AN ANALYSIS OF DISPUTES RELATED TO EARTH RETAINING STRUCTURE CONSTRUCTION PROJECTS IN SRI LANKA

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DECLARATION

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Dr. (Mrs.) Chandanie Hadiwattege Date

Dissertation Supervisor

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ABSTRACT

An Analysis of Disputes related to Earth Retaining Structure Construction Projects in Sri Lanka

In last two decades, here the technical and economic circumstances prevailing in the construction industry have changed dramatically to take precedence over the shortcomings of project disputes concerning Earth retaining structures (ERS), such as technical disputes and procurement. Different ERS construction methods are available in the construction industry, recently populated is soil nailing construction, in parallel procurement approaches have arisen with the improvement of most of the construction industry to suit various projects, having their own set of assumptions for each strategy.

Here the primary purpose of this research is to study an analysis of disputes related to earth retaining structure construction projects in Sri Lanka. Accordingly, the study discovered that factors initiating conflicts in ERS construction are in numerous forms. So these concern the nature or characteristics of contracts in which contracts or agreements are also ambiguous and unclear, allowing contracting parties to conduct themselves as opportunistic when postal changes are necessary. Factors related to role functions exist when the parties are not performing according to expectations. This study shows that some project participants ' contractual failure and subsequent post - contract adjustments as well as unscrupulous behavior are the root causes of soil nailing projects.

The study also found that, adequate mechanism for dealing with disputes in the standard contractual forms appeared in design and construction (D&B) and traditional procurement arrangements and where the provisions contradict the specific interests of the parties, the major party chose the friendly and amicable approaches to the resolution. Design and Build (D&B) procurement arrangements are better at resolving disputes, the availability of methodologies for dispute management in standard forms of contracts, the research study recommends as a strategy the framework that can decrease the conflicts occurrence in soil nailing projects.

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LIST OF ACRONYMS

ERS – Earth Retaining Structures

ERSC – Earth Retaining Structures Construction

MSE – Mechanically Stabilized Earth

BOQ – Bills of Quantities

DB – Design and Build

TR – Traditional Method

CL – Consultant

CT – Contractor

NBRO – National Building Research Origination

DRB – Dispute Resolution Boards

ROW – Right-Of-Way

PSPs – Procurement Selection Parameters

EOT – Extension of Time

WWM – Welded-Wire Mesh

CHAPTER 1

INTRODUCTION

1.1 Introduction

Earth retaining structures (ERS) are normally found in foundation engineering, ERS stabilizes the soil and rock by the movement or erosion downslope and usually retaining walls build of such steel, brick, concrete, steel and/or wood. The steel pile and the concrete retaining wall are mostly used for this purpose. In the early 20th century, gravity and semi-gravity walls were commonly used, gravity walls made of large masses of concrete or stone (Clouterre, 1991; FHWA, 1998). Compared to the cantilever walls, the design of these structures is relatively simple. However, it was not easy to build these types of retaining walls and require a lot of labours. These factors influenced the high construction cost of ERS.

A precast concrete retaining walls are now widely marketed mostly as a friendly structural system for installation, as they can be handled more easily, place and transport (Ahmad, 2007). precast concrete retaining walls are now broadly introduced on the market as a structural-system that is easier to operate, install and transport (Ahmad, 2007). The system is providing simple, reliable and cost-effective slope protection solutions (Ahmad, 2007).

Furthermore, soil nailing has been used for nearly three decades in Europe and warmer regions of the United States. The technique of soil nailing uses long metal or fiberglass rods to strengthen the soil in situ in a series of vertical or near- vertical benches excavated from the top of an existing soil mass. In close intervals, the nails are drilled and grouted (or driven) into the ground to form a composite structure with increased shear strength.

A shotcrete face, applied immediately after excavation or after installation of nails, retains the exposed soil surrounding the nails and can be used in some applications as the final wall surface. There are several types of ERS constructions generally available, with different methods and techniques of construction.

In accordance with Ren et al. (2001) "disputes or disagreements arise from poor resolution of claims." Disputes are arising or developing when disputes were not managed. The sooner the dangerous and potentially harmful conflict is resolved, the higher percentage of disputes are successful resolved for the lower cost (Harmon, 2003). Disputes are regularly arising due to the delays and who is responsible for them. And most construction contracts provide for an extension of the completion time. The only main reason is that the owner can keep all rights to recover the delay damages from the contractor.

Minimize conflicts or disputes by using negotiation as an identification tool and resolve changes in the workplace at the staff level and if essential by top managers (Henderson 1991). Well these outcomes in a change in order or a change if resolved through negotiations. Otherwise, the dispute will be resolved by dispute resolution system such as mediation, arbitration or otherwise litigation (Arditi and Patel, 1989).

1.2 Problem Statement

Many types of Earth Retaining Structures (ERS) constructions are available; these constructions are conducting with different techniques and method, and soil nailing is recently populated construction technics. ERS construction would be easy or difficult depending on the procurement approach undertaken. Many studies have been done related to ERS construction. Yet the disputes related to earth retaining structure construction is rarely researched so far. Therefore, this research tries to address the gap in analysing disputes related to earth retaining construction.

1.3 Aim

The aim of this research to investigate the nature of disputes resolution in Earth Retaining Structure (ERS) constructions with special attention on soil nailing technique.

1.4 Objective

- Critically review the ERS construction related dispute resolution
- Explain the soil nailing technique and it's applications
- Analyses disputes related to ERS construction
- Appraise dispute resolution approaches related to soil nailing construction scenario

1.5 Methodology

This study is aimed at an analysis of disputes related to earth retaining structure construction projects in Sri Lanka. To achieve this purpose, in this research, case study is used together as a strategy for personal interviews.

Research Approach

The researcher also will examine/ study the whole population as individuals or groups using a qualitative approach and can also identify people's beliefs, opinions, understandings, and views of people (Fellows and Lui, 2003). The case study method was identified as the most appropriate term in this research.

1.6 Scope and Limitations

Research is restricted to experts in the soil nailing construction industry in Sri Lanka, which is consists of senior managers, contract managers, project managers, quantity surveyors and engineers. Research is also limited as traditional and D&B procurement approach.

1.7 Thesis Structure

Chapter - 01 : Chapter one provides an overview of the study background, aim and objectives, specific scope of research, the report is organized with a short introduction to the methodology for research.

Chapter - 02 : In chapter two, a brief literature survey is given an analysis of disputes related to earth retaining structure construction projects. This chapter explains the different construction of ERS techniques and resolving disputes using suitable ADR approaches.

Chapter - 03 : Explain the methods of research and analysis methods adopted for this study.

Chapter - 04 : Analysis of data and discussion of findings

Chapter - 05 : The study concludes with the findings, specific recommendations and further approaches to research.

CHAPTER 2

LITERATURE REVIEW

2.0 Earth Retaining Structure Construction

2.1 Earth Retaining Structure

The retaining wall is a structure that generally supports a mass of soil laterally and the stability of the soil is mainly due to its own weight and also the weight of any soil right above its foundations / base. The retaining walls are inherent parts of different foundations, and the design of the foundation engineer is one of the functions (Peck et al., 1974). Since then, concrete has been the predominant material, either flat or reinforced. Almost all retaining walls are predictable to resist the earth's pressure that they support (Peck et al.,1974). Therefore, to resist sufficient structure design and construction require a detailed understanding of the lateral force the retaining the soil retaining structure and the retained soil mass. These lateral forces are caused by the lateral pressure of the earth (Das. 1994).

Furthermore, the character of most of the back-fill material has a considerable influence on forces acting against the retaining wall's inner face. Pure sand or gavels are regarded as better than any other soil because they drain freely and are not less stable over time. Earth retaining structure can be categorised such as sheet pile wall**,** cantilevered wall**,** gravity wall, soil-strengthened**,** gabion meshes, soil nailing**,** anchored wall**,** and mechanical stabilisation gravity walls depend on their mass weight to resist pressure from behind and often have a small "batter" reversal in order to achieve greater stability by leaning back to the retained soil. They are often made of dry- stacked / mortar- less stone or segmented concrete units for short landscaping walls, and dry- stacked gravity walls are slightly flexible and do not necessitate a rigid footing (Ahmad, 2007).

The soft soils and tight areas usually use sheet pile walls. these are made of steel, plastic, vinyl, wood planks, fiberglass driven to the ground. There are structural design methods for this type of wall, but these are more complicated than a gravity walls (Ahmad, 2007). The taller sheet pile walls generally necessitate a tie-beck anchor "dead-man' positioned some distance behind the face of the wall, which is tied to the face of the wall, usually through a cable or bar, anchors should be perfectly positioned behind the possible ground/soil failure plane (Ahmad, 2007).

The cantilevered wall was the most popular type of taller retaining wall. They consist of a comparatively small stem of reinforced steel, mortared masonry or cast- in concrete. These cantilevered walls are occasionally strapped from the front have a counterfort on the back to increase stability against heavy loads (Ahmad, 2007).

The anchored wall usually uses cables and or stays anchored behind all of this soil or rock. Commonly driven by boring into the material, anchors at the end of the cable are then extended either by mechanical means or often by injecting highly pressurized concrete. Somehow which expands to form a bulb in the soil. However, it is technically difficult, this technique has always been extremely beneficial if the load is very high or if the stall is slender and weak. There is a soil- strengthened system that does not consisting of simply wall itself nevertheless reduces the earth's pressure on the wall. These are generally used for one of the other wall types (Ahmad, 2007).

Here the gabion mesh kind of the soil strengthening, frequently used without such an external wall, it consists mainly of stone or other material and it also filled wire mesh boxes. The mesh-cages also decrease internal forces and erosive forces. Mechanically stabilized earth (MES), is built with artificial reinforcement by means of layered horizontal mats fixed at its ends, providing additional internal sharpening resistance beyond simple gravity wall structures (Ahmad, 2007). The wall face is usually precast concrete units that tolerate a certain difference in motion.

Soil nagging really is a great technique system, where excavations on the soil slopes or retaining walls are reinforced by inserting relatively slender elements – usually steel bars, Usually, the bars are placed in a pre-drilled hole and grouted into place or and drilled and grouted simultaneously, soil nailing is normally installed un-tensioned at a slightly downward inclination (Ahmad, 2007).

2.2 Nature and the Development of the Soil Nailing Technique

At the beginning of the 1960s, the soil nailing method has been developed, partly by rock bolting and multiple anchoring systems and partly by the reinforced filling (Clouterre, 1991; FHWA, 1998). At the beginning of the 1960s, the new Austrian tunneling technique was the very first proto type to strengthen the earth/soil, for this work they use steel bars and shotcrete. In the early 1970s, semi-empirical designs for soil nailing evolution has started with the increasing use of this technique.

In the United States and France, the following development work began at the beginning of the 1990s. The outcome of this research and development work have been provides a frame work for the formulation of the soil nailing technique design and build approach in the following decades. Soil nailing is the most popular method of stabilization of the slope in Sri Lanka today.

Soil nailing is the technique of stabilising the soil structure with passive inclusions or strengthenings, usually known as soil-nails. These can be included and connected completely, (e.g. drilled and grouted nails), or driven into the earth/ground. In either case, the nails limit the deformation of the soil near the exposed face and transfer the stress to a more stable area behind the wall (Carlos et al., 2015).

2.2.1 The construction procedure

The usual construction arrangement of the soil nail wall is accurately described below and is illustrated in Figure 2.1

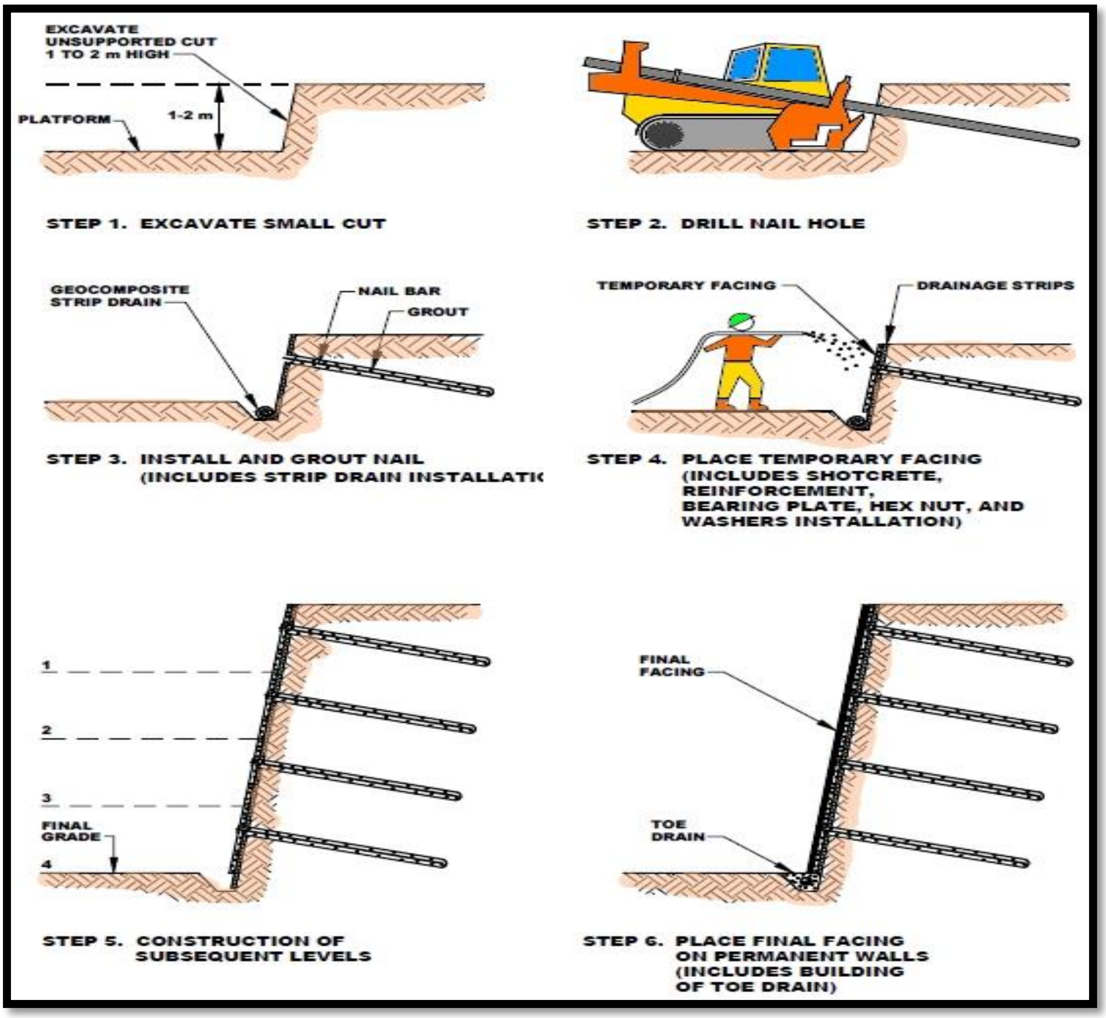

Figure 2.1 -Usual construction of the soil nailed wall. Porterfield et al. (1994)

The first step is an excavation, the initial lift depth of excavation (unsupported cut) may be 2 ft to 7 ft, but typically 3 ft to 5 ft and is slightly below the height of the first row of nails Porterfield et al (1994). The excavated platform should be large enough to allow safe access to the nail installation machinery and tools on the ground. Secondly, the drilling holes use specialized drilling machinery and tools from the excavated platform in the drilling of nail holes (Porterfield et al. 1994).

