of stress, strain, and displacement, and a review of design assumptions such as field and deviation stress conditions. The collected geotechnical data are further interpreted to form the basis for the subsoil classification system and the definition of measures for subsequent tunnel excavation, including the allocation required for additional construction measures. This allows for detecting and recording abnormal behaviour and geohazards, such as flooding, and defining possible end or inner support measures if necessary [48]. With a focus on risk management, the Emerald Book includes all relevant geohazards in the risk register in the geotechnical risk management plan [61], which further comprises the overall construction risk management plan [30].

3.2. Systemic Conditions and Tunnelling Classes in ÖNORM B 2203-1

Compared to the FIDIC Emerald Book, ÖNORM B 2203-1 takes systemic conditions and tunnelling classes as the basis for project planning and remuneration. In projects based on the ÖNORM B 2203-1, the stakeholders have to agree upon documentation and invoicing procedures, which are conducted according to the respective tunnelling classification matrix before the start of construction [54], as exemplified in Figure 2. The ÖNORM B 2203-1:2022 definition of the tunnelling classes comprises the first organising number, determined by the specified round length, and the second organising number, calculated from the extent and the type of the supporting measures [62]. All supporting measures installed in the specified cross-sections are to be considered. The tunnelling classes are further ordered for the excavation work, required methods of loosening, a subdivision of the

partial cross-sections, and the excavation sequence. The definition and distribution of planned excavation classes allow the Client to more precisely estimate the cost of a given tunnel project based on the geological qualities of the project region. The evaluation area is contractually fixed and independent of actual settlement lines [54]. The application of unit prices and advance rates in the context of the discussed methodology involves their utilisation within specific areas defined by the cut-off length, the first organising number (depicted on the left side of Figure 2), and the region encompassed by the second organising number (visible in the upper part of Figure 2). The determination of the first organising number is contingent upon the length of excavation, whereas the calculation of the second organising number relies on the summation of evaluated support means per metre of the tunnel, divided by the evaluation area. The duration of constructing each tunnel section is also a variable that influences the final invoicing.

FIRST ORGANISING NUMBER	ROUND LENGTH UP TO		SECOND ORGANISING NUMBER									
	TOP HEADING OR TOP + BENCH HEADING	BENCH	SUPPORT NUMBER									
			1	2	3	4	5	6	7	8	9	
1	No limit	PROJECT-SPECIFIC SPECIFICATION										
2	4.0 m											
3	3.0 m											
4	2.2 m				4/2.4	4/3.6						
5	1.7 m						5/4.5	5/6.1				
6	1.3 m							6/5.5		6/7.5		
7	1.0 m											
8	0.8 m											
9	0.6 m											

Figure 2. Example of a Tunnelling Class Matrix for top, bench, or top-plus-bench headings based on the ÖNORM B 2203-1 standard.

The Schedule of Baselines follows the GBR and the Employer's reference design [63]. It contains all the activities and their anticipated quantities for the underground excavation and lining [45]. Generally, the Schedule of Baselines should include the characteristics of expected utilities, underground structures, probe drilling, and other investigations associated with subsurface physical conditions. The Schedule of Baselines also contains advanced grouting for poor or contaminated ground, waterproofing grouting, seepage, water ingress, and related hindrances treatment. Significantly, this document details the treatment of geological overbreak and related hindrances, waterproofing, and construction of the final lining. The occurring interruptions depict changes in the construction method for excavation and lining works due to unforeseeable subsurface physical conditions or orders of the Employer or authorities. The Schedule of Baselines is divided into individual drives and construction methods per zone that reflect a section or part of the works.

Each work section includes a design for systematic excavation, support, and lining works based on the associated boundary conditions [49]. A common approach to dealing with conventional tunnelling projects is to define different tunnelling classes. Each class corresponds to tasks and activities that address a specific range of geological conditions. The design of tunnelling classes includes evaluating the entire drilling and support process, defining acceptable impacts on adjacent facilities and the environment, and verifying compliance with the project's long-term structural and maintenance requirements. The tunnelling classes must cover the full range of systemic conditions specified in the GBR for each tunnel type, size, and construction method. Typically, the organisation of the GBR involves classifying all activities necessary to complete a tunnel round as a construction activity bundle.

3.3. Comparison of Performance Certificates

The ÖNORM B 2203-1 standard provides the two variants for recording the excavation services of the calotte and the bench in the specifications. The first variant is used for tendering a service item for the miners' expenses (wages) and other cost components (miscellaneous) that are directly related to the excavation. The second variant is used to create a service item for the labour costs of the tunnelling crew [54]. The first variant is recommended for projects with shorter tunnel sections. The various cost element is the tunnelling equipment's wear-and-tear maintenance expense. The standard specifies that each driving class will have a separate item with the unit m^3 in the tunnelling specifications. For the second variant, an allocation item for the labour costs of the tunnelling crew is created, with items not part of the time-dependent costs allocated to this item [35]. Furthermore, one item per excavation zone (first organising number of an excavation class) is created for the remuneration of the other performance-dependent and time-independent costs in m^3. These items are then used for the invoicing and remuneration of the partial excavations of the calotte and bench. According to ÖNORM B 2203-1, the services of the excavation process, i.e., loading, removal, and dumping, as well as the reuse of the excavated material, are recorded in separate positions.

An essential feature of the tendering documents is the presentation of defined excavation profiles of the tunnel cross-sections and the boundary surfaces by the Client. The standard states that the excavation positions of the variants already cover the additional excavation on the cavity side up to this boundary surface. If, under certain circumstances, more extensive excavations beyond the boundary surface occur, separate positions for the lining of the additional excavation should be included in the specifications, irrespective of the excavation classification.

According to the FIDIC Emerald Book, the monthly progress reports are prepared by the Contractor and submitted to the Engineer [45]. As defined in the contract data, each progress report is submitted in one paper-original, one electronic copy, and (if any) additional paper copies. The first report covers the first month of work following the commencement date, with further reports submitted monthly after that until the project's completion date. Each progress report must include charts, diagrams, and detailed descriptions of progress, the Contractor's documents, procurement procedures, materials fabrication, deliveries to the construction site, and excavation cycle times. Further, the report must contain ground support installation times and activities, planned and unplanned cycle time delays, and the physical conditions of the ground encountered at the working faces.

The report must include copies of quality management documents, inspection reports, survey results, and compliance verification documentation (including certificates of materials) or any recorded deviations. This information can include photographs or video recordings showing the manufacturer's status. Finally, the document should contain a comparison of actual and planned progress, with details of any events or circumstances that can adversely affect the completion of the works, and the measures adopted to overcome such delays.

3.4. Comparison of Field Measurement Sheets

The Emerald Book has provisions for measuring excavation and lining works and the time adjustment for completion and contract price [45]. Unless stated otherwise in the contract, only the excavation and lining works are subject to measurement [59]. The agreed contract covers all other underground works and items necessary for proper execution. The contract price and time for completion have to be adjusted following the measurements.

Sub-Clause 4.12, "Unforeseeable Physical Conditions", has to be applied if unforeseeable physical conditions outside the limits described in the GBR are encountered and lead to the Contractor suffering delays and incurring costs [63]. Further, the contract data must state the measurement method for the Schedule of Baselines and the Bill of Quantities. Usually, the Contractor is responsible for the measurement and must submit relevant

measures with complete supporting records to the Engineer at the contractually specified dates or monthly intervals.

The field measurement sheets that document the excavation are used for data processing by applying for items with certain specifications. For non-existing or new additional services, settlement agreements are decided between the Contractor and site supervision, which interfaces with the responsible contract managers. The field measurement sheets and dimensioning sheets are usually administrated jointly by the Client and the Contractor, forming the basis for invoicing. The site supervisor prepares the acceptance protocols with the respective timestamp, and the construction manager checks them and uses them for invoicing. To avoid printing out the measurement sheets, the accounting department processes and sends them to the site supervisor digitally, after which the site supervisor revises and approves them digitally. The Contractor is responsible for preparing and delivering a report to the Client for review and approval to eliminate inconsistencies. Since both the Contractor and the Client sign the report, it is a helpful piece of written evidence, especially for the proof of delays and additional costs [64]. The obligation to generate daily construction reports does not have to be separately stipulated in the contract if the contract is based on the ÖNORM B 2110 standard, as the ÖNORM requires the Contractor to do so anyway [52]. The data entry into the field measurement sheet is thus carried out continuously by adding standardised items to the bill of quantities. After exporting the data to Excel, the data are compared to the support installation logs and adjusted if the Contractor makes changes to quantities. The summarised data are transferred to the invoicing software such as RIB iTWO, ib-data's ABK, or others to form the settlement total at the end of the month [62].

3.5. Comparison of Sample Contract Forms

As discussed in previous sections of this article, the ÖNORM B 2203-1 model and the FIDIC Emerald Book differ in essential aspects but also show some parallels. According to both contract models, the Client must attach a subsoil prognosis to the contract [35]. It is within the Client's sphere of influence to carry out a careful subsoil prognosis and to implement the existing contractual provisions or recommendations of the two models as best as possible. This requires a suitable ground classification and the specification of possible excavation methods in the respective areas, from which the classification of the excavation classes (ÖNORM model) [54] or sections (Emerald Book) can be derived [45]. One significant difference, however, is the form of execution of the project. In the Austrian contract model, the Client, with his vicarious agents, generally carries out the approval and implementation planning, and the Contractor is commissioned with the construction work.

Consequently, a tunnel construction project is carried out as a general contractor model, with the tunnel construction contract being based on a unit price contract. Explicit regulations on excavation hindrances, additional excavation, water complications, and sludge disposal can be found only in the ÖNORM model [54]. The Contractor takes over the execution or detailed planning within the specifications, such as the GBR and the reference design defined by the Client. The pricing of the construction contract is a lump sum with specific adjustment options (surcharges/deductions) due to the extent of the tunnelling and lining services. A constructive service description with corresponding items exists

are put out to tender through a functional service description.

The tunnelling classification enables a flexible payment model in both the ÖNORM B 2203-1 [65] and the FIDIC Emerald Book [35]. The tunnelling services can thus be invoiced according to the actual distribution of the classes or sections in connection with the contractual tunnelling speeds. This enables an appropriate, performance-based remuneration of the time-related and on-site overhead costs based on the geology encountered [34]. In addition, both contract models contain precise specifications for handling performance deviations, and the multi-stage dispute resolution processes positively contribute to conflict reduction [18,66]. The ÖNORM and the FIDIC contract models are characterised by

unique features, such as the possibility of submitting alternative offers and enabling value engineering.

Furthermore, the models include roles for technical consultation and assessment of the tunnel construction site. The tunnelling expert in the ÖNORM [58] model and the Engineer in the Emerald Book [46] significantly influence low-conflict project management. While the tunnelling expert is used only for consultation, the Engineer in FIDIC acts as a contract administrator who is given far-reaching decision-making competencies, e.g., regarding construction supervision, invoicing control, and the assessment of supplementary claims [67,68]. The Emerald Book includes only early contractor involvement for the detailed planning. However, a cooperative approach by conducting obligatory, regular partnership meetings is pursued only in the ÖNORM model. Table 1 below gives a general overview of the compared contract characteristics.

Table 1. Overview and comparison of contract characteristics.

Contract Characteristic	FIDIC Emerald Book	ÖNORM B 2203-1
Geotechnical Baseline Report	Emphasises the importance of a GBR as the basis for project planning; GBR describes anticipated subsurface conditions and defines risk allocation	Takes systemic conditions and tunnelling classes as the basis for project planning and remuneration; tunnelling classes are determined by specified round length, extent, and type of supporting measures
Construction planning and monitoring	Requires continuous monitoring of excavation work and submission of subsoil interpretation to the Engineer; Engineer may reassess the time for construction work based on field conditions	Defines excavation classes and systemic conditions for different geological ranges; design of tunnelling classes includes evaluating drilling, support processes, and compliance with long-term structural requirements
Performance certificates	Two variants for recording excavation services: one for miners' expenses and other cost components, and another for labour costs of the tunnelling crew	Specifies separate items for labour, other performance-dependent, and time-independent costs
Field measurement sheets	Provides provisions for measuring excavation and lining works; measurements subject to adjustment of contract price and completion time	Measurement method stated in contract data; Contractor is responsible for the measurement and submission of relevant measures; field measurement sheets are used for invoicing
Sample contract forms	Client attaches subsoil prognosis to the contract; contractor commissioned for construction work; pricing is based on a lump-sum with adjustment options	Client carries out approval and implementation planning, and Contractor is commissioned for construction work; pricing is based on a unit price contract with adjustment options

In tunnelling, the certainty of payment for Contractors is significantly influenced by the distribution of subsoil risks [30]. The obligation to apply a flexible remuneration model for the tunnelling services and the time-related costs dependent on tunnelling creates a basis for an appropriate, fair distribution of subsoil risks in both contract models. However, differences in contractual provisions can also be observed regarding payment security for Contractors [35]. For instance, the FIDIC contract predominantly transfers the completeness risk to the Contractor [45], in contrast to the Austrian standard. The study of [35] concludes that the Contractor is generally more secure in remuneration with the ÖNORM contract model than with the FIDIC model. Furthermore, project-specific provisions should be made, especially regarding possible complications beyond the scope of the sample contracts to increase the security of remuneration for the Contractor. Such reimbursement models and their compatibility are the focus of the next section.

4. Compatibility of Reimbursement Models

Regarding reimbursement, the FIDIC Emerald Book sample contract specifies invoicing by actual measurement and unit prices, but most contract provisions can be applied

equally to lump-sum contracts [6]. As the overarching standard, the ÖNORM B 2110 specifies three types of security, these being the security deposit, the liability bond, and the cover bond [52]. In the FIDIC standards, the retention money, the performance security, and the advance payment guarantee are listed as securities. The performance security is to be compared with the security deposit, and the retention money must be understood as a combination of liability and cover bond. However, unlike the ÖNORM, the advance payment guarantee does not have an equivalent provision, even though the structure of the ÖNORM and the FIDIC guarantee adhere to similar settlement standards. The ÖNORM differs in the percentage specified for guaranteed amounts, costs, and repayment due dates.

Regardless of which FIDIC contract is used, the Contractor should manage items subject to varying field conditions (primary drilling and primary support) under a single-price contract system [2]. This allows the application of various site condition clauses [69] to reduce costs, determine their impact and evaluate time. According to [70], the unit price structure should be organised to distinguish fixed, time-dependent, and quantity-related costs easily. In the Emerald Book, contract-based costs and completion times are identified in the GBR and are further remeasured during construction to adjust contract prices and completion times [49]. The time for completion and related costs can either increase or decrease, depending on whether the actual conditions are more or less demanding than initially anticipated.

Concerning payment, the Emerald Book distinguishes between parts of the work endangered to subsurface physical conditions and sections supposedly without any impact [59]. Tunnelling classes have to be periodically remeasured based on quantity and time-related rate items included in the baseline for the specific work item. Nonetheless, work not affected by any ground risks [71,72], such as that related to Force Majeure, is reimbursed at a fixed amount of the contract price (fixed fee). For unit price contracts, adjustments and compensation are based on the additional drilling and lining work measures and the deviation to the benchmark production rates and costs specified in the original GBR.

The fixed-rate items include all services required for the excavation work but, according to [59], are independent of the variation in ground conditions. One could, for example, allocate the one-off costs of transport and assembly construction site facilities, site clearance, construction of the base infrastructure, etc., and other costs such as leasing/depreciation of the key equipment and wage costs for non-productive personnel such as for the foreman or the site manager to these items. The provisions base the fixed-rate items on a lump sum, possibly a unit price. In contrast, the contractually forecast construction duration based on the Schedule of Baselines is used for the time-related items.

In the Austrian context, the ÖNORM A 2050 procedural standard for procurement of works, services, and supplies regulates the awarding of contracts for services like an invitation to tender, offer, and award [73]. This procedural standard suggests three types of pricing, these being unit price, lump-sum price, and direct price. The unit price contract with its remuneration system is generally used for tunnel construction projects in Austria. This contract type is usually used if the type of construction work and quality of the work can be precisely defined and if quantities can be approximately determined. Tenders providing unit prices are carried out because of underlying constructive service catalogues with activities subdivided into individual service items. The Client quantifies the services in the items using estimated quantities (preliminary rates), and the Contractor calculates his unit prices for the respective services for his offer [35,74]. The target remuneration can subsequently be derived from the quantity details of the items in the specifications with the unit prices agreed in the contract. After the construction work is completed, the services are invoiced with the agreed unit prices and the executed quantities. The standards state that the quantities are generally invoiced according to the relevant contract standards (in tunnelling according to ÖNORM B 2203-1 [54] or ÖNORM B 2203-2 [75]) or project-specific agreements. The planned measurement shall apply if doubts arise while invoicing the quantities on site. The result of the settlement with any adjustments to the charges, for

example, the claim for additional costs, represents the actual remuneration, which is the focus of the next section.

4.1. Remuneration

The critical point for construction companies is the flexible classification of the tunnelling services during execution in the contractual tunnelling class matrix proposed in [54]. Invoicing occurs based on the actual distribution of the tunnelling classes, including allocating to the respective special jacking, and incident management with the contractually agreed jacking speeds [35]. The support measures used to secure the excavation (anchors, tunnel arches, shotcrete, etc.) are recorded in separate items, irrespective of the excavation classes. Furthermore, the ÖNORM B 2203-1 standard specifies some time-dependent costs and the invoicing procedure of support measures anchors, shotcrete, mesh mats, etc. The tunnel construction contract is an indispensable basis of the flexible remuneration model.