The next step is the installation of the nail and as well as grouting, In the drilled hole, the tendons are placed, the grout pipe and tendon are inserts in the drill holes, as well as the hole is filled with grout, placed under gravity or a nominal low pressure (less than 5 psi to 10 psi) (Porterfield et al. 1994). The installation of strip drains on the excavation surface is then installed, the strip drains are continuously placed between nearby nails and unroll down to the next excavation lift, which runs from the top of the excavations to slightly below the base of the excavation (Porterfield et al. 1994).

Then construction of initial shotcrete facing, the initial facing of the unsupported cut is applied. The initial face consists of reinforced with 100 mm thick layer of shotcrete. The reinforcement consists of the Welded Wire Mesh (WWM). For bending resistance, vertical and horizontal steel bars are positioned around the nail heads. When the shotcrete begins to cure, a steel plate is placed on the tendon, which protrudes from the drill hole. The plate is pressed in fresh shotcrete, hex nuts and washers are mounted to tie the nail head against the plate, the hex nut is clamped within 24 hours of the initial shotcrete placement (Porterfield et al. 1994).

Some installed nails should be tested and as well to prove their capacity or to prove /verify the specified load, the shotcrete should achieve its minimum compressive strength of 3 days specified for the planning purposes, as well as the shotcrete curing time period should be taken into account as 72 hours (Porterfield et al. 1994).

Finally, geocomposite strip drainage is mostly used to prevent the development of water pressure behind the wall-facing; basically strip type vertical-geocomposite drains are normally installed among the temporary facing and the excavation; drainage system as well includes a footing drainage system and weeping hole system to remove collected drainage water from the wall (Carlos et al., 2015).

2.2.2 Applications of soil nail walls

The soil-nail walls could be used for road cuts, tunnel portals, extension of the road under existing bridge abutments, hybrid soil nail systems and existing retaining structures repair and re-construction.

2.2.2.1 Roadway cuts

The soil-nailing was the most attractive in road cutting and it is necessary because it requires limited excavation and adequate right - of - way (ROW) and clearance limits. These elements assist to minimize the impacts on the environment along the transport corridor, and the impact on traffic can always be diminished because of the installation of soil-nail equipment are relatively small (Carlos et al., 2015). The system of road cuts shown below in Figure 2.3

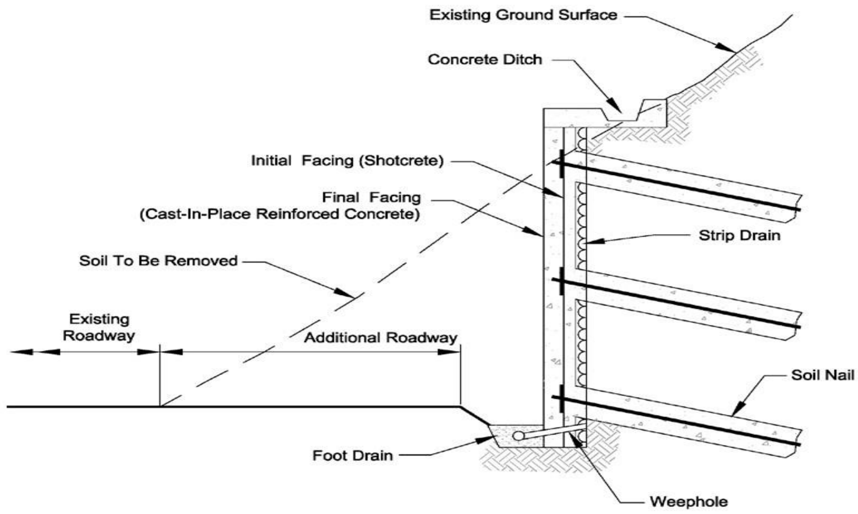

Figure 2.2-Roadway cut supported with soil nails

2.2.2.2 Road widening under existing bridge abutments

Soil-nail walls could be beneficial if an existing bridge abutment slope wants to be removed, whilst The overall costs for installing a wall under a bridge abutment could be comparable to those of other applicable technologies (Carlos et al., 2015).

The location, inclination and length of the soil nails must be planned very carefully so the nails do not intersect this existing abutment foundation and do not interfere with this existing bridge girders. The top/upper level soil nails should be placed between the clear space the bridge girders as well as should be parallel to them. In order to avoid hitting the foundation elements, the remaining lower rows of ground nails should be positioned and oriented (Carlos et al. 2015). Figure 2.4 shows an example of the road widening under an existing bridge.

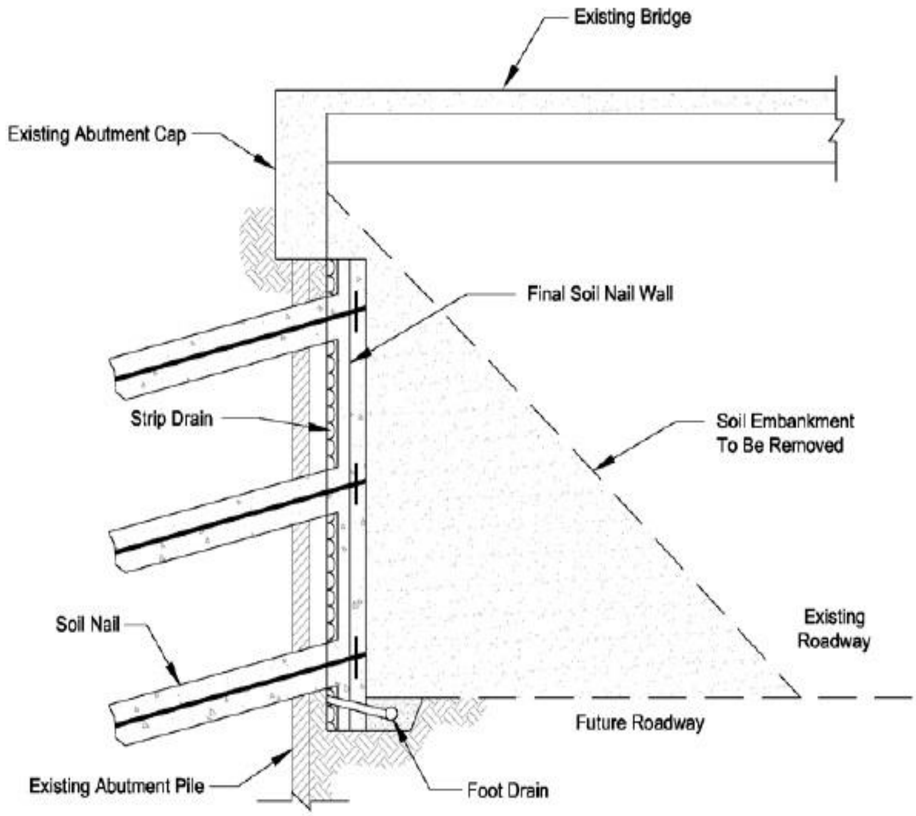

Figure 2.3 - Road widening under existing bridge.

The combined use of the soil nails and micro piles applications are attractive because they are able to help speed up construction by permitting the bridge to continue to operate when underpass paths expand. (Carlos et al., 2015).

2.2.2.3 Tunnel Portals

It is also possible to stabilize tunnel portals to use soil nails. Even though the general principle of the use of ground nails in tunnel portals seems to be similar to those of road cuts, other major aspects of the design and construction of this application must be taken into consideration. First, consideration must be given to the vertical stability of the shotcrete facing above the tunnel, consideration should be given to the potential transfer of soil nail loads to the tunnel structure at the portal and full evaluation of the interaction between the "soil nails and the initial shotcrete support and lining of the tunnel near the portal" (Carlos A et al., 2015). Soil nails should be installed with a suitable horizontal splay and vertical orientation to avoid interference with the tunnel support components (Carlos et al., 2015).

2.2.2.4 Repair and Reconstruction of Existing Retaining Structures

Soil nails could be used for "stabilise or strengthen failing or distressed retaining structures." Some walls of Mechanically Stabilized Earth (MSE) excessive and unnecessary deformation may occur because of poor construction, poor design, or may be both. Soil nails really can be directly installed on the face of an MSE wall even if the present faces are stable enough to resist drilling (Carlos A et al., 2015).

As the MSE wall continues to deform, the backfill and facing of the MSE wall would transfer loads to the installed soil nails, which would transfer loads to stable soils located behind the MSE- reinforced block of soil (Carlos A et al., 2015).

2.2.2.5 Hybrid Soil Nail Walls

Soil nail walls can also be used to combine the advantage of each method with other types of wall systems such as ground anchor walls and MSE walls. This can occur in walls with a complex layout or when the cost of other earth-retaining systems is too high.

In cut / fill situations, the combination of such MSE as well as soil nail walls might provide a much more cost-effective design than traditionally used full - height MSE walls or drilled shaft retaining walls (Carlos et al., 2015). Figure 2.5 shows the soil nail / MSE hybrid wall.

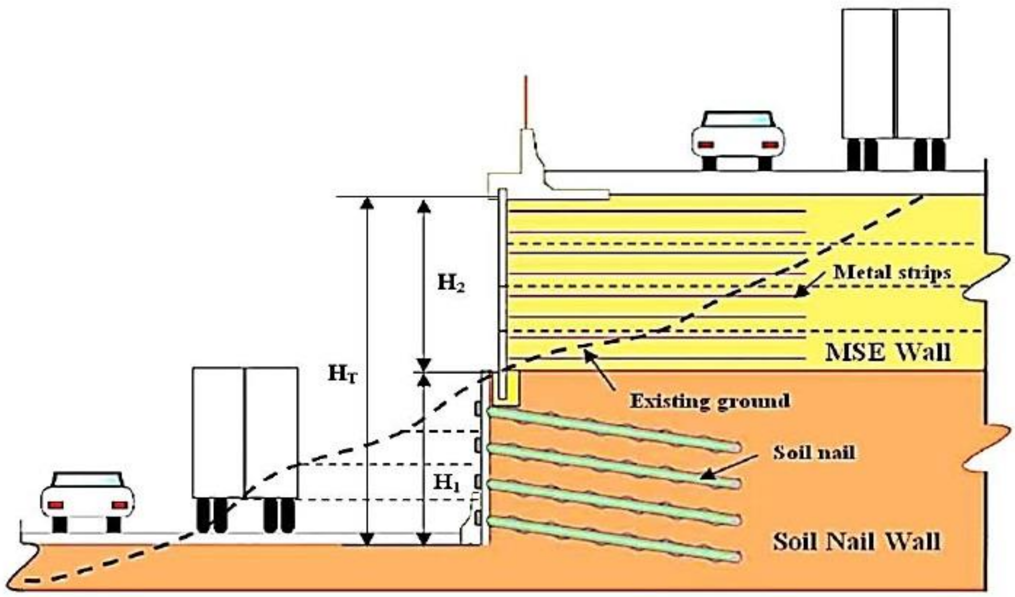

Figure 2.4-Hybrid soil nail / MSE wall.

2.2.3 Benefits of soil nailing

The soil nail can neither economically nor technically replace all other retention structural approaches, but that has certain advantages.

The economic evaluation of several projects has resulted in a cost-effective process for soil nailing. If big machinery cannot be employed, wall geometry is complex and construction space is limited the entire process is very cost efficient (Carlos et al. 2015). When proper drilling equipment is used, faster construction rates can be achieved. The tilt facing is the use of shotcrete that easily accommodates a tilted facing with benefits of overall stability and reduces shotcrete loss due to a rebound (Porterfield et al. 1994).

The soil nailing is usually much more feasible than other technologies, such as soldier piles, cast in reinforced concrete retention structures, the wall base equal the depth of excavation, which saves a large amount of material (Carlos et al., 2015). Redundancy of reinforcement: if a nail is overs-tressed for any reason it does not fail the entire wall system. Rather, the overstrained is redistributed to nearby nails. Nails are made of low- strength steel.