The Emerald Book stipulates that all services related to tunnelling or directly or indirectly influenced by the excavation work should be recorded in separate items. The Employer shall assign appropriate units to those services and determine estimated quantities for each item. All other services, mostly unaffected by the excavation work, are based on a functional service book and therefore reimbursed flatly. For these services, separate positions must be included in the tunnelling specifications [45,59].

As per the Emerald Book, the Contractor must provide the Engineer with a Statement of Completion and supporting documents within 84 days of the works' completion date [45]. The statement should encompass the amounts the Contractor deems entitled to and any accompanying supporting documents. These supporting documents and the relevant progress report should offer a comprehensive level of detail to enable the Engineer to thoroughly investigate the above-mentioned amounts. The statement must consist of the estimated contract value of the executed works and the documents the Contractor produced up to the end of the performance period. The schedule of payments shall include payments due on completion of milestones and other payments consistent with the corresponding data in the schedule of rates and prices, the Schedule of Baselines, and the complete Schedule. Additionally, any further sums that the Contractor considers being due at the completion date of the works are stated, and an estimate is made of any other amounts that the Contractor believes are due after the completion date. These estimated amounts shall include, for example, charges for claims for which the Contractor has submitted a notice.

4.2. Bill of Quantities for Excavation and Support Works

The Bill of Quantities (BoQ) sets out the quantities, units of measurement, and applicable unit rates and prices for all excavation and lining works [45]. Unless provided otherwise in the Employer's requirements, the initial quantities are determined by the Employer, consistent with the Employer's reference design, the GBR, and the Schedule of Baselines, at a level of detail needed to enable the Contractor to establish unit rates or prices for each activity or a group of activities. The Contractor is responsible for filling the BoQ with his proposed unit rates and prices. The Emerald Book and the ÖNORM B 2203-1 have multiple items listed in the BoQ. A "fixed-rate item" is a price or rate that remains unchanged regardless of any alterations in quantity. A "time-related item" refers to a rate or price for an item of work that is proportional to the time taken to execute the work and not the quantity of that work. A "quantity-related item" is designated a rate or price for a unit quantity of the item of work. A "value-related item" refers to a rate or price considered proportional to the item of work.

The excavation and support works are reimbursed based on unit prices, with the remaining works priced as a lump sum. The Client is responsible for structuring a BoQ for excavating and lining operations. The Emerald Book keeps all options open in this regard [45]. According to [76], for simple projects, it is possible to define one or two excavation classes for the Contractor to price or draw up a detailed BoQ characterising everything from shotcrete to each anchor.

The BoQ for the excavation and lining works includes fixed-rate items, equipment, supervision, facilities, and services required by the Contractor's personnel, fees for the Contractor's overhead charges, and the maintenance of such provisions for the defined period of works [45]. The unit rates and prices should not vary with changes in measured quantities and have to cover the entire remuneration of the Contractor for such excavation and lining works. The time-related rate items cover the availability and maintenance of the fixed-rate items, which are measured in calendar days for either an extension or reduction of time. The excavation and lining works have quantity-related rate items that include the supply and installation of plant equipment for the corresponding section of the works. The value-related charges are included as percentage additions in the rates and are needed for compliance with contractual provisions such as insurance [77], securities, permits, and levies for the relevant portion of the excavation and lining works.

4.3. Quantity-Related Items

Services that depend on the completed quantity are to be reimbursed in specially provided items [54]. Material consumption due to excavation support (shotcrete, anchors, segments, etc.) and other quantity-related ancillary work (e.g., production of pressure grouting columns) fall under such services. In addition, it is routine in the international environment to reimburse the expenditure for the tunnelling team (wage costs) in this item type [35], in which positions are usually based on a m^3 unit for each specified excavation section [54]. The respective unit price reflects the calculated time required per unit and tunnelling scenario. The quantity-related items are paid based on the determined quantity with contractually agreed unit prices.

The Emerald Book stipulates that value-related costs, including time-related costs, construction interest, and insurance premiums, are to be considered using a surcharge (percentage rate) on all items in the unit price [45]. A characteristic rule profile for determining contractually relevant invoicing limits for tunnelling or the handling of a related additional excavation, as found in the work contract standards of the ÖNORM model, does not exist in the FIDIC tunnel construction contract model. Nevertheless, the sample Schedule of Baselines shows that the contracting parties are advised to agree on an expected quantity of the geological outbreak contractually [45].

4.4. Time-Related Items

In tunnelling construction, a significant portion of the costs incurred by the Contractor is time related. The deviations in physical conditions and corresponding construction methods lead to time adjustments for completion [78]. The time available to the Contractor for the underground excavation, tunnel driving, and lining works has to be measured and adjusted based on the difference between the subsurface physical conditions described in the GBR and quantified in the Schedule of Baselines, and the conditions encountered on site [45]. The Schedule of Baselines details the anticipated activities or items of work that are consistent with the conditions described in the GBR. The BoQ must include time-related items allowing adjustments in the contract price corresponding to the adjustments in time [79]. The production rates provided by the Contractor in the Schedule of Baselines form the basis for the completion and baseline schedules, which set out the milestones' completion time [40,45].

The time-related items are essential for the contracts as a mainstay of the remuneration model to ensure contractual adjustments regarding construction time and remuneration. The contract stipulates that due to the extent of the contractual tunnelling speeds and the actual distribution of the tunnelling sections, there are differences in the estimated, flat-rate time-related costs of the fixed-rate items [80]. The differences in the time-related rates are compensated via these items. Due to unforeseen underground conditions, these time-bound items are also used to reimburse additional costs from supplements. Usually, the time-related costs are invoiced based on actual calendar days without any link to the service densities provided based on the contractually agreed construction schedule.

Further, the invoicing effort is significantly lower with a lump-sum or partial lump-sum contract than with a conventional unit price model. However, the contractually agreed prices represent fair remuneration only if the conditions encountered during construction do not differ significantly from the contractual conditions. The Contractor can make a supplementary claim for the price adjustment or the construction period if there is a substantial difference. The fault sensitivity of the contract model concerning the construction process and the cost development in the event of unforeseeable events and standstills is relatively high. For example, during downtimes, the tunnelling crew can hardly be deployed for any other work, meaning that the costs of the crew remain.

4.5. Documentation of Tunnel Construction

As noted by previous research [62,81], only a small proportion of the data exchanged on the construction site are automatically passed on wholly and digitally. The required protocols and reports are often written by hand and filed in paper form, leading to a high degree of manual work steps and time consumption to prepare the data for further use. For invoicing, all quantities for each partial monthly invoice are often manually compiled in a spreadsheet and assigned to the corresponding items in the BoQ. Since a tunnel construction project usually runs over several years, a substantial number of reports is generated, all of which should be filed and stored due to the contractually agreed documentation obligation. Sufficient physical space must be made available for this purpose, and the filing logistics must be strictly adhered to by all persons involved to make it easier to search for documents when needed later. Thus, many of these issues can be effectively addressed by employing centralised digital data storage of construction documentation [62,82,83].

According to the Emerald Book, the Contractor must provide monthly progress reports to the Engineer following the format specified in the Employer's requirements or an acceptable alternative format unless otherwise agreed upon in the contract [45]. Reporting should continue until the works' completion date or until outstanding work is completed as listed in the taking-over certificate unless specified otherwise in the contract.

Based on the Austrian contracts, a report should provide comprehensive information such as detailed descriptions, charts, diagrams, photographs, and video recordings to illustrate progress on and off the construction site [81]. Additionally, the reports should include information on the manufacturer, location of manufacture, percentage progress, expected dates for manufacture, inspections, tests, and shipment for every significant item of plant, materials, and Contractor's key equipment [84]. The reports should also provide information on each stage of design, procurement, manufacture, delivery, construction, testing, commissioning, and trial operation, including details about excavation cycle times, ground support installation times and activities, planned and unplanned cycle time delays, and the physical conditions and reactions of the ground encountered at the working faces or excavation headings.

In the FIDIC Emerald Book, contract progress reports should contain the information specified in Sub-Clause 6.10 [Contractor's Records] [45]. Contents are copies of quality management documents, inspection reports, test results, and compliance verification documentation, such as material certificates. Additionally, the reports should contain a list of variations and any notices issued by either party under Sub-Clause 20.2.1 [Notice of Claim]. In addition, the reports should include information on health and safety statistics, hazardous or pollution incidents [44], activities related to environmental aspects, damage to third-party property, and any social disturbance and public relations [45]. The progress reports should also include comparisons of actual and planned progress, with details of any events or circumstances that may adversely affect the completion of the works in accordance with the contract and the time for completion and the adopted measures to overcome delays.

The daily construction reports, shift reports, excavation reports, and cycle diagrams are essential for Austrian tunnel construction sites when applying the ÖNORM B 2203-1. The reports document the current state of construction, including all relevant information about

contractual performance and any impacts and disruptions to the building process [82]. The daily construction report is the starting point for data collection on a tunnel construction site. It documents the activities in the tunnel, specifically the present shift-related personnel, material, equipment data, and any special incidents [81]. The excavation report has no standard form, though it is typically used for documentation on all tunnel construction sites and operational areas.

The so-called cycle diagram is the one form of tunnelling report that shows the individual activities chronologically over 24 h. The respective site supervisor and representative Contractor for each shift sign every report. Installed support materials of each excavation are documented daily according to their type and quantity. The support installation protocol contains the used support measures and forms the basis for invoicing. The Client and Contractor on site mutually agree upon the support measures, and both contracting parties sign the protocol. The protocol includes the quantities, type, and unit of the installed support measures and essential comments regarding the installation. General information such as the excavation number, construction time, date, length of the tunnel round, excavation, and the underlying design is recorded for an additional overview.

The ÖNORM B 2203-1 documentation can supplement FIDIC Emerald Book projects as it provides a comprehensive daily reporting system for tunnel construction sites. While the Emerald Book specifies monthly progress reports, the ÖNORM B 2203-1 daily construction report offers a more detailed and specific account of daily activities, which can be crucial in identifying any issues or delays that may arise during construction. The Austrian reporting system includes information on personnel, equipment, material data, and special incidents to accurately record activities and provide a basis for invoicing. Additionally, the excavation reports and cycle diagrams provide a clear chronological overview of the activities required for tunnelling and the time needed for their execution. The daily documentation of installed support materials is beneficial in ensuring that the Client and Contractor agree on the support measures used. As both parties sign the protocol, disputes can be avoided during further project execution. The ÖNORM B 2203-1 dispute resolution models and FIDIC Emerald Book are discussed in the following section. Table 2 shows a brief overview of the discussed reimbursement models.

Table 2. Compatibility of reimbursement models.

Selected Characteristics	FIDIC Emerald Book	Austrian Standards
Invoicing	Actual measurement and unit prices	Unit prices, lump-sum contracts
Security provisions	Retention money, performance security, advance payment guarantee	Security deposit, liability bond, cover bond
Comparison of securities	Performance security (similar to security deposit), retention money (combination of liability and cover bond), no equivalent provision for advance payment guarantee	Security deposit, liability bond, cover bond
Payment for ground risks	Differentiation between impacted and unaffected sections	Reimbursed at a fixed amount (fixed fee) for unaffected sections
Adjustment and compensation	Based on additional drilling, lining works, and deviation from benchmark production rates and costs	Adjustments based on quantity and time-related rate items
BoQ categories	Fixed-rate items, time-related items, quantity-related items, value-related items	Unit prices, lump sum, direct price
Excavation and lining works	Reimbursement based on unit prices; remaining works priced as lump sum	Unit prices for excavation and lining works
Quantity-related items	Reimbursement for material consumption, tunnelling team costs	Quantity-based unit prices
Time-related items	Adjustments based on subsurface conditions, completion time	Adjustments in contract price corresponding to time adjustments

Table 2. *Cont.*

Selected Characteristics	FIDIC Emerald Book	Austrian Standards
Documentation	Monthly progress reports, comprehensive information on progress, manufacturer details, construction stages	Comprehensive reports, documentation obligations
Reimbursement models	FIDIC Emerald Book	ÖNORM B 2110

5. Dispute Resolution Models

Dispute resolution is an essential aspect of project management in any construction project, including conventional tunnel construction projects. Disputes can arise for various reasons, such as differing site conditions, delays in project completion, changes in project scope, or payment issues. To avoid costly disputes, construction contracts typically include dispute resolution provisions that outline the procedures for resolving disputes between the parties [85]. This section compares the dispute resolution models of the ÖNORM B 2203-1 and the FIDIC Emerald Book concerning conventional tunnel construction projects. The strengths and weaknesses of both models in the context of tunnel construction projects are highlighted. The section will conclude with suggestions for project owners and stakeholders on selecting and implementing the appropriate dispute resolution model for conventional tunnel construction projects.

5.1. Risk Allocation in FIDIC Emerald Book

One of the core topics of the FIDIC contract model is the distribution of risks in tunnelling projects, which follows the concept that the one who can better handle a risk should bear it. As a result, the risk of physical conditions that do not correspond with the anticipated subsurface conditions and groundwater is assigned to the Employer. The Contractor, on the other hand, is responsible for the execution of the project. In other international projects [34,86], attempts are often made to transfer the geological risk to the Contractor.

Some FIDIC contracts [87] include a list of risks through which all bidders receive the same initial data. The comparability of the bids is ensured by appending the prices. Whether the specified risk distribution or other contract components are primarily negotiable does not depend on using FIDIC terms and conditions but much more on whether the project's Employer is public or private [77]. Due to the overriding budgetary constraints to which public sector bodies are largely subject, contract negotiation is usually ruled out [34].

The expert interviews conducted by [34] show that the FIDIC variants used internationally in mechanised and cyclical tunnelling almost always provide the possibility of supplements. However, the FIDIC addendum system or another form of dispute management depends on the respective contract author [33]. The contract must clarify which risk sphere the supplement originates from. The additional costs for the Employer or any construction time extension can be calculated in a second step. Time limits for submitting supplements and determining who acts as the decision-maker can be agreed upon individually. An overview of the essential similarities between the sample contract and remuneration models is shown in Table 3.

Table 3. Essential similarities of sample contract and remuneration models.

Selected Characteristics	FIDIC Emerald Book and ÖNORM Standard
Quantity determination for invoicing	Theoretical plan dimensions
Validity of the standard	Through Contract
Preparation of permit applications	By the Employer
Subsoil risk	Employer
Calculation risk	Contractor
Process risk	Contractor

The general principles for underground works expressed in the Emerald Book include risk allocation particulars in tender documents for underground works. This allocation of risks attempts to reflect which party is best prepared to control them [51]. The guidance notes to the Emerald Book [45] recommend that the tender documents for underground works should include detailed information about the anticipated subsurface conditions and the related design considerations that served as a base for the Employer's reference design. This geotechnical and tunnelling design data must be detailed in the GBR, which serves as the single source of allocation of risks of subsurface physical conditions. The anticipated quantities of excavation and lining works are listed in the Schedule of Baselines, which the tenderer uses to state the corresponding production rates for each work item. When the anticipated subsurface conditions defined by the set of parameters of subsurface physical conditions are available, the risk of production rates and relevant cost deviations are allocated to the Contractor. The reaction of the surrounding ground to the underground excavation or tunnel driving and support measures depends on its geotechnical parameters, the design concept, and the construction methods [42]. The guidance notes to the Emerald Book also recommend a schedule of the Contractor's key equipment with the essential items explicitly made available for the execution of the works.

5.2. Excavation Hindrances

The ÖNORM B 2203-1 regulates difficult tunnelling only for water hazards [54]. The additional time required to control a mountain water ingress is considered via additional times for the excavation in the construction time model. Exceeding the upper water limit designates an interruption of excavation. The standard stipulates that extra payment items must be provided to support the excavation outside the specified driving areas. The application of shotcrete protection on the cavity side is already compensated for with the standard position of the support measure [35], while filling an additional excavation with shotcrete beyond boundary surfaces requires separate positions in the specifications. Circumstances in the subsoil require advanced safety measures, such as pipe shields, ground freezing, or jet grouting. Such measures are referred to as special measures and equipment and can usually not be carried out with the equipment of the standard drive. The ÖNORM B 2203-1 standard prepares separate items for the predicted special measures. Positions must be provided for setting up, holding, and clearing the equipment and for the performance of the work itself.

5.3. Dispute Adjudication

Following previous FIDIC contract forms, the Engineer has a double role in the Emerald Book [46]. For one, the Engineer is hired by the Employer and entrusted with contract management while treating both parties equally, fairly, and equitably in resolving or determining any matter or claim. Given the importance of GBR management during construction, the Emerald Book necessitates an essential role for Engineers who oversee the execution of work on the site [46]. Since large-scale construction projects are generally characterised by conflicts [88], and Engineers play a central role in resolving disputes between parties, their position requires high impartiality. The core functions of the Engineer include assessing the Contractor's execution readiness planning, providing general construction supervision, and supervising and recording excavation work.

The Engineer must oversee the measures the Contractor took related to excavation and document the subsoil conditions encountered. Engineers further review the extent and invoicing of excavation work and approve or fix any contractual adjustments regarding payment and construction time within the framework of the contract. Finally, the functions include execution instructions during changes in services made by the Employer or regarding unpredicted subsoil conditions and the assessment of the execution of the excavation following the contract or decision of supplementary claims [14], especially those for unforeseen subsoil conditions.

Representing the safety officer, the Contractor decides what actions to take. Still, the Engineer should evaluate how well the General Conditions and the contract are being adhered to and whether the Contractor's measurements should be accepted [45]. If no agreement can be reached, the Engineer has to make a fair decision, and the Contractor decides whether to file a claim. Following a Notice of Dissatisfaction (NOD) from either party, the matter is passed on to the Dispute Avoidance/Adjudication Board (DAAB) [15], which will be appointed throughout the project's lifecycle [15,89]. After these two options are exhausted, the dispute will proceed to external arbitration or litigation [16,90]. Due to the importance of GBR implementation, robust technical and commercial controls on the site by Employers and Contractors enable parties to be more proactive and prudent in addressing and dealing with potential deviations.