Nails are made of steel with relatively low strength. In comparison with the use of permanent anchors, the problem of corrosion protection is greatly reduced. With little environmental disturbance, the soil nailing can be constructed, meaning little noise and almost no vibration. The application of a flexible facial system allows the construction of green walls (Carlos et al., 2015).

Moreover, the failure mode is good, that is, without any major deformation, the retaining structure doesn't suddenly collapse, so there are many nails, and failure by any person could not affect the system stability. superfast deflection can be controlled, as with conventional tiebacks systems, by installing additional nails or by stressing on the upper level of the nail a small proportion of their workload, by providing the advantage of a shorter diameter for nail installation in heterogeneously soils with cobbles, boulders, weathered areas or hard rock areas (Carlos et al., 2015).

While many advantages exist, soil nailing earth retaining carries numerous modes of failure. Such cases should be considered as the possible root causes of disputes. the next section presents modes of soil nailing for such failures.

2.2.4 Failure modes of soil nailing

The failure modes are categorised into three (03) modes: internal failure, external failure and facing failure (FHWA, 2003). Taking into account the failure level as shown in Figure 2.6

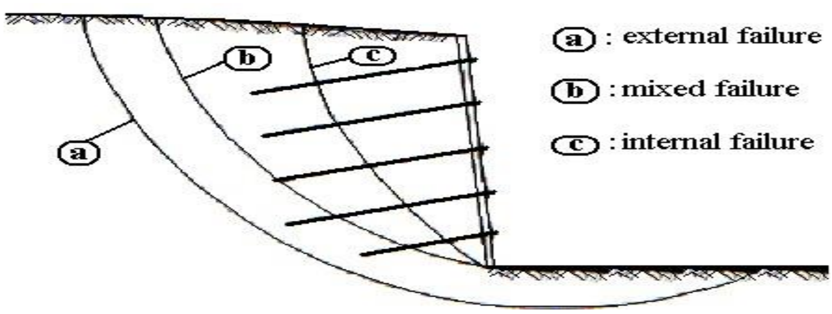

Figure 2.5 – Different types of failure

External modes of failure which refer to the development of possible surfaces of failure which pass through or behind soil nails (FHWA 2003). This is shown in Figure 2.7 (i.e. surfaces of failure that could cross the nails or cannot cross them).

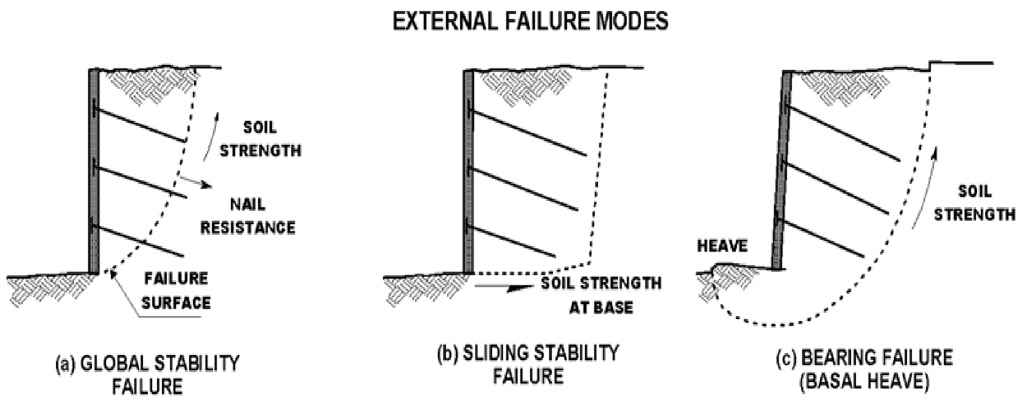

Figure 2.6- External failure modes

In external modes of failure, the soil nailed wall mass is typically treated as a block (FHWA, 2003). Byrne (1998) defined three modes of failure, global stability failures and sliding stability failures and bearing stability failures. Figure 2.8 shows that

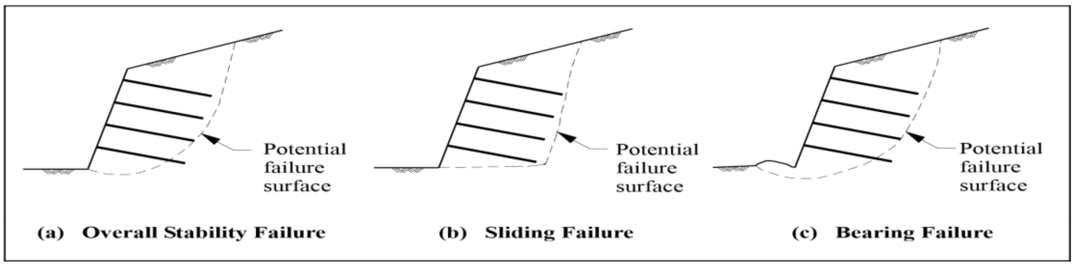

Figure 2.7 – External potential failure surface

Internal modes of failure are the failure of load transmission mechanisms among the soil, the nail and the grout. As the bond strength is mobilized, as previously stated, tensile forces are developed in the nail. As detailed in Figure 2.9, different internal failure modes can be implemented in accordance with the tensile strength and length, bond strength, and bond stress distributions.

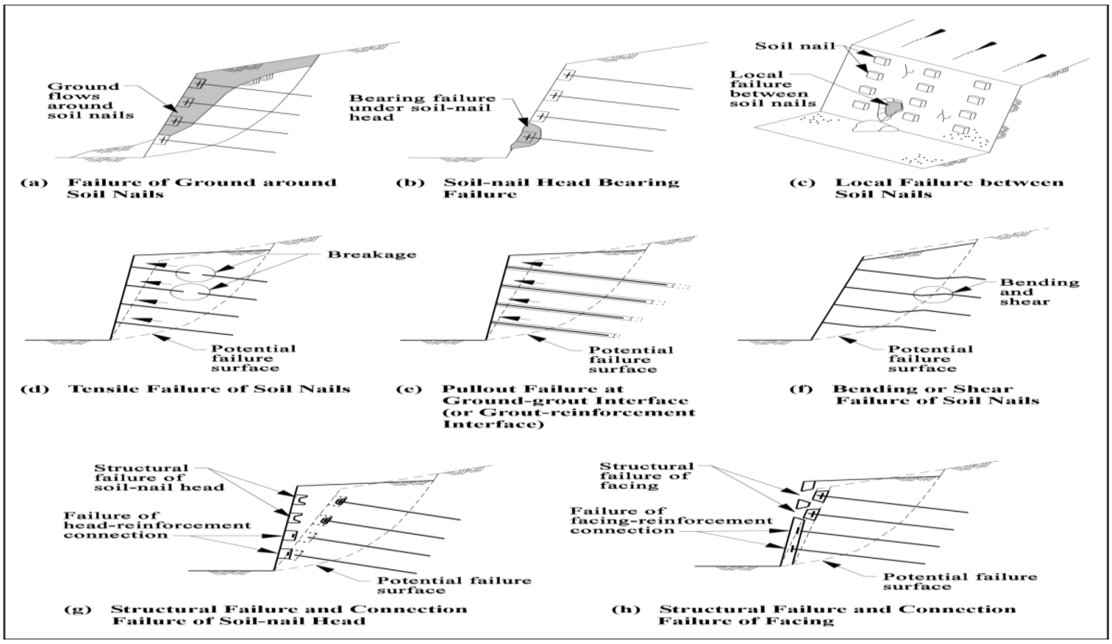

Figure 2.8 – Internal failure modes

Failure of ground mass, disintegration of the ground and flow around the soil nails and soil- nail heads, failure of the soil- nail head bearing failure below the soil- nail heads, local failure between the soil nails, structural failure of the soil nail under combined tension, shear and bending, tensile failure of the soil nail, structural failure of the soil-nail head or face, i.e., bending or punching shear failure, or failure at head-reinforcement or facing-reinforcement connection (FHWA, 2003).

Pullout failure at ground-grout or ground-reinforcement interface, nail pullout failure is a soil-grout interface failure due to insufficient intrinsic bond strength and/or insufficient nail length, nail bending and nail shear, nail tensile failure, the nail can fail in tension if there is an inadequate tensile strength (Carlos et al., 2015). The structural failure and connection failure of the soil nail head, the structural failure of the soil nail head, the failure of the head reinforcement connection and the structural failure and connection failure of the face structural failure, the failure of the face reinforcement connection (Carlos et al., 2015).

The most common type of failure modes at the facing-nail head. They are of three types (03), as illustrated in figure 2.

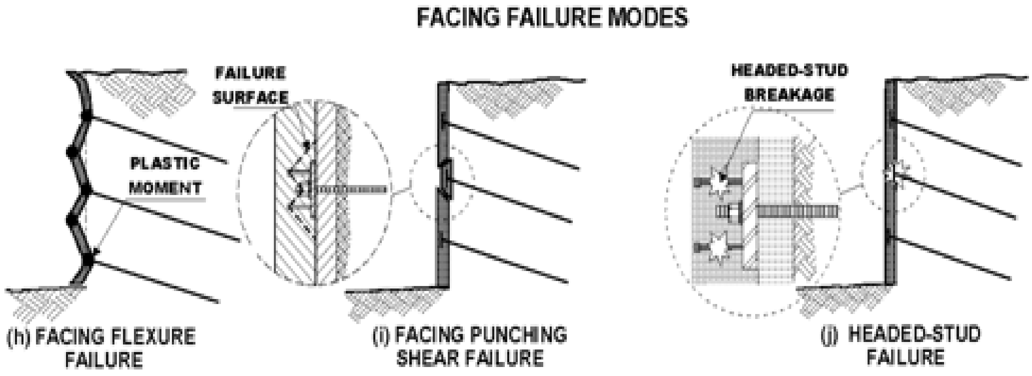

Figure 2.9 - Facing failure modes

Flexure failure is a failure mode due to an excess bending beyond the face's flexural capacity. For both temporary and permanent facings, this fault mode should be seen separately and the sharpening fault mode on the face of the nails should be evaluated for temporary and permanent facings, and a tensile fault in the headed stud should be evaluated if the headed stud is failed in tensions (Carlos et al., 2015). This failure mode is a matter of permanent facings only.

2.3 Dispute in ESR Construction

2.3.1 Disputes in construction industry

The definition of dispute is a matter 'in dispute'. Some other authors simply refer “disputes as a simple disagreement,” while others refer “disputes as the result of a refusal of a claim (Kumarasawamy, 1997).” In accordance with Ren et al. (2001) “disputes or disagreements arise from poor resolution of claims.” The authors characteristic the increase amount of disputes to industrial, social and project factors. Diekmann & Girard (1995) generally defines “disputes as any contractual issue or dispute that must be resolved beyond the staff of the job management.”

Conflict is considered to be behavioural from a permissible point of view, while disputes are considered to be justifiable. In simple terms, “when a claim or assertion made by one party is rejected by the other party and that rejection is not accepted (Eggleston, 1993; Kumaraswamy, 1997; Bunni, 2005)." In accordance with Bunni. (2005) "there has to be a claim, a rejection and a non-acceptance of the rejection. It is not considered to exist on the basis of a claim alone."

Disputes are arising or developing when disputes were not managed. The sooner the dangerous and potentially harmful conflict is resolved, the higher percentage of disputes are successful resolved for the lower cost (Harmon, 2003). Disputes are regularly arising due to the delays and who is responsible for them. And most construction contracts provide for an extension of the completion time. The only main reason is that the owner can keep all rights to recover the delay damages from the contractor.

Mistakes or errors in design that could be lead disputes, such as related to delays and extra costs. Frequently no planning or sequencing is given to the release of design information, which then influences on construction Figure 2.11 illustrates concepts and causal links between conflict and conflict.

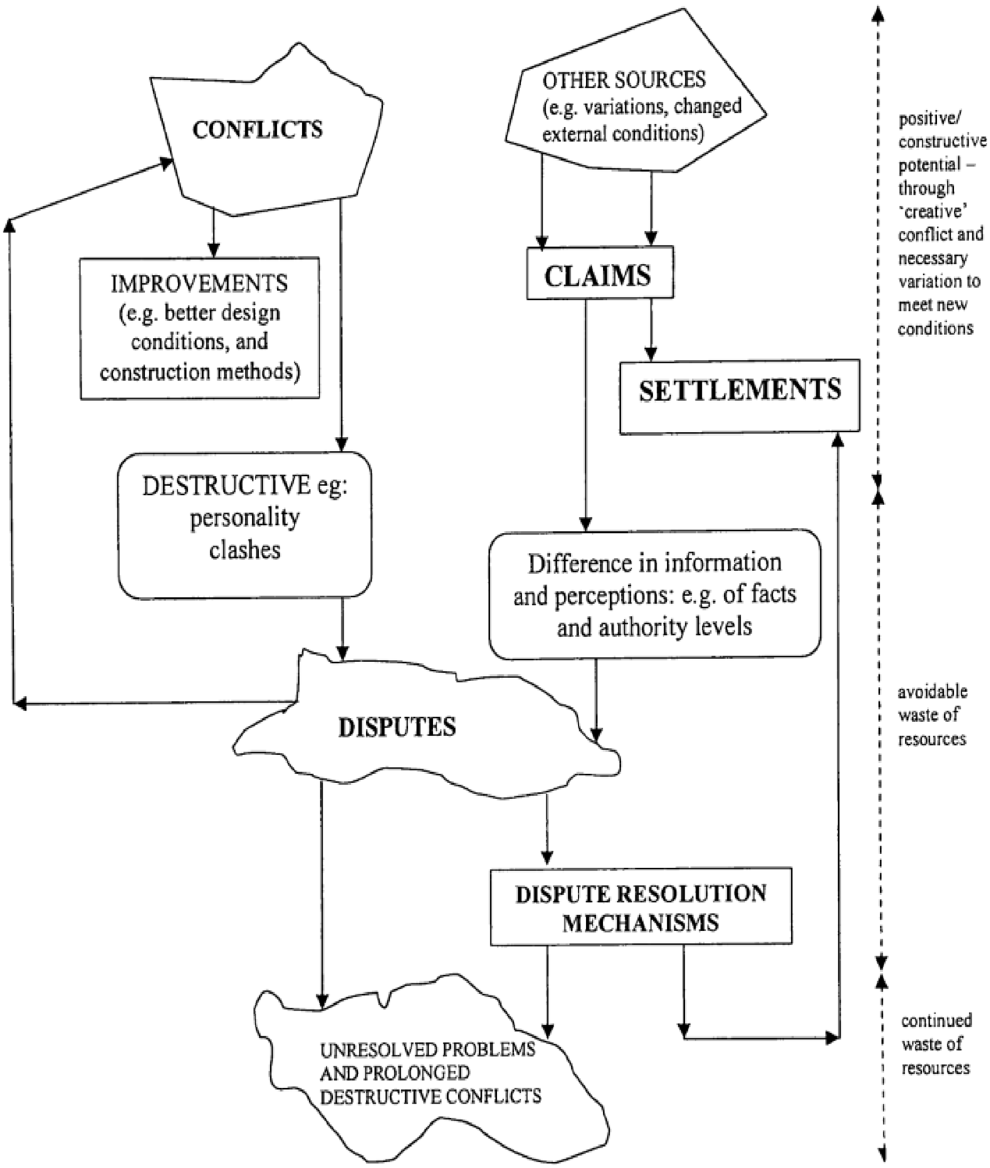

Figure 2.10 - Concepts and Causal linkage of conflicts and disputes
(Kumarasawamy, 1998)

Construction disputes can result from a combination of behavioral and environmental factors. "Since construction projects usually involve long- term transactions with high uncertainty and complexity," every detail cannot be resolved and every contingency cannot be foreseen at the outset. The causes of disputes are classified according to their nature and mode of occurrence, as shown in Table 2.1 and Figure 2.10.

Table 2.1 – Common causes of disputes by categories (Kumarasawamy1997)

CATEGORY OF DISPUTES	CAUSES OF DISPUTES
Owner Related	Variations initiated by the owner
	Change of scope
	Late giving of possession
	Acceleration
	Unrealistic expectations
	Payment delays
Contractor Related	Delays in work progress
	Time extensions
	Financial failure of the contractor
	Tendering
	Quality of works
	Technical inadequacy of the contractor
Design Related	Design errors
	Inadequate/incompleted specifications
	Quality of desing
	Availability of information
Contract Related	Ambiguities in contract documents
	Different interpretation of the contract provisions
	Risk allocation
	Other contractual problems
Human Behavior Related	Adversarial/controversial culture
	Lack of communication
	Lack of team spirit
Project Related	Site conditions
	Unforeseen changes
External Factors	Weather
	Legal and economic factors
	Fragmented structure of the sector

In addition, in order to avoid disputes, it is essential to have the personality of the Engineer or employers representative and their approach to proper and fair contract management on behalf of the Employer. Where the contract incompetently describes. Which party should take the risk of the conditions of the site, disputes are inevitable if the adverse site delays the progress of work or requires more costly methods of engineering.

Variations are an important cause or problem of construction conflicts, specifically if there is a significant number or the variations have an effect on partially finished work or are issued as the work is close to completion. Here the nature and, as well as number of such variations, can make a relatively simple project into a complex one.

2.4 Dispute Avoidance and Resolution

Henderson (1991) determines general factors that affect the efficiency of dispute avoidance such as "the clarity of original bid documents, the ability of the Contractor to plan and execute the job, recognition by the Employer that changed conditions exist and the ability of the owner to respond in a timely manner."

Henderson (1991) clearly determines that avoiding disputes is the greatest way to deal with the risk of disputes. "Proposed preventive measures for avoiding disputes proposed include: use value engineering and peer review, have bid documents checked for constructability, clarity and completeness, avoid too many or too complex addenda, evaluate job cost during the design process using a professional estimator, provide and use adequate CPM scheduling and update requirements, provide adequate tracing mechanisms for requests for information, substitution requests and change order proposals, review the A/E's specifications whether they represent your project requirements, allow a reasonable time for designing the project and for bidding, enquire that the contractor's bid documents be placed in escrow and promote open and factual communication."

Minimize conflicts or disputes by using negotiation as an identification tool and resolve changes in the workplace at the staff level and if essential by top managers (Henderson 1991). Well these outcomes in a change in order or a change if resolved through negotiations. Otherwise, the dispute will be resolved by dispute resolution system such as mediation, arbitration or otherwise litigation (Arditi and Patel, 1989).

Betant et al. (1995) here again propose general necessities of the project, its similar to Henderson's (1991) which would help reduce disputes in major projects if they are fulfilled. Unlike Betant et al. (1995), Unlike Betant et al. (1995), whose work directly addressed the necessities in the preparation of contracts, Henderson (1991) focused entirely on the procurement contract suggestions and the execution of the works.

Inspection of the contractor's bid sum in respect of possible errors or underestimation of many of these ambiguous items, drafting up clear tender documents to reduce the mistakes and uncertainties, using general conditions of the contract with adequate interpretation, clearly classifying and discussing risk allocation provisions with the contractor.

Minimize changes in designs where changes are unavoidable and all these changes are openly discussed with the contractor and the cost impact agreed before the order is issued should be avoided interface with other contractors, minimizing disputes by negotiating reasonable claims in good faith.

Henderson (1991) suggest that “dispute prevention measures to be advised to contractors at various construction phases. Before bidding and negotiating the contract, the author proposes to investigate the conditions of the subsurface, the accessibility of the project site, keep weather and all other investigations records, the Contractor is advised to read the contract carefully before signing the contract and to pay particular attention to clauses relating to: incorporation by reference provisions, flow- down clauses, different site conditions, compensation clauses, no damage to delay clauses and change clauses, contractor should impose a discipline on the project management team during the course of the work to maintain proper job documentation, which would serve as evidence when a dispute arises.”

2.5 Dispute under Different Procurement System

2.5.1 Dispute in traditional procurement method

The unusually a lot of disputes identified in projects where that are traditional procurement approaches are observed along with fragmentation (Latham 1994), Competition with prices (Bourn 2001) and poor/bad communication as well as the sequential process resulting in delays (Morledge et al. In 2006). The question of fragmentation in connection with the traditional procurement method is not restricted to the construction process.

Also, there's a fragmentation of the relationship between client and the project team. Contractors and designers are used in time and space separately. They often have a relationship of suspicion (Ndekugri & Turner, 1994). The result is poor communication, conflict and adversity (Latham 1994; Masterman 2002).

It is hardly explicit in the traditional method to provide accurate bills of quantities, hence the inevitability of excessive variations, a well- known cause of construction disputes (Semple et al. 1994; Bourn 2001).

2.5.2 Dispute in design and build procurement method

The use of design and construction has shown a dispute reduction. Ndekugri and Turner (1994) testified to a survey of the design and construction problems of contractors, designers and construction clients. The use of the approach to design and construction procurement leads to a decrease in disputes which showed one of the findings.

The few conflicts that the design and construction of projects encountered inaccuracies in the customer's brief, a dispute among the client brief and the contractor's proposal and the estimation of variations. Conlin et al. (1996) It has been found that the design and construction disputes were few in comparison with projects in which traditional procurement approach were used. Design and construction disputes primarily related to quality.

CHAPTER 3

RESEARCH METHODOLOGY

3.0 Research Methodology

This section explains the reasons for the scientific approach used in this study. The chapter presents the research design information, the sample size population, a variety of data collection techniques and statistical analyses. The research system is shown in Figure 3.1.

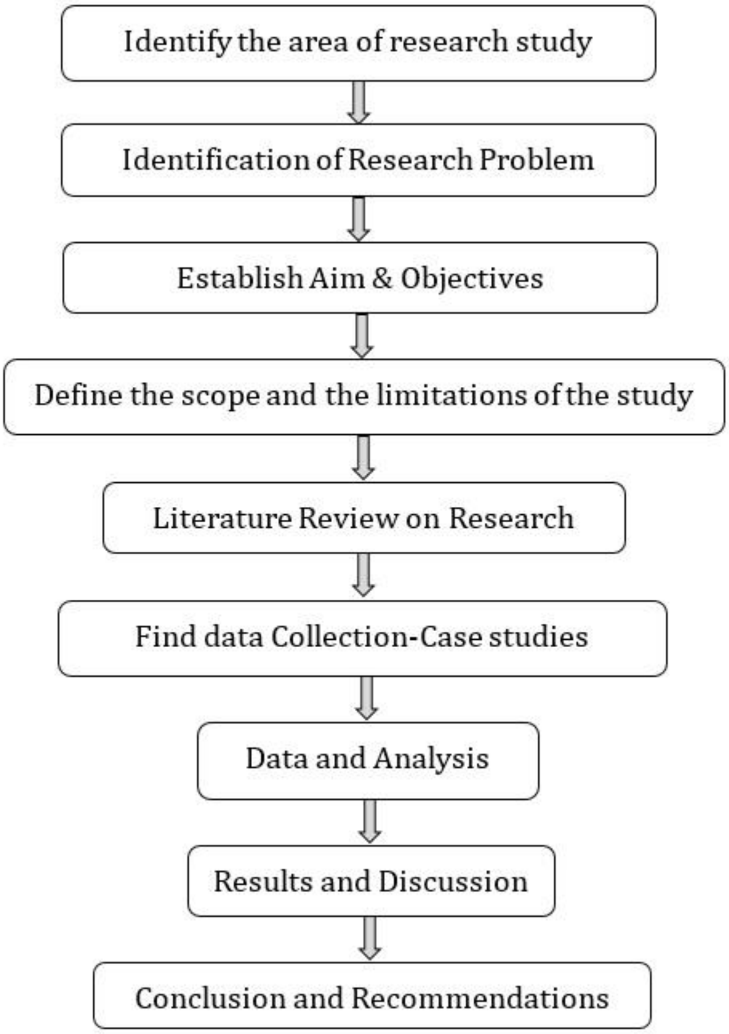

Figure 3.1-Research methodology flowchart

The identification of the research method involves the determination of three (03) key factors. Identify the philosophy of research on which the research is based. Choose a suitable method for researching theory. Finally, choose the method of research for collecting and analyzing data. Finally, choose the method of research for collecting and analyzing data. Therefore, improving the most suitable research design for the specific research study is of paramount importance. As shown in Figure 3.2

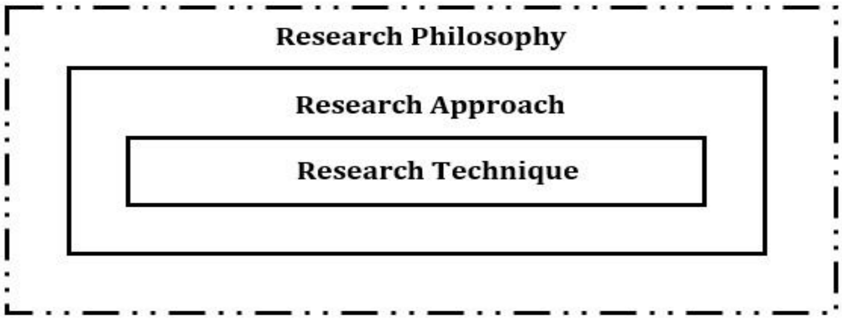

Figure 3.2-Nested Research Methodology (Kagioglou et al., 2000)

3.1 Research Approach

For each type, the difference between quantitative and qualitative methods is greatly approximated as categories covering many different authentic techniques (Gambeson, 2005; Long et al, 2000; Wilson & Natale, 2001; Hanson & Grimmer, 2007). By looking at the full range, this can be better understood of subjectivist methods used in the current social sciences according to Burell and Morgan (1979). The quantitative method is usually positivistic and seeks to collect factual information and to find out about the connections between realities and how these facts and relations comply with previous research theories and findings (Kraemer, 2002). Survey researchers and experimental researchers mainly adopt quantitative approaches.

The qualitative research's approach is not as old as the quantitative and has really emerged mainly in the last three or four decades. (Creswell, 2003:5). It is a process of understanding the research that examines a social or human problem based on different methodological research traditions.

In this case study method and technique was identified as the most appropriate. The researcher, therefore, studies the whole population as groups or individuals and can identify beliefs, understandings, opinions, and viewpoints of people (Fellows and Lui, 2003).