5.4. Claim Management as Defined in the FIDIC Contract Model

The FIDIC Model Contracts specify that the Contractor is entitled to an extension of the construction period and additional remuneration under certain circumstances. Justified claims made by the Contractor may be based, for example, on the late availability of plans or the Employer's instructions, unforeseen physical conditions (water ingress, ground properties, etc.), and fossils found [45]. To make the required claim, the Contractor must notify the consulting Engineer within 28 days of awareness of the reason. After the deadline, a loss of claim will occur, and the Engineer will not have to accept any liability concerning the event or circumstance in question [8]. Subsequently, the FIDIC contracts make a distinction in the prescribed procedure as to whether the claim is for an extension of the construction period or additional remuneration.

In the case of a claim for additional remuneration, the Contractor must present the circumstances warranting the claim to the consulting Engineer within 14 days after the first notification [45]. This means that the Contractor must prepare a comprehensive provisional cost estimate within 42 days of becoming aware of the basis of potential excessive costs or delays. In case of a claim for an extension of the construction period based on an obstruction to the construction process, the Contractor must prepare an updated construction schedule no later than 42 days after the obstruction ceases to exist and submit it to the consulting Engineer. In case of non-compliance with one of the deadlines mentioned, the claims are usually forfeited [45]. The overview of the essential differences between standards-based contract forms and reimbursement models is shown in Table 4.

Table 4. Essential differences between sample contract and reimbursement models.

Selected Characteristics	FIDIC Emerald Book	ÖNORM Standard
Independent standards for cyclical tunnelling	-	ÖGG planning guidelines ÖNORM B 2203-1 ÖNORM B 2118
Pricing	Lump-sum contract	Unit price contract
Remuneration model	Flexible according to tunnelling sections as specified in the GBR	Flexible according to the tunnelling classes
Ground investigation	GBR by Employer	Geotechnical report by Employer
Time required for the decision on excess or reduced cost claims	Within 42 days	Within 2 months
Structure of the rock mass/Classification of the subsoil	Homogeneous and heterogeneous zones depending on the project	Rock mass behaviour types
Minimum technical requirements of the tunnelling method	Geotechnical Baseline Report by the Employer	Geotechnical planning
Detailed design	By the Contractor	Usually by the Employer
Determination of tunnelling class	Effort for excavation, support and ancillary measures, preliminary subsoil investigation, seepage treatment	Number of support measures Tunnelling method

Table 4. *Cont.*

Selected Characteristics	FIDIC Emerald Book	ÖNORM Standard
Compensation for time-related costs	Schedule of Baselines/Actual calendar days	Construction timetables
Service description	Constructional description for tunnelling and support measures; otherwise, functional service description	Constructional description
Service specifications	Items for tunnelling and lining services	Structured by single items
Safety and health protection	By the Contractor	By the Employer
Dispute resolution	3-stage procedure (mandatory)	2-stage procedure (can be agreed upon)
Warranty period	Determined by the Client, dependent on the project	2 years for movable items 3 years for immovable items

5.5. Selecting and Implementing the Appropriate Dispute Resolution

Section 5 discusses the importance of dispute resolution in construction projects, particularly conventional tunnel construction projects. Disputes can arise for several reasons, such as changes in the project scope, payment issues, and delays in project completion. Construction contracts include dispute resolution provisions to avoid costly disputes. This section compares the dispute resolution models of the ÖNORM B 2203-1 and the FIDIC Emerald Book concerning conventional tunnel construction projects. ÖNORM B 2203-1 can facilitate dispute resolution in FIDIC Emerald Book contracts by providing standard guidelines for contract interpretation and dispute resolution procedures, thereby reducing ambiguity [91] and potential disagreements between parties. Detailed documentation with ÖNORM 2203-1 can help facility management by providing a systematic approach to facility operations and maintenance, ensuring compliance with legal and regulatory requirements, and reducing the risk of equipment failure or accidents. This section also discusses the allocation of excavation hindrances, special measures and equipment, and the differences between the two models.

6. Results and Assessment

The previous sections have delineated FIDIC Emerald Book and ÖNORM B 2203-1 as contracting models offering comprehensive project execution guidelines comprising contract formation, tunnel design, construction, quality control, and commissioning. The functional organisation charts of the ÖGG project structure guideline [92] and FIDIC Emerald Book [45,70] highlight key differences in terms of the roles and responsibilities assigned to various positions within the project structure (see Figure 3).

In the ÖGG project structure guideline (left side of the comparison chart), the role of a tunnel engineer is explicitly mentioned, indicating their involvement in the design and construction of the tunnel. ÖNORM 2203-1 also includes specific positions for geotechnical monitoring and geological documentation. The chart also contains independent controlling and finance management roles, emphasising the need for separate entities responsible for overseeing project controls and financial management. On the other hand, the FIDIC Emerald Book (right side of the comparison chart) does not explicitly feature a dedicated role for a tunnel engineer. Instead, it encompasses the position of a FIDIC Engineer responsible for overall project management and coordination. One notable difference between the models is that Austrian guidelines include a role for health and safety [93] seen on the left side of Figure 3, while the FIDIC Emerald Book does not specifically feature this role [45]. Another difference is that the FIDIC Emerald Book includes a role for quality control, depicted on the right side of Figure 3 [45], which is not explicitly included in the ÖNORM 2203-1.

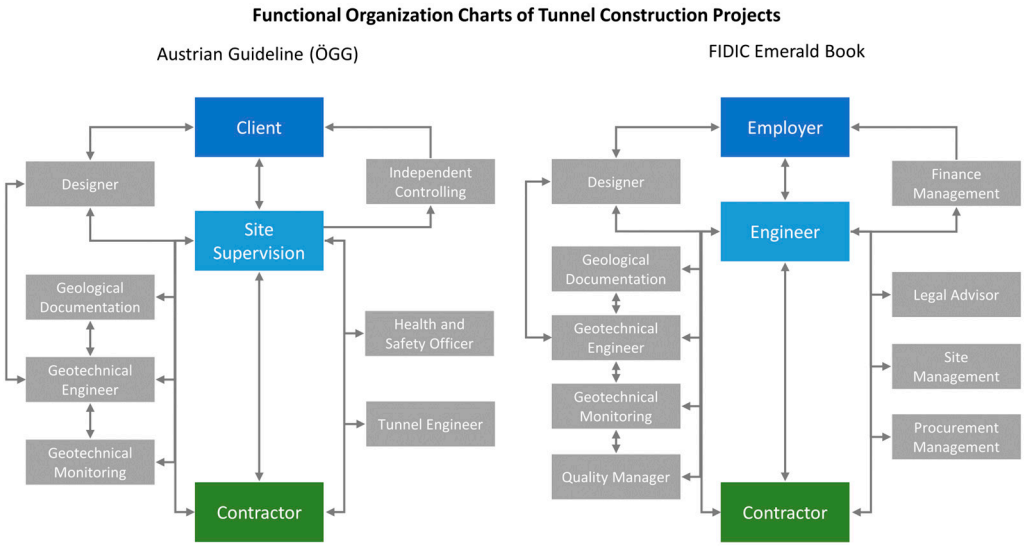

Figure 3. Comparison of functional organisation charts of Austrian (**left**) and FIDIC Emerald Book (**right**).

The ÖNORM B 2203-1 [54] and the FIDIC Emerald Book [45] guide the design and construction of tunnels, including tunnel alignment, excavation, support systems, and ventilation. Additionally, both models outline the roles and responsibilities of parties involved in the project, such as the Client, Contractor, and Engineer [45], and provide risk management guidelines, including risk assessment and mitigation strategies, as discussed in Section 5. However, the contract models differ in other aspects. For instance, the ÖNORM B 2203-1 offers more technical specifications, while the FIDIC Emerald Book emphasises risk allocation and management. The ÖNORM B 2203-1 model emphasises environmental protection and sustainability, reflecting the importance of these issues in Austria. It also provides more detailed guidance on specific aspects of tunnel construction, such as geotechnical investigations and tunnel lining design. The FIDIC Emerald Book is more focused on the contractual aspects of the project.

The ÖNORM B 2203-1 model can benefit project execution based on FIDIC Emerald Book contracts in various ways: cooperation, project management, reimbursement, and dispute resolution. For instance, as discussed in Section 3, it can provide additional technical specifications that the FIDIC Emerald Book does not cover. It can also offer guidance on project management and cooperation issues that may arise during the project execution. Additionally, the ÖNORM model can supplement the reimbursement and dispute resolution provisions of the FIDIC Emerald Book by providing additional guidance on calculating and paying project costs, serving as the basis for the Client's internal controlling, and resolving disputes that may arise during the project.

Concerning cooperation, the ÖNORM B 2203-1 model can provide additional options and guidance to promote communication and collaboration among the parties involved in the project. It sets out procedures and processes that can help ensure the project's efficient and effective execution. Regarding project management, the ÖNORM model can assist by outlining clear guidelines for the roles and responsibilities of each party, as well as project scheduling and reporting, as discussed in Section 4 [81]. The ÖNORM model can supplement the reimbursement process by establishing standard payment procedures, including payment milestones and procedures for claims and deviations. This can ensure that all parties are paid fairly and reduce disputes over payments. Finally, regarding dispute resolution discussed in Section 5, the ÖNORM B 2203-1 model can supplement the FIDIC contracts by providing standard procedures for dispute resolution, such as mediation and arbitration. This can help resolve disputes promptly and efficiently, reducing the risk of delays or cost overruns.

The sections have pointed out the importance of thoroughly reviewing the contract terms before agreeing, to ensure an understanding of the obligations and responsibilities of all the involved parties. As has been shown, the FIDIC Emerald Book provides general contractual conditions and information for preparing tender documents for tunnelling projects. In turn, the ÖNORM B 2203-1 is unique in that it aims to combine technical features of cyclical tunnelling with a contractual framework. Moreover, using a unit price contract, the framework creates a transparent distribution of risk spheres and cost security for the Employer. It also has been pointed out that the FIDIC Emerald Book incorporates a Geotechnical Baseline Report, a tailored "Unforeseeable Physical Conditions" clause, and a flexible mechanism for remuneration. Meanwhile, the ÖNORM B 2203-1 offers flexibility with a clear definition of excavation classes and their adaptation to rock conditions.

7. Summary and Conclusions

This paper demonstrates that the recently published FIDIC Emerald Book enables Employers to handle tunnel construction projects more cooperatively. It offers more transparent construction management processes and improved cooperation among the project participants. The risk distribution and remuneration models, the key figure of the Engineer, and the obligation of a DAAB all play a decisive role in this contract form. The project participants should implement the existing contractual provisions in the best possible way specific to the project.

The ÖNORM B 2203-1 and the FIDIC Emerald Book provide guidelines and specifications for project execution, including contract formation, tunnel design, construction, testing, and commissioning. One fundamental similarity between the two models is that they emphasise the importance of project management and stakeholder cooperation. However, there are also some differences between the two models. For example, the ÖNORM focuses more on providing detailed technical specifications, while the FIDIC Emerald Book emphasises risk allocation and management. There are several ways the ÖNORM model can supplement the project execution based on FIDIC contracts with respect to cooperation, project management, reimbursement, and dispute resolution. For example, the ÖNORM model can provide additional guidance on technical specifications that the FIDIC Emerald Book does not cover. It can also provide guidance on specific project management and cooperation issues that may arise during the project execution.

The main suggestion of the paper is that the ÖNORM model can beneficially supplement the reimbursement and dispute resolution provisions of the FIDIC Emerald Book by providing additional guidance on calculating and paying project costs and resolving disputes that may arise during the project. As has been seen and discussed, the Emerald Book stipulates that value-related costs, including time-related costs, construction interest, and insurance premiums, are to be considered using a surcharge (percentage rate) on all items in the unit price. A characteristic rule profile for determining invoicing limits for tunnelling or the handling of a related additional excavation, as found in the work contract standards of the ÖNORM model, does not exist in the FIDIC tunnel construction contract model. Nevertheless, it can be seen from the sample Schedule of Baselines that the contracting parties are advised to agree on an expected quantity of the geological outbreak contractually. Furthermore, the authors recommend that the Employers provide relevant regulations in the construction contract beyond the framework of the Emerald Book, especially concerning excavation hindrances as defined in the ÖNORM B 2203-1 standard.

The results of this study provide an overview of the similarities and differences between international construction contracts. The findings give insights into how global construction contract management practices can be optimised by integrating the ÖNORM patterns and approaches into the FIDIC framework. Practitioners can use the results of this study to make informed decisions when choosing a construction contract for international tunnelling projects.

As the FIDIC Emerald Book has been introduced only recently, there is a lack of case studies examining the practical implementation of the ÖNORM B 2203-1 in FIDIC-based

tunnelling projects, which subsequently limits the current research. Including case studies is crucial for obtaining empirical evidence and practical insights into contract administration, dispute resolution, and risk allocation within the specific context of tunnelling. Moreover, forthcoming revisions of the mentioned norms, standards, and contractual forms may incorporate changes, which must also be considered in future research. Future research endeavours should address these limitations by incorporating case studies, as this will significantly contribute to an improved understanding and application of FIDIC contracts in conventional tunnelling projects, leading to enhanced project outcomes and fewer disputes between contracting parties.

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References

1. Klee, L. *International Construction Contract Law*; John Wiley and Sons: Hoboken, NJ, USA, 2018; ISBN 978-1-119-43038-4.
2. Marulanda, A. Adapting the FIDIC Standard Forms of Contract for Underground Construction Projects. In Proceedings of the World Tunnel Congress, Iguassu Falls, Brazil, 9–15 May 2014; p. 7.
3. van Staveren, M. *Uncertainty and Ground Conditions: A Risk Management Approach*; CRC Press: London, UK, 2018; ISBN 978-0-429-21391-5.
4. Charrett, D. *FIDIC Contracts in Europe: A Practical Guide to Application*; Taylor & Francis: Milton Park, UK, 2022; ISBN 978-1-00-077915-8.
5. Baker, E.; Mellors, B.; Chalmers, S.; Lavers, A. *FIDIC Contracts: Law and Practice*; CRC Press: Boca Raton, FL, USA, 2013; ISBN 978-1-317-91190-6.
6. Widhalm, S. Vergleich Nationaler und Internationaler Bauverträge am Beispiel der ÖNORM B 2110 und den FIDIC-Standards. Master's Thesis, Technische Universität, Wien, Austria, 2020.
7. Suzuki, N.; Whorlow, J.R. A Study on the Conditions of Contract Relationship of FIDIC. In Proceedings of the World Congress on Engineering, London, UK, 5–7 July 2017; Volume 2.
8. Bellamy, J.; Ho, J. Exclusion and Limitations of Liability. In *Wilmot-Smith on Construction Contracts*; Wilmot-Smith, R., Darling, P., Eds.; Oxford University Press: Jericho, NY, USA, 2021; ISBN 978-0-19-883280-5.
9. Abdul-Malak, M.A.; Khalife, S. Classification and Analysis of Notice Requirements for Construction Contract Administration. *J. Leg. Aff. Disput. Resolut. Eng. Constr.* **2017**, *9*, 04517016. [CrossRef]
10. Abdul-Malak, M.-A.; El Masri, F. Understanding the Engineer's Role in Administering the Construction Contract. *Proc. Int. Struct. Eng. Constr.* **2016**, *3*, 375–380. [CrossRef]
11. Fawzy, S.A.; El-adaway, I.H. Contract Administration Guidelines for Managing Conflicts, Claims, and Disputes under World Bank–Funded Projects. *J. Leg. Aff. Disput. Resolut. Eng. Constr.* **2012**, *4*, 101–110. [CrossRef]
12. Niraula, R.; Kusayanagi, S. Contract Administration for a Construction Project under FIDIC Redbook Contract in Asian Developing Countries. *Soc. Soc. Manag. Syst. Internet J.* **2011**, *7*, 1–7.
13. Recent Trends in Construction Technology and Management. Available online: http://www.lavoisier.eu/books/civil-engineering/recent-trends-in-construction-technology-and-management/description_4707041 (accessed on 27 June 2023).
14. Abdul-Malak, M.-A.U.; Tabbara, L.M. Experts Involved in Claims and Disputes Resolution: Mapping and Classification of Engagement Possibilities. *J. Leg. Aff. Disput. Resolut. Eng. Constr.* **2023**, *15*, 1–15. [CrossRef]
15. McCrea, R.; Gould, R. Dispute Boards: Trends, Observations, Developments and Procedures. In *Construction Arbitration and Alternative Dispute Resolution*; Routledge: Milton Park, UK, 2021; ISBN 978-1-00-315597-3.
16. Dedezade, T. Enforcement of DAB Decisions under the FIDIC Forms of Contract. In *Construction Arbitration and Alternative Dispute Resolution*; Routledge: Milton Park, UK, 2021; ISBN 978-1-00-315597-3.
17. Kandil, O.; Yehia, N.; Hamed, T. Design Liability under FIDIC Red Book and Some Civil Law Jurisdictions. *J. Leg. Aff. Disput. Resolut. Eng. Constr.* **2022**, *14*, 06521003. [CrossRef]
18. Okudan, O.; Çevikbaş, M. Alternative Dispute Resolution Selection Framework to Settle Disputes in Public–Private Partnership Projects. *J. Constr. Eng. Manag.* **2022**, *148*, 04022086. [CrossRef]