3.2 Research Design

The main aim of this research study is to investigate the disputes related to earth retaining structure construction and resolving disputes using suitable ADR approaches, case studies were conducted via personal interviews and documentary reviews in this research. As shown in Figure 3.3

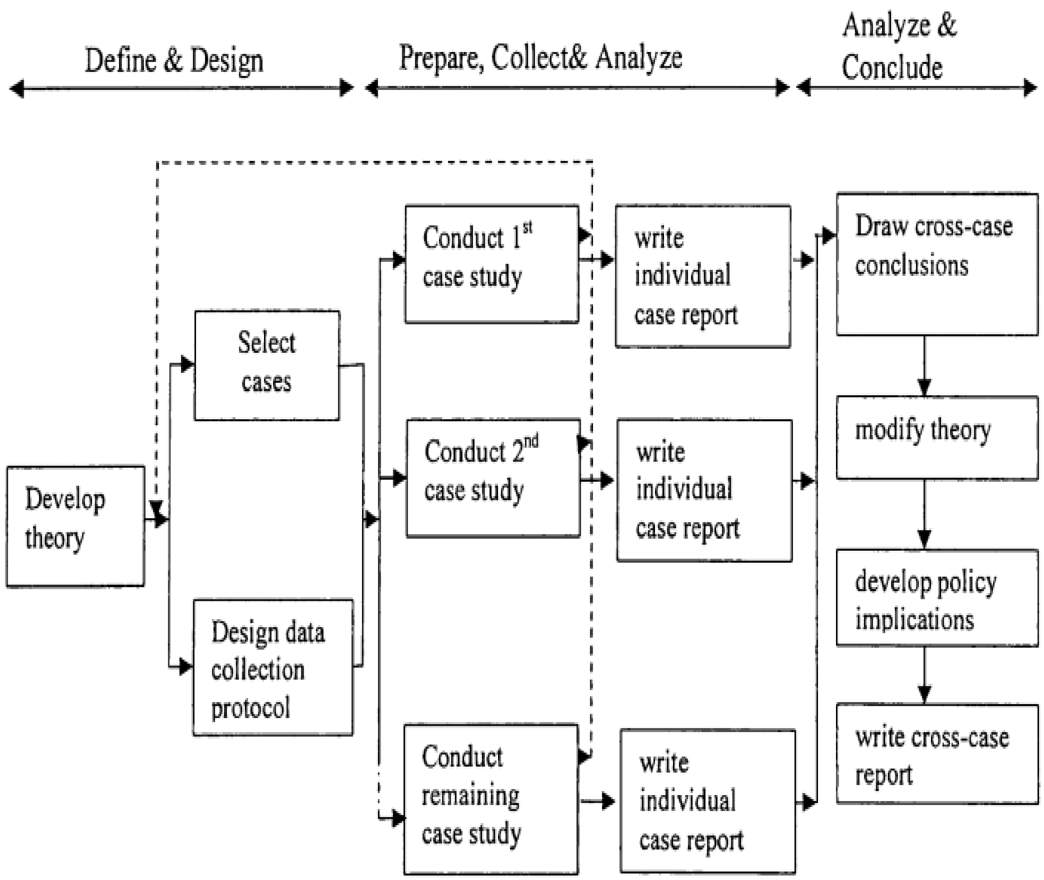

Figure 3.3-Case Study Method (Yin, 2003)

3.3 Data Collection and Analysis

The data was collected mostly from the local participants via the interviews, one of the many structural processes that were designed and developed. Before the interview was carried out, the draft interview guideline was sent to the target interviewee and the date as well as time of the interview was determined. This provided the interviewee with the opportunity to study the questions. As illustrated in figure 3.4.

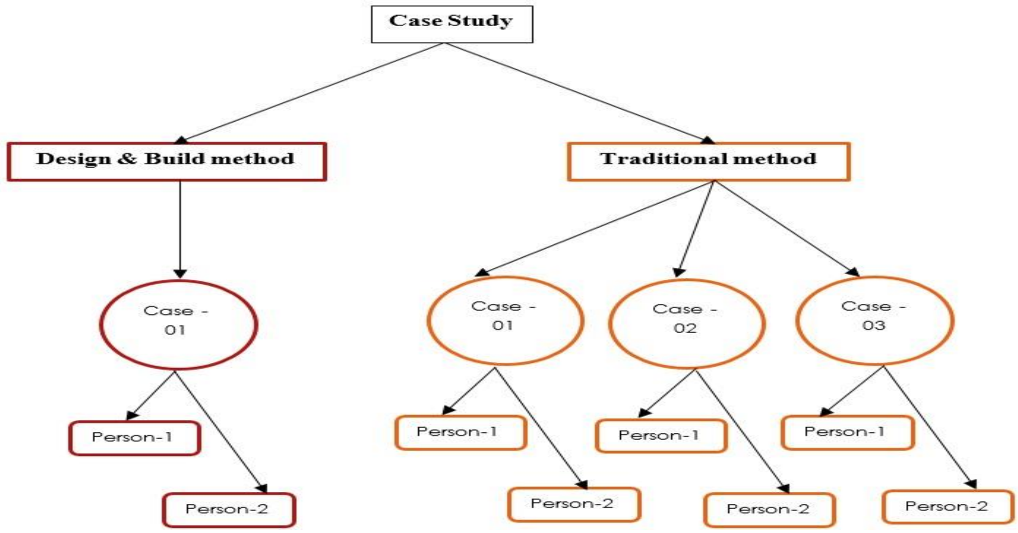

Figure 3.4-The data collection and analysis procedures.

The researcher interviewed eight (08) construction project professionals. The researcher introduced himself to the respondent at the beginning of the interview to effectively create a pleasant atmosphere, the respondent expressed his gratitude and stated that all of the collected data would only be used for research purposes and would not be passed on to any other party.

The interview lasts or time about 20 minutes. These interviews provided far-extending, accurate and clear information from the interviewee because of the clarification provided by the researcher and the interview objective. The literature reviewed and the observations made projects that raised questions in interviews with senior practitioners working as project managers and project engineers and project quantity surveyors.

CHAPTER 4

DATA ANALYSIS AND DISCUSSION OF FINDINGS

4.0 Introduction

The primary aim of this section is to study and examine conflicts relating to earth-retaining structure construction with special attention on soil nailing technique in Sri Lanka, from level of root cause, how do they progress / develop, how do they are handled and managed in a real project setting. The information was gathered from each case study relating to the project description, issues / areas on which disputes were experienced, causes of dispute in each issues / areas identified, how the conflict arose/surfaced, and how was it handled and managed?

So the final portion of this section is a cross-case analysis in which the issues/areas in which conflicts have occurred, the causes of disputes, how conflicts have arisen and how they have been handled and managed are pooled and compared. This chapter actually describes here the analysis of the data followed by the research discussions on the findings. The findings completely relate as well to the research questions of the study. Data were obtained from individual interviews from construction professionals. This section presents the data collected from four (04) soil nailing projects in Sri Lanka, located at different places. One (01) project was a design and build procurement project and the other three (03) were traditional procured projects.

4.1 Data Collection and Analysis

Various approaches and data collection were used in this thesis for research questions, the data collected using different strategies, techniques and sources for each study: interviews, direct observations, and analysis of documents. The interview phase had two (02) main purposes such as First, to determine the existence of disputes in soil nailing projects, and secondly, to generate a list of variables on disputes that had been combined with the variables established in the literature review to form the basis of a questionnaire.

Interviews had been conducted with prominent key individuals in soil nailing projects that included; clients/ consultants, contractors, sub-contractors, (project managers, project deputy general manager, engineers and quantity surveyors). The interviews had been individually conducted with the consulting group followed by the category of the contractor until all categories had been completed. Interviews had been conducted because the aim was to explore, collect and develop interviewees ' ideas on the situation of conflicts in soil nailing projects. This kind of interview attempts to understand how people think and feel about research topics that are contrary to the standardized interview. The interviewees listed in Table 4.1

Table 4.1 Number of individuals interviewed

Designation	Number
Senior Engineer	3
Senior Quantity Surveyor	1
Project Manager	3
Project Deputy General Manager	1

Interviewers completely understand the research objectives and that the interview could naturally move from topic to topic while maintaining an interesting conversation fiction. The case study code system shown in Table 4.2

Table 4.2 Case study code system

Procurement System	Case study	Interview's	Code
Design and build	C1	CL-C1I1	CL-C1I1
		CT-C1I2	CT-C1I2
Traditional Method	C2	CL-C2I1	CL-C2I1
		CT-C2I2	CT-C2I2
	C3	CL-C3I1	CL-C3I1
		CT-C3I2	CT-C3I2
	C4	CL-C4I1	CL-C4I1
		CT-C4I2	CT-C4I2

CL- Consultant, CT - Contractor

4.2 Case Introductions

CASE 01

According to the respondents, the project clearly representing case-study one (01) is design and construction of retaining wall on Kandy (Central province). The contract value is LKR 194 million and project duration is 30 months (design and build procurement method). In this project's constancy, consultant and contractor both parties are considered to have earth retaining structures built to hold back a bank of the earth where grade changes. There are different types of walls and not all of them require the consent of the building. The retaining-wall should be designed to support the lateral load otherwise pressure of the earth otherwise fill behind it and any loads applied and prevent the build- up of water behind or below the wall, which increases the lateral pressure and reduces the capacity and sliding resistance of the wall. There are many types of earth retaining structures, like gravity, sheet pile, cantilever as well as anchored earth, according to their inclination to the face, which mechanically stabilize the walls and slopes of the earth (reinforced earth). Soil nailing is the method of strengthening the natural slopes of the soil by installing grouted steel bars (called nails) in the slope of the soil in order to increase the shear capacity of the surface of the failure.

Soil nailing was one (01) of the latest in situ methods and techniques for soil improvement and stabilize the slopes. The entire process of soil nailing consists of entire strengthening the natural soil by using small bars or metal rods that are ground in the pre-drilled holes. The technique offers a wide range of such applications for stabilising deep excavations and steep slopes to stabilize. Recently, Soil nailing became a very popular method of stabilizing the slope, particularly if it is located under historic buildings or adjacent to them. Stabilization by nails drilled into existing structures of masonry, such as failure to retain walls, provides long- term stability without demolition and costs of reconstruction. To date, there are no internal or external failures in this project.

CASE 02

According to interviewees, the project representing case study two (02) is Rectification of unstable slopes segments on an A-grade Road, contract value is LKR 460 million and project duration is 24 months (traditional procurement method). In the constancy of this project, consultant and contractor both parties are considered earth retaining structures are designed to prevent the soil from unnatural slopes. In accordance with interviewees "ERS are used to bound soils between two (02) different elevations often in areas of terrain possessing undesirable slopes or in areas where the landscape needs to be shaped severely and engineered for more specific purposes like hillside farming or roadway overpasses." The construction of the soil nail wall really is a good technique used to stabilize the soil in areas where landslides may be a problem. By inserting bars in the soil with steel reinforcement and anchors them in the ground, the soil nail can prevent landslides. Soil Nail walls are not recommended to use on clayey soil and perhaps clean sands where the cohesion of the soil is minimum.

Soil nailing is a useful, practical as well as proven technique used to make excavations and stabilize slopes by strengthening the ground in-situ with comparatively small, completely bonded inclusions, generally steel bars. These are introduced into the soil mass, the surface of which is stabilized locally by sprayed concrete, and act to produce a reinforced ground zone. This zone then performs as a homogeneous and resistant unit to support the unreinforced ground behind, "in a manner similar to a conventional gravity retaining wall." In order to stabilize the slopes and excavations of soil the three (03) principal classifications of in-situ reinforcement methods and techniques are used. These are mostly nailing, micro- piling as well as dowelling. The reinforcement is installed horizontally or sub- horizontally in soil nailing in order to improve the soil's shear resistance by acting in tension.

Soil nail walls are particularly well when the ground conditions that necessitate vertical or near vertical cuts. They were used successfully for road cutting such as removing the end slope under existing bridge slopes during underpass expansion; repairing, stabilizing and rebuilding existing retaining structures; and turning portals.

Soil nail walls can be taking into account as retaining structures for any permanent or temporary vertical or near-vertical cut construction, up to date project have not any internal or external failures.

CASE 03

The project representing case study three (03) is a rectification of slope failure at Expressway. The contract value is LKR 216 million and project duration is 12 months (traditional procurement method). In the constance of this project, consultant and contractor both parties are considered "earth retaining structures are engineered to retain soil and or rock and they are commonly used to accommodate changes in grade, provide increases in the right-of-way and buttress the toe of slopes." Earth retaining structures could be categorized according to the inclination of the face: If they are more than 70 degrees, they are typically categorised as retaining walls, while the inclination of the face is less than 70 degrees. There are so many kinds of retaining structures are available, including gravity, sheet pile, cantilever and mechanically stabilized earth (reinforced earth) walls and slopes of anchored earth. It is not suggested to use soil nail walls on clay soils or clean sands where soil cohesion is minimal.

Soil nailing earth retaining structures are built by the assembly of facing units linked to rods or strips held by friction. The movement resistance of the ties is controlled by the portion of the anchors/nails behind the theoretical active wedge. The soil nail wall construction process has some areas that are suggested and can offer great advantages, particularly if there is no other alternative available. One of the most important things about the soil nail construction process is that you start at the top and as you dig the wall is extended on a per lift or depth basis.

This project is the slope stabilisation. Soil nailing is an in-situ soil reinforcement technique that has been used for stabilising slopes and retaining excavations and the soil nailing process includes the installation of nails into the excavated cut or in the slope either by driving and grouting in pre-drilled holes. Shotcrete facing is often used in soil nailing wall construction.

The main functions of the facing are to ensure the stability of the ground between the reinforcement layers and to protect the soil from surface erosion. The facing is generally reinforced with a welded wire mesh and its thickness is obtained by application of successive layers of shotcrete. This technology is flexible for structural elements and installation techniques can be easily adapted to provide the most appropriate solution for specific site conditions. Therefore, this method has also been used successfully in remedial construction. Up to date project have not any internal or external failures.