19. Thi Hoa, N. Consideration of Whether the FIDIC Dispute Adjudication Board's Decision Should Be Regarded as an Award or as a Mediated Settlement Agreement. *J. Leg. Aff. Disput. Resolut. Eng. Constr.* **2022**, *14*, 04522016. [CrossRef]
20. Muhammad, R.; Nasir, A.R. Integrating BIM in Construction Dispute Resolution: Development of a Contractual Framework. *Buildings* **2022**, *12*, 1828. [CrossRef]
21. Lau, C.H.; Mesthrige, J.W.; Lam, P.T.I.; Javed, A.A. The Challenges of Adopting New Engineering Contract: A Hong Kong Study. *Eng. Constr. Archit. Manag.* **2019**, *26*, 2389–2409. [CrossRef]
22. Diniz-Vieira, G.; Pistone, R.; Melâneo, F.; Baião, C. Transposition into National Law of the New EU Public Procurement Directives and the Impact on Subsurface Construction Contracts—The Portuguese Case. In *Tunnels and Underground Cities. Engineering and Innovation Meet Archaeology, Architecture and Art*; CRC Press: Boca Raton, FL, USA, 2020; pp. 4446–4454, ISBN 978-1-00-303165-9.
23. Mehra, P. Lessons from Adverse Geological Occurrences during Excavation in Rohtang Tunnel, India. In *Tunnels and Underground Cities. Engineering and Innovation Meet Archaeology, Architecture and Art*; CRC Press: Boca Raton, FL, USA, 2019; pp. 3999–4005.
24. Sakaeda, H. Marmaray Project: Tunnels and Stations in BC Contract. *Tunn. Undergr. Space Technol.* **2005**, *20*, 612–616. [CrossRef]
25. Tsitsas, G.; Kolev, C.; Radoi, L.; Petrila, V. Technical and Contractual Trends for Micro Tunneling Projects in Romania and Bulgaria. *Adv. Eng. Forum* **2017**, *21*, 609–618. [CrossRef]
26. Moss, S.; Schneider, T.; Fiechter, J.R. Applying FIDIC Contracts in Switzerland. In *FIDIC Contracts in Europe*; Routledge: Milton Park, UK, 2022; ISBN 978-1-00-320123-6.
27. Frad, T. Applying FIDIC Contracts in Austria. In *FIDIC Contracts in Europe*; Routledge: Milton Park, UK, 2022; ISBN 978-1-00-320123-6.
28. Likhitruangsilp, V.; Ioannou, P.G. Risk Allocation in Standard Forms of General Conditions for Tunneling Contracts. In Proceedings of the Building a Sustainable Future—Proceedings of the 2009 Construction Research Congress, Seattle, WA, USA, 5–7 April 2009; pp. 1250–1259.
29. Providakis, S.; Rogers, C.D.; Chapman, D.N. Predictions of Settlement Risk Induced by Tunnelling Using BIM and 3D Visualization Tools. *Tunn. Undergr. Space Technol.* **2019**, *92*, 9. [CrossRef]
30. di Prisco, C.; Flessati, L.; Peila, D.; Pizzarotti, E.M. Risk Management in Tunnelling. In *Handbook on Tunnels and Underground Works*; CRC Press: Boca Raton, FL, USA, 2022; ISBN 978-1-00-325617-5.
31. Ertl, H. Risk Allocation in the FIDIC Forms of Contract, and the Emerald Book's Place in the Rainbow Suite. In *Tunnels and Underground Cities. Engineering and Innovation Meet Archaeology, Architecture and Art*; CRC Press: Boca Raton, FL, USA, 2020; ISBN 978-1-00-303165-9.
32. Dix, A.E. The Renaissance of Fairness in Ground Risk Allocation—The New ITA/FIDIC Emerald Book. *Int. J. Civ. Eng. Technol.* **2020**, *11*, 43–52. [CrossRef]
33. Nairac, C. The Claims, Dispute Avoidance and Dispute Resolution Procedure in the New FIDIC Emerald Book. In *Tunnels and Underground Cities. Engineering and Innovation Meet Archaeology, Architecture and Art*; CRC Press: Boca Raton, FL, USA, 2019; pp. 4520–4529.
34. Chylik, B. Vergleich Nationaler und Internationaler Vertrags-und Vergütungsmodelle im Maschinellen Tunnelvortrieb. Diploma Thesis, Technische Universität, Wien, Austria, 2018.
35. Schoiswohl, D. Vertragsmodelle im Tunnelbau: Das ÖNORM-Modell und das FIDIC Emerald Book im Vergleich—Abwägung der Risiken und der Vergütungssicherheit für Ausführende. Diploma Thesis, Technische Universität, Wien, Austria, 2021.
36. Fellows, R.F.; Liu, A.M.M. *Research Methods for Construction*; John Wiley & Sons: Hoboken, NJ, USA, 2021; ISBN 978-1-119-81473-3.
37. Hoecke, M.V. Methodology of Comparative Legal Research. *Law Method* **2015**, *12*, 1–35. [CrossRef]
38. MacRoberts, M. *MacRoberts on Scottish Construction Contracts*; John Wiley & Sons: New York, NY, USA, 2014; ISBN 978-1-118-27345-6.
39. Cioni, S. How to Include the NATM-Contractual-Practice into FIDIC-Contracts. Master's Thesis, University of Leoben, Leoben, Austria, 2016.
40. Glover, J.; Elliott, F. The Emerald Book: The New FIDIC Tunnelling Contract. *Int. Q.* **2019**, *26*, 1.
41. FIDIC. FIDIC Launches New Tunnelling and Underground Works Contract | International Federation of Consulting Engineers. Available online: https://fidic.org/node/23574 (accessed on 22 December 2022).
42. Wiesner, W. The Austrian Contract Form OENORM B 2203 for Underground Works: A Well-Established Alpine Predecessor of the FIDIC-ITA Emerald Book. *Int. Constr. Law Rev.* **2021**, *3*, 361–371.
43. Ndekugri, I.; Smith, N.; Hughes, W. The Engineer under FIDIC's Conditions of Contract for Construction. *Constr. Manag. Econ.* **2007**, *25*, 791–799. [CrossRef]
44. Seppälä, C. *The FIDIC Red Book Contract: An International Clause-by-Clause Commentary*; Kluwer Law International B.V.: Alphen aan den Rijn, The Netherlands, 2023; ISBN 978-94-035-2063-6.
45. FIDIC; ITA. *Emerald Book: Conditions of Contract Underground Works*; FIDIC: Geneva, Switzerland, 2019.
46. Maclure, J. The Role of the Engineer in the Emerald Book. In *Tunnels and Underground Cities. Engineering and Innovation Meet Archaeology, Architecture and Art*; CRC Press: Boca Raton, FL, USA, 2019; ISBN 978-0-429-42444-1.
47. Randall, J.; Essex, P.E. *Geotechnical Baseline Reports for Construction: Suggested Guidelines*; American Society of Civil Engineers: Reston, VA, USA, 2007; ISBN 978-0-7844-0930-5.