CASE 04

As per the respondents, the project representing case study four (04) is rectification of slope failure at Hakgala. The contract value is LKR 248 million and project duration is 15 months (traditional procurement method). In the constance of this project, consultant and contractor both parties are considered as “earth retaining structures are used to hold back earth and maintain a difference in the elevation of the ground surface as well as the retaining wall is designed to withstand the forces exerted by the retained ground or ‘backfill’ and other externally applied loads and to transmit these forces safely to a foundation and/or to a portion of the restraining elements, if any located beyond the failure surface.” Soil nail is a structural element that transfers loads to the ground to support or reinforce excavated or existing slopes. The ' nail ' can consist simply of a steel tendon but is usually embedded in a cement ground to improve load transfer and protect against corrosion. “Soil nailing” has been accepted as a generic term for all applications of ground installations.

Again in accordance with interviewees “the soil nail as a stabilizing measure for distressed slopes and for new very steep slopes has the distinct advantage of strengthening the slope without excessive earthworks in order to provide access to the construction and working space associated with the commonly used retaining system, such as reinforced concrete wall, reinforced soil wall, etc.” Furthermore, due to its relatively simple construction method, relatively free maintenance.

The soil nail system saves costs for the deep excavation project as well as enables the basement to be built in a relatively unobstructed workplace environment. The fundamental principle of such soil nailing would be to strengthen as well as strengthen existing soil though by installing steel bars which are closely separated, known as "nails, into a slope as construction proceeds from the top down." Even this method generates a reinforced section which is stable in itself and capable of holding the ground behind it. The reinforcements are passive and develop their reinforcing action through nail ground interactions as the ground deforms during the construction. In many cases, soil nailing has been used, including new road cut support, existing road expansion,repair of existing retaining structures and reinforcing unstable slopes. There are no internal or external failures to date of the project.

4.3 Core Data Analysis

This section identifies as well as discusses clear specific disputes that have arisen within the project. For each and every dispute clearly identified, the real issue area of conflict is openly discussed, caused, how it surfaced and how it came about and how it has been handled and managed in terms of its management tactics and mechanisms.

4.3.1 Dispute related to ERS and methods of resolutions

4.3.1.1 Within Case Analysis (Case Study-C_1)

Both the interviewees are agreed on the prevailing of the following five (05) kinds of disputes; conflict in payment delays, delays in the issuance of certificates by the consultant, changes in scope / design changes, mistakes and errors in design drawings, delays due to the main contractor's payment of subcontractors. The dispute resolution methods are also agreed

Conflict or dispute in delays of payments: Conflict or dispute in this area had been in respect of the timeframe stipulated against the actual time in the contract when the client made payments according to the contract, the payments should have been made within 28 days well after the consultants issued the payment certificate. However, payments were not made within the given period for a number of certificates. The main reason for the delay in payments was the client's lack of funds for that particular time period or frame.

So according to the original contract document, no provision was made for payment delays. However, the contractor did not try to terminate the contract because it maintained a good business relationship with the government project client. When such delays happened, the project members met, discussed and reached a compromise whereby the contractor used to reduce on-site labor, plant and material resources while waiting for payments.

The client, on the other hand, clearly expressed his Commitment and legal liability paying the contractor in accordance with the contract, nonetheless had been constrained by a lack of funds, while at the same time the contractor, on the other hand, was also committed to carrying out the work in accordance with the contract, while maintaining a good business relationship with the client. This had been reflected in the addition to the contract where the payment delay mechanism has been changed by the introduction of a condition for the contract requiring the customer to pay interest on late payments at bank borrowing rates for delayed days instead of the contractor terminating the contract. This had been established credible commitment by the client to gain the trust of the contractor that the vendor will fulfill the commitment to payment within 45 days of the issuance of the payment certificate.

Delays in issuing certificates by the consultant: Payment process involved different stages as shown in Table 4.1

Table 4.3 Schedule of some payments delays to the Contractor

Interim Payment Application	Delay Duration
04	98 Days
05	114 Days
06	131 Days
07	111 Days

Delays have been experienced throughout the process from the assessment of the contractor's application to the payment phase. The dispute at this point was in relation to the time when the consultant was spending on the evaluation that the contractor considered unreasonable / unfair. However, the contract did not provide for the time frame within which consultant had to assess and issue payment certificates. In accordance with sub- clause 3.5. The consultant shall assess and issue payment certificates "within a reasonable time frame".

On the one hand, the contractor saw the consultant irresponsible for taking an unreasonable long time in discharging his services, the consultant, on the other hand, blamed the contractor for incomplete submissions of documents, exaggerating his claims and thus requiring more time to verify the applications.

Basically, there was a mutual misunderstanding between each other's position on what was a "reasonable period of time" for consultants to evaluate and issue payment certificates, which occurred at a perceived conflict stage. This had been clearly reflected in the addendum to the contract where the mechanism for dealing with delays in the issuance of payment certificates was changed by the introduction of a contractual condition requiring the consultant to check and verify the applications within 30 days. At the same time consultant point out, this addendum contractor should submit all "completed supporting documents" to the payment application.

Change of scope/Design changes: the dispute in this region was between the client / consultant and contractor because designer prepared the drawings at pre-contract stage. During that particular period site conditions are changed due to the adverse weather conditions and further landslides.

Therefore, designer need to do the new drawings according to the new site conditions. These kinds of situations happen in the post-contract stage also. This kind of site changes cannot control both parties and it is considered as act of god. The conflict at this stage was time extension and related claims, are shown in Table 4.4. The data were collected from consultant and contractor EOT documents.

Table 4.4 Schedule of EOT events (C_1)

No	EOT Event	Contractor Requested Days	Consultant Approved Days
01	Excavation and removal of excess materials	9 Days	5 Days
02	Clearing, grubbing	16 Days	11 Days
03	Trimming & preparation of surface	33 Days	22 Days
04	Temporary working platform for additional works	22 Days	15 Days
05	Soil and Rock drilling Work	40 Days	26 Days
06	Nail Heads installation	51 Days	33 Days
07	Pillow Construction	12 Days	10 Days
08	Long Drain	2 Days	2 Days
09	Protection of Protective Net	46 Days	33 Days
10	Adverse Weather Conditions	22 Days	14 Days
11	Holidays during the Extended Period (New Year, Vesak Period)	09 Days	04 Days
12	Omission:-100mm thick shotcreting ,Grid Beams	(66) Days	(66) Days
	Total	**196 Days**	**109 Days**

Tables 4.4 explain the dispute areas (Contractor Requested Days Vs Consultant Approved Days) because contractor prepared the EOT according to the actual site work based calculation. On the other hand, consultant checked the EOT according to the contractor given original master programme, consultant calculates the EOT days for pro-rata basis for each activity. In the meantime, consultant argued that as reputed and experience contractor know to give the suitable/workable master programme. Where the mechanism for dealing with EOT and relates disputes, both parties come to mutual negotiation settlement as given in Table 4.5.

Table 4.5 EOT event mutual negotiation settlement (C_1)

<table>
<tr><th>EOT Event</th><th>Mutual Negotiation Settlement</th></tr>
<tr><td>Clearing, grubbing</td><td rowspan="9">If there are any additional or quantity variation, the contractor shall be submitted notice (as per sub-clause 19.1) to the consultant and maintain the day work sheet for each activity, the contractor need to submit the day work sheet to consultant and get the approvals to every day (as per sub clause 3.5)</td></tr>
<tr><td>Excavation and removal of excess materials</td></tr>
<tr><td>Trimming & preparation of the surface</td></tr>
<tr><td>Temporary working platform for additional works</td></tr>
<tr><td>Soil and Rock drilling Work</td></tr>
<tr><td>Nail Heads installation</td></tr>
<tr><td>Pillow Construction</td></tr>
<tr><td>Long Drain</td></tr>
<tr><td>Protection of Protective Net</td></tr>
</table>

Adverse weather conditions are another issue because when the adverse weather happened works cannot be carried out as the site at least two days due to the high risk of further landslides and site soil conditions.

In this case, the contractor submitted the meteorology department rainfall data, that rainfall data mention Kandy, but the construction site is situated in Peradeniya. According to the daily work progress sheets the rainfall data it is not matching, there for consultant requested to fix a rainfall measurement unit at the site.

Errors and mistakes in design drawings: In this particular area, there was a conflict respect of facilities, which were essential to be designed in certain places, nonetheless which were misplaced in the design and certain were not appropriate for use. For example, the distance between two (02) nails is not suitable for the particular project and another one is soil nailing reinforcement bar it mentions 25mm diameter bar, according to the site condition it must be 32mm diameter. These were some of the mistakes and design errors that were actually found to be in conflict with the contractor's team, the mistakes, and errors that were noted expressly to the contractors' team.

These are the result of limited knowledge, such as handling the design related software for soil nailing, lack of experience and misunderstanding of the necessities of the real or actual site conditions. It was informed to the client, to apply the liquated damages for the contractor culpable delays also design and build construction is not suitable because correction of errors and mistakes in the design drawings to take further time period to correct the drawings to consultant, meaning that the time factor is very important to this kind of projects. These are landslide mitigation projects, therefore, the government is highly responsible for any damages to physical or property. However, the consultant is re-doing the construction drawings/correction drawings to finish the project as soon as possible.

Delay in progress due to the payment of sub-contractors by the main contractor: the subcontractors were fully engaged in various types of work. They had separate contracts with the contractor; the contractor and his subcontractors had a conflict over payments in this area. It was informed that, contrary to their agreements, the contractor did not pay his subcontractors in time. The sub-contractors usually in retaliation used to stage a "go slow" at work that affected the progress of the work.

4.3.1.2 Within case analysis (Case Study-C2)

Both the interviews are agreed to the following four (04) kinds of disputes availability, for example; delays in issuing certificates by the consultant, poor communication, change of scope/design changes, delay in progress due to the payment of nominated sub-contractors by the main contractor and inadiquence of drilling machines. Also they have agreed on the methods of resolutions for the disputes.

Delays in the issuing certificates by consultant: As discussed in sub- section 4.3.1.1, the cause was resolved similarly to the case study one (C1). The addendum to the contract where the new mechanism for coping with delays in the issuance of payment certificates has been changed by introducing a contractual condition requiring the consultant to actually check and verify the application within 28 days.

Poor communication: Dispute in this section or area was experienced in respect of instructions between the contractor and the consultant. The contractor notified that several instructions have been issued verbally of the contractual requirements, that required all written instructions to be issued and should be confirmed in writing within seven (07) days, as provided for in the contract when issued verbally. It has been informed that verbal instructions caused issues in evaluating the work carried out or done. For instance, consultant gave the instruction to chemical blast and to remove the rock at the site. When the contractor claim the variation then consultant refused to pay the full amount because consultant mention we gave the instruction to remove two number of rocks but contractor removed five number of rocks.

Even though there was no written document to be referred to, it was difficult to determine what was the correct message conveyed through the verbal instruction. The reason for the conflict was because, as provided for in the contract, the communication process for issuing instructions has not been followed.

This was apparently regarded as an act of duty of care or negligence for the reason that the consultant was fully aware of the protocol of issuing orders or instructions to the contractor. But however, the dispute was solved in favor of the contractor after taking into consideration the contractual provisions requiring the consultant to issue written instructions or verbal instruction in writing within seven (07) days, which the consultant did not carry out.

Delay in progress mainly due to the payment by the main contractor of nominated subcontractors and inadequacy of drilling machines: The dispute was in the payment process between the main contractor and his subcontractors because of poor communication between the principal contractor and his subcontractors. Interviews have noticed that, sometimes the main contractor did not pay his nominated subcontractors within a reasonable time period, especially when partial payments have been paid. The subcontractors notified that they were looking for a conversation with the main contractor to solve the issue, the contractor was resolute until the client was asked to pay them directly.

However, the application was not fulfilled because the client did not make any payment without a contract (there was no contract between the client and the subcontractors) in accordance with the condition of the contract. For the good faith consultant instructed to the main contractor to pay the sub-contractor for the reasonable time period. However, the subcontractors were entitled or had juridical rights to enforce the contractor's payments, but they apparently did not want to exercise it, as their good business relationship and harmony with the main contractor would have been spoiled.

Inadequate of drilling machines is another cause for the delay of the progress because when a drill machine was broken all works are idle that particular time period, there are is no any alternative method to do the work.

Change of scope/Design changes: The cause resolved similarly to case study one (C_1) as discussed in Sub-section 4.3.1.1, the conflict at this stage was time extension and related claims, Table 4.6 mention the dispute area, the data were collected from consultant and contractor EOT documents.

Table 4.6 Schedule of EOT events (C_2)

No	EOT Event	Contractor Requested Days	Consultant Approved Days
01	Delay occurred wildlife approvals	71 Days	38 Days
02	Clearing, grubbing and removing trees	04 Days	04 Days
03	Excavation & removal of excess material	08 Days	07 Days
04	Soil and Rock drilling Work	08 Days	08 Days
05	Shotcreate works	75 Days	53 Days
06	Pillow Construction	26 Days	12 Days
07	Horizontal PVC drains	09 Days	07 Days
08	Adverse Weather Conditions	31 Days	22 Days
09	Holidays during the Extended Period	09 Days	04 Days
10	Omission:- Grid Beams	(70) Days	(70) Days
	Total	**171 Days**	**85 Days**

Delay occurred in waiting for wildlife approvals while carry out the construction work contractor had to face some difficulties until receiving the approval from the wildlife. There was no possibility to meet contractor requirements on scheduled considering all the facts; this is the critical situation for this project. However, consultant mention that during that particular period contractor did some other works on the site, therefore, the contractor is only entitled for 38 days as the Extension Of Time (EOT). EOT calculations are resolved similarly to case study one (C_1) as discussed in Sub-section 4.3.1.1.

Table 4.7 EOT event mutual negotiation settlement (C_2)

EOT Event	Mutual Negotiation Settlement
Clearing, grubbing and removing trees	If there are any additional or quantity variation, the contractor shall be submitted notice (as per sub clause 20.1) to the consultant and maintain the day work sheet for each activity, the contractor need to submit the day work sheet to consultant and get the approvals to every day (as per sub clause 3.5)
Excavation & removal of excess material	
Soil and Rock drilling Work	
Shotcreate works	
Soil and Rock drilling Work	
Pillow Construction	
Horizontal PVC drains	

Adverse weather conditions are resolved similarly to case study one (C_1) as discussed in Sub-section 4.3.1.1.

4.3.1.3 Within case analysis (Case Study-C3)

Both the interviews explained of the following four (04) kinds of disputes; delays in issuing certificates by the consultant, poor communication, change of scope/design changes, delay in progress due to the payment by the main contractor of nominated subcontractors and inadiquence of drilling machines. Also they have agreed the methods of resolutions for the disputes.

Delays in issuing certificates by the consultant:

By submitting an application for a payment certificate to the consultant, the consultant will evaluate the application and issue a payment certificate to the contractor and the original submitted to the client for payment. However, before payments were made, the technical team of the client re-examined the certificates submitted. It was notified that the certificate was returned to the consultant for correction or adjustment in the event of any error or doubt found in the valuation certificate. This mechanism formed a double-verification system of payment certificates to ensure that certified payments are correct, even though on the other hand, in the payment process, it caused more bureaucracy, leading to delays in payments.

This was reflected in the mutual agreement between the three (03) parties where the mechanism for dealing with delays in issuing certificates of payments the consultant need to check and verify the applications within 28 days. In the same time client's technical team check and verify the certificate within 14 days.

Poor communication: The cause resolved similarly to case study two (C2) as discussed in Sub-section 4.3.1.2. For instance, consultant gave the instruction to removes the tree at the site. When the contractor claim the variation then consultant refuse to pay the full amount because consultant gave the instruction to remove one (01) tree but contractor removed two (02) trees.

In the meantime, forest department was ready to take the legal action against the contractor because the contractor cut and removed trees without getting proper approvals. In this case, consult also answerable for this incident. The reason for the dispute was the non-adherence with the communication procedure for issuing instructions in accordance with the contract. This was apparently considered an act of negligence, since the consultant was fully aware of the protocol for issuing instructions to the contractor. Also the consultant mentioned that, if there are any verbal instructions given by consultant then the contractor can request for the confirmation latter/document of verbal instruction. However, the conflict was resolved by using ADR first method negation with forest department then the contractor is agreed to claim the payment for one tree removing work.

Delay in progress due to the main contractor's payment of sub- contractors and insufficient drilling machines:

The main-contractor engaged subcontractors to carry out various types of work. They had completely separate agreements or contracts with the contractor; the contractor and his subcontractors had a dispute over payments in this area. It was notified that, completely contrary to their contract agreements, the main contractor did not pay his sub-contractors in particular time period.

The sub-contractors usually in retaliation used to stage a “go slow” at work affected the work progress. The client had to intervene, using his "dominant” position in the project, and it was informed that rules were introduced outside the formal contract, which compelled the contractor to pay its subcontractors. However, one of the rules and regulations was to report all payments made to the contractor at each site meeting the subcontractors were required to report if they received their payments from the contractor or did not receive them.

When asked by the subcontractors why they did not take legal action against the contractor, their answer was that they obviously did not really want to spoil their business relationship with the contractor because in the future they expected more jobs from the same contractor. Inadequate drilling machines issues were resolved similarly to the case study two (C2).

Change of scope / Design changes: The dispute was resolved similarly to case study one and case study two (C1, C2) as discussed in Sub-section 4.3.1.1 and Sub-section 4.3.1. The conflict at this stage different from the previous cases was the time extension and related claims. Table 4.8 presents the dispute related data which were collected from consultant and contractor EOT documents.

Table 4.8 Schedule of EOT events (C3)

No	EOT Event	Contractor Requested Days	Consultant Approved Days
01	Clearing, grubbing and removing trees	08 Days	05 Days
02	Excavation & removal of excess material	12 Days	08 Days
03	Soil and Rock drilling Work	30 Days	24 Days
04	Shotcreate works	15 Days	12 Days
05	Horizontal PVC drains	03 Days	02 Days
06	Adverse Weather Conditions	13 Days	10 Days
07	Holidays during the Extended Period (New Year, Vesak Period)	07 Days	03 Days
	Total	**88 Days**	**64 Days**

EOT calculations were resolved similarly to case study one and two (C_1, C_2) as discussed in Sub-sections 4.3.1.1 and 4.3.1.2.

Table 4.9 EOT event mutual negotiation settlement (C3)

EOT Event	Mutual Negotiation Settlement
Clearing, grubbing and removing trees	If there are any additional or quantity variation, the contractor shall be submitted notice (as per sub-clause 20.1) to the consultant and maintain the day work-sheet for each activity, the contractor need to submit the day work-sheet to consultant and get the approvals to every day (as per sub clause 3.5)
Excavation & removal of excess material	
Soil and Rock drilling Work	
Shotcreate works	
Horizontal PVC drains	

Adverse weather conditions are resolved similarly to case study one and two (C_1, C_2, C_3) as discussed in Sub-section 4.3.1.1 and 4.3.1.2.

4.3.1.4 Within case analysis (Case Study-C_4)

Both the interviews revealed five (05) kinds of disputes such as delays in issuing certificates by the consultant, poor communication, change of scope/design changes, delay in progress due to the payment of nominated sub-contractors by the main contractor, and inadiquence of drilling machines. Also they have agreed the methods of resolutions for the disputes.

Delays in issuing certificates by the consultant: The dispute has been resolved similarly to case study two (C_2) as discussed in Sub-section 4.3.1.2

Poor communication: The dispute was resolved similarly to case study one and two (C_1, C_2) as discussed in Sub-section 4.3.1.1 and Sub-section 4.3.1.2. For instance, consultant gave the instruction to do additional area shotcrete work at the site. When the contractor claimed the variation the consultant refused to pay the full amount because the consultant gave the instruction to do the shotcrete work for a particular area but the contractor did additional area shotcrete work. The dispute was resolved similarly to case study two (C_2).

Delay in progress due to the late payment of sub-contractor work by the main contractor and Inadequate drilling machines: The disputes were resolved similarly to case study three (C_3) as discussed in Sub-section 4.3.1.3. Inadequate drilling machines related issues are resolved similar to case studies one, two and three (C_1, C_2, C_3) as discussed in Sub-section 4.3.1.1, 4.3.1.2, and 4.3.1.3.

Change of scope / Design changes: The disputes were resolved similarly to case studies one, two, and three (C_1, C_2, C_3) as discussed in Sub-section 4.3.1.1, 4.3.1.2, and 4.3.1.3. The conflict at this stage different to the previous scenarios was time extension and related claims. Table 4.10 presents the disputed areas. Data were collected from consultant and contractor EOT documents.

Table 4.10 Schedule of EOT events (C_4)

No	EOT Event	Contractor Requested Days	Consultant Approved Days
01	Clearing, grubbing and removing trees	08 Days	07 Days
02	Excavation & removal of excess material	25 Days	21 Days
03	Soil and Rock drilling Work	12 Days	10 Days
04	Authority approvals (Hakgala Gardens)	27 Days	27 Days
05	Adverse Weather Conditions	13 Days	10 Days
	Total	**85 Days**	**75 Days**

EOT calculations were resolved similarly to case studies one, two, and three (C_1, C_2, C_3) as discussed in Sub-section 4.3.1.1, 4.3.1.2, and 4.3.1.3. The authority approvals for hydro seeding materials is the main delay event in this project, because gardans authority board are not recommending normal hydro seeding materials due to forming of bacterias which will affect to the gardens plants, construction parties waiting for gardens authority board approvals for hydroseeding materials.

The both parties come to mutual negotiation settlement as given in Table 4.11

Table 4.11 EOT event mutual negotiation settlement (C_4)

EOT Event	Mutual Negotiation Settlement
Clearing, grubbing and removing trees	If there are any additional or quantity variation, the contractor shall be submitted notice (as per sub-clause 20.1) to the consultant and maintain the day work-sheet for each activity, the contractor need to submit the day work-sheet to consultant and get the approvals to every day (as per sub clause 3.5)
Excavation & removal of excess material	
Soil and Rock drilling Work	

Adverse weather conditions related disputes were resolved similarly to case studies one, two and three (C_1, C_2, C_3) as discussed in Sub-section 4.3.1.1, 4.3.1.2, and 4.3.1.3.

4.3.2 Cross case analysis

And in this segment, in fact the theoretical context of case studies actually presented, areas / problems in which conflict has occurred, causes of conflict, how conflicts arose and how they were handled and managed. Case studies are reinterpreted to determine whether there have been conflicts, in each case, their causes and management can be linked to other cases.

Conflicts in Change of scope/Design changes (EOT Conflicts)

There was conflict in this area respect of changes in scope which were in conflict with the extension of time. In this kind of cause, the client has not any issues to pay the variations and additional works because client allocated little bit more contingencies for this types of constructions. In these types of particular soil nailing construction, scope changes are nature which cannot be avoided.

These changes of scope are conflicts related to the extension of time, because contractor's EOT claims are unreasonable /unfair. This was found in all four (04) case studies. Such conflicts were resolved by maintaining the day worksheet for each activity, the contractor needs to submit day worksheet to consultant and get the approvals to every day.

Conflict in the issuing of consultant's payment certificates to contractors

These disputes are directly related to the time taken by the consultants to evaluate the contractors ' claims, which were considered too long by the contractors. In all four (04) research case studies, this was found. The causes of the dispute in all projects were found to be the maintenance of the consultants ' tendency, insufficient billing supporting documents and exaggerated contractors ' claims demanding additional time for consultants to evaluate, and the There are no contractual mechanisms to implement the timely evaluation and issuing of certificates. By improvement of communication between the consultant and the contractor, these conflicts were resolved.

This can be clarified by the actual fact, if there is no contractual enforcement mechanism to the issuance of the certificate in due time, the time remains at the consultant's discretion so that such conflict can be avoided if both parties are effective.

The conflict between delays in payments by the client to the contractor

Dispute or conflict was obviously due to the client's failure to pay the contractor within the contractual set time period. In case study one, it has been experienced which is procured as a D&B project. The major reason of delay in payment delays were lack of funds from the client. The tactic used to resolution the dispute was to provide a contractual condition requiring the customer to pay the interest of the contractor on the amount due for payment during the delayed period. This was not effective in this case, however, since the key problem was the lack of funds.

Delay in payment of sub-contractors by main contractors

In all four (04) projects, disputes in this area have been experienced. They were caused by the main contractors ' tendency to dominate their subcontractors. But even so, the subcontractors always had rights and privileges against the contractors they did not practice it, to maintain a good working relationship with their contractors. Yet, such dispute was different in case one project which was procured under D&B. In there the dispute remain unsolved. In case two project, consultant instructed to the main contractor to pay the sub-contractor for the reasonable time period. In the case three and four projects client use his "dominant" the position of the project, it was necessary to intervene.

This was notified, somehow rules were finally introduced outside the formal contract compelled the contractor to pay his subcontractor. However, one of the rules was to report all payments made to the contractor at each site meeting and subcontractors were required to report if they received their payments from the contractor or did not receive them.

Poor communication

There has been a dispute between the consultant and the contractor in this area, in case studies two, three and four projects due to non-adherence of communication procedure set in contract.

Errors or mistakes in the design

In case one project, which is procured under D&B method, in some places, the facilities had to be designed, but the design was missing and some were not suitable for use. These were caused by limited knowledge such as handling the design related software for soil nailing, lack of knowledge, experience and misunderstanding of the necessities of the actual site conditions by the main contractor. Such disputes have not been experienced in other traditionally procured case studies.

Table 4.12 indicates that, selected case study conflict's area. (summary of cross case analysis)

Table 4.12 Summary of cross case analysis

Item No	*Description of conflict's area*	*Case Study-01 (D&B)*	*Case Study-02 (TR)*	*Case Study-03 (TR)*	*Case Study-04 (TR)*
1.0	Conflict in delays of payments	√	-	-	-
2.0	Delays in issuing certificates by the consultant	√	√	√	√
3.0	Change of scope/Design changes (EOT)				
	- Soil and Rock drilling Work	√	√	√	√
	- Excavation and removal of excess materials	√	√	√	√
	- Adverse Weather Conditions	√	√	√	√
	- Trimming & preparation of surface	√	-	-	-
	- Shotcreate works	-	√	√	-
	- Nail Heads installation	√	-	-	-
	- Pillow Construction	√	√	-	-
	- Protection of Protective Net	√	-	-	-
	- Clearing, grubbing	√	√	√	√
	- Long Drain/Horizontal PVC drains	√	√	√	-
	- Temporary working platform for additional works	√	-	-	-
	- Delay occurred wildlife/authority approvals	-	√	-	√
4.0	Errors and mistakes in the design drawings	√	-	-	-
5.0	Delay in progress due to the payment of sub-contractors by the main contractor	√	√	√	√
6.0	Poor communication	-	√	√	√

According to the cross case analysis most common conflicts are delays in issuing certificates by the consultant, change of scope/design changes (EOT) and delay in progress due to the payment of sub-contractors by the main contractor.

The above results reveal and outline the nature of disputes in ERS construction in Sri Lanka. The major areas of disputes, their causes, the intensity of disputes at different stages of project life and the members of a project team among which conflicts do occur and various dispute resolution approaches were mapped and summarized.

Courses behind the causes are summarized and given in table 4.13 and 4.14.