48. Ericson, G. The Geotechnical Baseline Report in the New FIDIC Emerald Book—Suggested Developments. In *Tunnels and Underground Cities. Engineering and Innovation Meet Archaeology, Architecture and Art*; CRC Press: Boca Raton, FL, USA, 2019; p. 7, ISBN 978-0-429-42444-1.
49. Gomes, R.A. Considerations on the Practical Development of the Geotechnical Baseline Report (GBR) for the FIDIC Emerald Book and Similar Contract Forms. In Proceedings of the ITA-AITES World Tunnel Congress, WTC2020 and 46th General Assembly, Kuala Lumpur, Malaysia, 15–21 May 2020; p. 6.
50. Ertl, H.; Hechenblaickner, K. New Contract Form for Underground Works. Presented at the FIDIC International Contract Users' Conference, London, UK, 2–5 December 2019.
51. Abdel Salam, M.E. Contractual Sharing of Risks in Underground Construction: ITA Views. *Tunn. Undergr. Space Technol.* **1995**, *10*, 433–437. [CrossRef]
52. ASI ÖNORM B 2110: 2013 03 15—Allgemeine Vertragsbestimmungen für Bauleistungen—Werkvertragsnorm. Available online: https://shop.austrian-standards.at/action/de/public/details/470259/OENORM_B_2110_2013_03_15 (accessed on 22 December 2022).
53. ITA. ITA Position Paper on Types of Contract: ITA Working Group on Contractual Practices in Underground Construction. *Tunn. Undergr. Space Technol.* **1996**, *11*, 411–429. [CrossRef]
54. ASI ÖNORM B 2203-1: 2001—Untertagebauarbeiten—Werkvertragsnorm—Teil 1: Zyklischer Vortrieb. Available online: https://shop.austrian-standards.at/action/de/public/details/93793/OENORM_B_2203-1_2001_12_01 (accessed on 10 November 2022).
55. Tesch, M. Gebirgsverhaltenstypen Als Grundlage Einer Ausschreibung Und Kalkulation—Chancen Und Probleme. Master's Thesis, Montanuniversität Leoben, Leoben, Austria, 2017.
56. ÖGG. *ÖGG Richtlinie für die Geotechnische Planung von Untertagebauten mit zyklischem Vortrieb*, 3rd ed.; Österreichische Gesellschaft für Geomechanik: Salzburg, Austria, 2021. Available online: https://www.oegg.at/de/publikationen (accessed on 5 July 2023).
57. Spiegl, M.; Galler, R.; Sander, P. Application of the ÖGG Guideline for Cost Estimates on International Megaprojects: Kostenermittlung Für Internationale Großprojekte Auf Basis Der ÖGG-Richtlinie. *Geomech. Tunnelbau* **2018**, *11*, 680–692. [CrossRef]
58. Purrer, W. Dispute Adjudication in Austrian Conditions of Contract for Underground Works. *Geomech. Tunn.* **2021**, *14*, 529–536. [CrossRef]
59. Neuenschwander, M.; Marulanda, A. Measuring the Excavation and Lining in the Emerald Book. In *Tunnels and Underground Cities. Engineering and Innovation Meet Archaeology, Architecture and Art*; CRC Press: Boca Raton, FL, USA, 2019; ISBN 978-0-429-42444-1.
60. Gillion, F.; Blamire-Brown, C.; Morson, R.; Frye, R. FIDIC Emerald Book and Geotechnical Baseline Reports—Digging Into the Use of GBRs in Underground Works. *Int. Constr. Law Rev.* **2019**, *4*, 506–525.
61. Kleberger, I.P.J. (Ed.) Geotechnical Risk in Rock Mass Characterisation—A Concept. In *Geotechnical Risk in Rock Tunnels*; CRC Press: Boca Raton, FL, USA, 2003; ISBN 978-0-429-22444-7.
62. Winkler, L.; Melnyk, O.; Goger, G. Prerequisites for BIM-Based Invoicing in NATM Projects. *Geomech. Tunn.* **2022**, *15*, 279–283. [CrossRef]
63. Lau, C.S.; Dematteis, A.; Ovena, R.; Fabio, A.D. *Experiences on the Use of GBR in Tunnel and Cavern Projects*; CRC Press: Boca Raton, FL, USA, 2023; pp. 2038–2045.
64. Kropik, A. Die Dokumentation der Bauleistung. *Osterr. Bauztg.* **2017**, *7*, 1–7.
65. Schmidberger, P. Flexibles Bauzeit-und Vergütungsmodell für den Tunnelbau mit besonderem Blick auf die Ausschreibungsphase. Diploma Thesis, Technische Universität, Wien, Austria, 2020.
66. DAUB Konfliktarmer Bauvertrag im Untertagebau—Aufruf zu mehr Miteinander statt Gegeneinander—Tunnel. *Tunnel* **2020**, *3*, 4.
67. Klee, L. Claim Management System under FIDIC Forms. In *International Construction Contract Law*; John Wiley & Sons: Hoboken, NJ, USA, 2018; pp. 807–812, ISBN 978-1-119-43055-1.
68. Matseke, D.; Khatleli, N.; Root, D. An Overview of Multi-Criteria Decision Making Techniques in Construction Projects Claims Management. *Proc. Int. Struct. Eng. Constr.* **2022**, *9*, 1–6. [CrossRef]
69. Ndekugri, I.; McDonnell, B. Differing Site Conditions Risks: A FIDIC/Engineering and Construction Contract Comparison. *Eng. Constr. Archit. Manag.* **1999**, *6*, 177–187. [CrossRef]
70. Weselik, N.; Hamerl, T. *Handbuch des Internationalen Bauvertrags: Mit Einer Kommentierung Wesentlicher FIDIC-Vertragsmuster*; Linde Verlag GmbH: Wien, Austria, 2014; ISBN 978-3-7143-0271-4.
71. Zoppis, E. Contract Conditions for Ground Risk Under The 1999 Fidic Suite of Contracts: A Critical Review. Ph.D. Thesis, King's College, London, UK, 2016.
72. Linde-Arias, E.; Perri, J.; Nwandem, O. Geotechnical Baseline Reports in the FIDIC Emerald Book—A Fair Allocation of Ground Risks? *Const. L. Int.* **2022**, *17*, 25.
73. ASI ÖNORM A 2050: 2006 11 01—Vergabe von Aufträgen über Leistungen—Ausschreibung, Angebot, Zuschlag—Verfahrensnorm. Available online: https://shop.austrian-standards.at/action/de/public/details/226622/OENORM_A_2050_2006_11_01 (accessed on 12 December 2022).
74. Alhyari, O. Owners' Obligations Under FIDIC Construction Contracts. In *Collaboration and Integration in Construction, Engineering, Management and Technology*; Springer: Berlin/Heidelberg, Germany, 2021; pp. 197–202, ISBN 978-3-030-48464-4.
75. ASI ÖNORM B 2203-2: 2023 03 01—Untertagebauarbeiten—Teil 2: Kontinuierlicher Vortrieb—Werkvertragsnorm. Available online: https://shop.austrian-standards.at/action/de/public/details/726699/OENORM_B_2203-2_2023_03_01 (accessed on 24 April 2023).

76. Ertl, H.; Hechenblaickner, K. Das Emerald-Book—Ein Meilenstein Auf Dem Weg in Die Zukunft. *Geomech. Tunn.* **2021**, *14*, 794–800. [CrossRef]
77. Gravitt, D. Risk and Insurance in Construction. *Constr. Manag. Econ.* **2013**, *31*, 502–503. [CrossRef]
78. Bertrand, M.; Fontana, A.; Salot, C.; Dumoulin, C.; Macary, M. Contractual Practices & Project Management: TELT Time Adjustment Mechanism. In *Expanding Underground—Knowledge and Passion to Make a Positive Impact on the World*; Taylor & Francis: Milton Park, UK, 2023; pp. 3377–3385.
79. Singh, G.; Banjoko, O.O. The Development of a Rational Bill of Quantities. *Constr. Manag. Econ.* **1990**, *8*, 31–47. [CrossRef]
80. Schönwälder, A. Variantenstudie zur Kosten-und Leistungsermittlung im Tunnelbau: Erstellung eines Berechnungsprogramms. Diploma Thesis, Technische Universität, Wien, Austria, 2010.
81. Kvasina, G. Dokumentation bei zyklischem Tunnelvortrieb—Erhebung von wesentlichen Parametern von Bauzeit und Kosten als Grundlage für ein digitales Modell. Diploma Thesis, Technische Universität, Wien, Austria, 2018.
82. Huymajer, M.; Operta, D.; Mazak-Huemer, A.; Huemer, C. The Tunneling Information Management System—A Tool for Documenting the Tunneling Process in NATM Projects. *Geomech. Tunn.* **2022**, *15*, 259–264. [CrossRef]
83. Mazak, A.; Galler, R.; Wenighofer, R.; Goger, G.; Bednar, T.; Huemer, C.; Wimmer, M. TransIT: Interdisziplinäres Forschungsprojekt Zur Digitalen Transformation Im Tief-Und Tunnelbau. *Bauaktuell* **2020**, *4*, 168–169.
84. Schiefer, K. Digitalisierungspotential von tradierten Dokumentationsprozessen im Tunnelbau. Diploma Thesis, Technische Universität, Wien, Austria, 2018.
85. Construction Dispute Boards. In *International Construction Contract Law*; John Wiley & Sons: Hoboken, NJ, USA, 2018; pp. 442–484, ISBN 978-1-119-43055-1.
86. Helm, U.; Bonke, F. A New Standard for Tunnelling Contracts. *Tunneling J.* **2017**, 48–50.
87. Klee, L. Risk in Underground Construction. In *International Construction Contract Law*; John Wiley & Sons: Hoboken, NJ, USA, 2018; pp. 664–702, ISBN 978-1-119-43055-1.
88. Sabri, O.K.; Torp, O. Corrective and Preventive Action Plan (CAPA) for Disputes in Construction Projects: A Norwegian Perspective. *Infrastructures* **2022**, *7*, 63. [CrossRef]
89. Gaitskell, R. International Statutory Adjudication: Its Development and Impact. *Constr. Manag. Econ.* **2007**, *25*, 777–784. [CrossRef]
90. Yudhantaka, L.; Simamora, Y.S.; Anand, G. Binding Power of Dispute Board Judgment in Construction Dispute Settlement. *Yuridika* **2023**, *38*, 159–170. [CrossRef]
91. Koc, K.; Gurgun, A.P. Ambiguity Factors in Construction Contracts Entailing Conflicts. *Eng. Constr. Archit. Manag.* **2021**, *29*, 1946–1964. [CrossRef]
92. *ÖGG The Austrian Practice of NATM Tunnelling Contracts*; Austrian Society for Geomechanics: Salzburg, Austria, 2011.
93. Austrian Ministry of Finance RIS—Bauarbeitenkoordinationsgesetz—Bundesrecht Konsolidiert, Fassung Vom 24.04.2023. Available online: https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=10009146 (accessed on 24 April 2023).