Table 4.13 Summary of empirical investigation from questionnaire survey for Design and Build Method

Area of Conflict	*Causes of conflicts*
Design Errors	Cheap design hired instead of quality
	Inadequate brief
	In-experience of designer
	Incompetent designer
	Mis-interpretation of client's requirements
	Wrong design data
Change of scope/Design changes : Extension of Time	Soil and Rock drilling Work
	Excavation and removal of excess materials
	Adverse Weather Conditions
	Trimming & preparation of surface
	Nail Heads installation
	Pillow Construction
	Protection of Protective Net
	Clearing, grubbing
	Long Drain
	Temporary working platform for additional works
Change of scope/Design changes : Excessive Variations	Change in scope of work due to site conditions
	Errors in specifications
	Errors in bills of quantities
Delays in : Payments	Poor financial projection by main contractor-sub Contractor
	Inadequate supporting documents for payment applications
	Delay in the evaluation process
	Excessive claims made by the contractor
	Inadequate contract provisions for timely payments
Poor Communication	Poor feedback
	Negligence
	Non-adherence of communication procedures set
	Ineffective means of communication
	Lack of communication procedures
	Deliberate blockage of information flow

Table 4.14 Summary of empirical investigation from questionnaire survey for Traditional Procurement Method

Area of Conflict	*Causes of conflicts*
Change of scope/Design changes : Extension of Time	Soil and Rock drilling Work
	Excavation and removal of excess materials
	Adverse Weather Conditions
	Trimming & preparation of surface
	Shotcreate works
	Nail Heads installation
	Pillow Construction
	Protection of Protective Net
	Clearing, grubbing
	Long Drain
	Temporary working platform for additional works
Change of scope/Design changes : Excessive Variations	Change in scope of work due to site conditions
	Errors in specifications
	Errors in bills of quantities
Delays in : Payments	Poor financial projection by main contractor-sub Contractor
	Inadequate supporting documents for payment applications
	Delay in the evaluation process
	Excessive claims made by the contractor
	Inadequate contract provisions for timely payments
Poor Communication	Poor feedback
	Negligence
	Non-adherence of communication procedures set
	Ineffective means of communication
	Lack of communication procedures
	Deliberate blockage of information flow

4.3.3 Provisions for condition of contract to handling the disputes

FIDIC (1999-Yellow Book and 1999-Red Book) conditions of contract used for the D&B(C1) and traditionally procured (C2,C3,andC4) contracts. Table 4.15 separately explain the contractor and employer's legal entitlement. Most commonly used clauses are 1.9, 2.5, 4.12, 7.6, 8.4, 8.5, 8.6, 8.7, 13.3, 14.4, 14.8, and 20.1. Farther more following conditions are available as discussed hereon.

CASE STUDY-01 (C_1)

This project is procured as a design and build project. Both the interviewees agreed on that the following provisions are available for handle the disputes.

Table 4.15 Provisions for condition of contract (C_1-DB Project)

Sub-Clause	Contractor's Entitlement	Employer's Entitlement
1.9 Errors in the Employer's Requirements	Contractor may claim an extension of time, Cost and a reasonable profit for error in Employer's Requirements which was not previously discoverable	
2.1 Right of Access to the Site	Contractor may an claim extension of time, Cost and reasonable profit if Employer fails to give right of access to Site within the time stated in the Contract	
2.5 Employer's Claims		The procedure with which Employer must comply when claiming payment from the Contractor and when claiming an extension to the Defects Notification Period
4.7 Setting Out	Contractor May claim an extension of time, Cost and a reasonable profit for errors in original setting-out points and levels of reference	
4.12 Unforeseeable Physical Conditions	Contractor may claim an extension of time and Cost if he encounters physical conditions which are Unforeseeable	
4.19 Electricity, Water and Gas		Employer entitled to payment if Contractor uses power, water or other services provided by the Employer, if any, without prior notice under Sub- Clause 2.5

4.20 Employer's Equipment and Free-Issue Material		Employer entitled to payment if Contractor uses the Employer's Equipment, if any, without prior notice under Sub- Clause 2.5
4.24 Fossils	Contractor may claim an extension of time and Cost attributable to an instruction to Contractor to deal with an encountered archeological finding	
7.4 Testing	Contractor may claim an extension of time, Cost and reasonable profit if testing is delayed by (or on behalf of) the Employer	
7.5 Rejection		Employer may claim costs if defective Plant, Materials or workmanship is rejected and subsequently retested
7.6 Remedial Work		Employer may claim costs if Contractor fails to carry out remedial work and if he would not have been entitled to be paid for it
8.4 Extension of Time for Completion	Extension of Time for Contractor may claim extension of time if completion (see Sub-Clauses 8.2 & 10. 1) is or will be delayed by a listed cause	
8.5 Delays Caused by Authorities	Contractor may claim an extension of time if Country's public authority causes Unforeseeable delay	
8.6 Rate of Progress		Employer may claim costs attributable to revised methods which Contractor adopts in order to overcome a delay for which no extension of time is due
8.7 Delay Damages		Employer may claim prescribed delay damages if Contractor fails to achieve completion within Time for Completion
8.9 Consequences of Suspension	Contractor may claim an extension of time and Cost if Engineer instructs a suspension of progress	
9.4 Failure to Pass Tests on Completion		Employer may claim costs if Works or Section repeatedly fails Test on Completion
10.2 Taking Over of Parts of the Works	Contractor may claim Cost and reasonable profit attributable to the taking over of a part of the Work	Employer's entitlement to prescribed delay damages is reduced by a proportion related to the contract value of the part taken over

10.3 Interference with tests of Completion	Contractor may claim an extension of time, Cost and reasonable profit if Employer delays a Test on Completion	
11.3 Extension of Defects Notification Period		Employer may claim an extension of the Defects Notification Period if Works or Section or major Plant cannot be used for intended purpose because of any defect
11.4 Failure to Remedy Defects		Employer may claim costs if Contractor fails to remedy a defect for which Contractor is responsible
11.8 Contractor to Search	Contractor may claim Cost and reasonable profit if instructed to search for the cause of a defect for which he is not responsible	
12.2 Delayed Tests	Contractor may claim Cost and reasonable profit if Employer delays a Test after Completion	
12.3 Retesting		Employer may claim costs attributable to repeated failures of Test after Completion
12.4 Failure to Pass Tests after Completion	Contractor may claim Cost and reasonable profit if Employer delays access to the Works or Plant	Employer may claim prescribed non-performance damages in event of failure to pass Test after Completion
13.2 Value Engineering	Contractor may claim half of the saving in contract value of his redesigned post-contract alternative proposal, which was approved without the prior agreement of such contract value and of how saving would be shared	
13.3 Variation Procedure	The Contract Price shall be adjusted as a result of Variations	
13.7 Adjustments for changes in Legislation	Contractor may claim an extension of time and Cost attributable to a change in the Laws of the Country	Employer may claim payment of reduction in Contractor's Cost attributable to a change in the Laws of the Country
14.4 Schedule of Payments	If interim payment installments were not defined by reference to actual progress and actual progress is less than that on which the schedule of payments was originally based, these installments may be revised	
15.3 Valuation at Date of Termination		Works, Goods and Contractor's Documents are valued after Employer has terminated Contract

15.4 Payment after Termination		Employer may claim losses and damages after terminating Contract
16.1 Contractor's Entitlement to Suspend Work	Contractor may claim an extension of time, Cost and reasonable profit if Engineer fails to certify or if Employer fails to pay amount certified or fails to evidence his financial arrangements, and Contractor suspends work	
16.4 Payment on Termination	Contractor may claim losses and damages after terminating Contract	
17.1 Indemnities	Contractor may claim cost attributable to a matter against which he is indemnified by Employer	Employer may claim cost attributable to a matter against which he is indemnified by Contractor
17.4 Consequences of Employer's Risks	Contractor may claim an extension of time, Cost and (in some cases) reasonable profit if Works, Goods or Contractor's Documents are damaged by an Employer's risk as listed in Sub- Clause 17.3	
18.1 General Requirements for Insurances	Contractor may claim the cost of premiums if Employer fails to effect insurance for which he is the "Insuring Party"	Employer may claim cost of premiums if Contractor fails to effect insurance for which he is the "Insuring Party"
18.2 Insurance for Works and Contractor's Equipment (last paragraph)		Employer may claim payment of reduction in the cost of premiums if the Contractor's insurance of an Employer's risk becomes unavailable at commercially reasonable terms
19.4 Consequences of Force Majeure	Contractor may claim extension of time and (in some cases) Cost if Force Majeure prevents him from performing obligations	
19.6 Optional Payment, Termination and Release	Contractor work and other Costs are valued after progress is prevented by a prolonged period of Force Majeure and either Party then gives notice of termination.	
20.1 Contractor's Claim	The procedure with which the Contractor must comply when claiming an extension of time and/or additional payment.	

Table 4.15 presents provisions, which are available for contractor and employer. These are the key conditions in the contract and with the terms it is very easy to handle the disputes.

CASE STUDY-02, 03, 04 (C_2, C_3, C_4)

These projects are procures under traditional method. The interviewees are agreed on that the following provisions are available for handle the disputes.

Table 4.16 Provisions for the condition of contract

(C_2, C_3, C_4 – Traditional Method)

Sub-Clause	Contractor's Entitlement	Employer's Entitlement
1.9 Delayed Drawings or Instructions	Contractor may claim an extension of time, Cost and reasonable profit if Engineer fails to instruct within notified reasonable time	
1.9 Errors in the Employer's Requirements	Contractor may claim an extension of time, Cost and a reasonable profit for error in Employer's Requirements which was not previously discoverable	
2.1 Right of Access to the Site	Contractor may claim an extension of time, Cost and reasonable profit if Employer fails to give right of access to Site within the time stated in the Contract	
2.5 Employer's Claims		The procedure with which Employer must comply when claiming payment from the Contractor and when claiming an extension to the Defects Notification Period
4.7 Setting Out	Contractor May claim extension of time, Cost and a reasonable profit for errors in original setting-out points and levels of reference	
4.12 Unforeseeable Physical Conditions	Contractor may claim an extension of time and Cost if he encounters physical conditions which are Unforeseeable	
4.19 Electricity, Water and Gas		Employer entitled to payment if Contractor uses power, water or other services provided by the Employer, if any, without prior notice under Sub- Clause 2.5
4.20 Employer's Equipment and Free-Issue Material		Employer entitled to payment if Contractor uses the Employer's Equipment, if any, without prior notice under Sub- Clause 2.5

4.24 Fossils	Contractor may claim an extension of time and Cost attributable to an instruction to Contractor to deal with an encountered archeological finding	
7.4 Testing	Contractor may claim an extension of time, Cost and reasonable profit if testing is delayed by (or on behalf of) the Employer	
7.5 Rejection		Employer may claim costs if defective Plant, Materials or workmanship is rejected and subsequently retested
7.6 Remedial Work		Employer may claim costs if Contractor fails to carry out remedial work and if he would not have been entitled to be paid for it
8.4 Extension of Time for Completion	Extension of Time for Contractor may claim an extension of time if completion (see Sub-Clauses 8.2 & 10. 1) is or will be delayed by a listed cause	
8.5 Delays Caused by Authorities	Contractor may claim extension of time if Country's public authority causes Unforeseeable delay	
8.6 Rate of Progress		Employer may claim costs attributable to revised methods which Contractor adopts in order to overcome a delay for which no extension of time is due
8.7 Delay Damages		Employer may claim prescribed delay damages if Contractor fails to achieve completion within Time for Completion
8.9 Consequences of Suspension	Contractor may claim an extension of time and Cost if Engineer instructs a suspension of progress	
9.4 Failure to Pass Tests on Completion		Employer may claim costs if Works or Section repeatedly fails Test on Completion
10.2 Taking Over of Parts of the Works	Contractor may claim Cost and reasonable profit attributable to the taking over of a part of the Work	Employer's entitlement to prescribed delay damages is reduced by a proportion related to the contract value of the part taken over
10.3 Interference with tests of Completion	Contractor may claim extension of time, Cost and reasonable profit if Employer delays a Test on Completion	

11.3 Extension of Defects Notification Period		Employer may claim extension of the Defects Notification Period if Works or Section or major Plant cannot be used for intended purpose because of any defect
11.4 Failure to Remedy Defects		Employer may claim costs if Contractor fails to remedy a defect for which Contractor is responsible
11.8 Contractor to Search	Contractor may claim Cost and reasonable profit if instructed to search for the cause of a defect for which he is not responsible	
12.2 Delayed Tests	Contractor may claim Cost and reasonable profit if Employer delays a Test after Completion	
12.3 Evaluation	Engineer evaluates each item of work, applying measurement and appropriate rate or price	
12.3 Retesting		Employer may claim costs attributable to repeated failures of Test after Completion
12.4 Omissions	Contractor may claim a Cost which, although it had been included in a BoQ item, he would not recover because the item was for work which has been omitted by Variation	
12.4 Failure to Pass Tests after Completion	Contractor may claim Cost and reasonable profit if Employer delays access to the Works or Plant	Employer may claim prescribed non-performance damages in event of failure to pass Test after Completion
13.2 CONS Value Engineering	Contractor may claim half of the saving in contract value of his redesigned post-contract alternative proposal, which was approved without the prior agreement of such contract value and of how saving would be shared	
13.3 Variation Procedure	The Contract Price shall be adjusted as a result of Variations	
13.7 Adjustments for changes in Legislation	Contractor may claim an extension of time and Cost attributable to a change in the Laws of the Country	Employer may claim payment of reduction in Contractor's Cost attributable to a change in the Laws of the Country
14.4 Schedule of Payments	If interim payment installments were not defined by reference to actual progress and actual progress is less than that on which the schedule of payments was originally based, these installments may be revised	

14.8 Delayed Payment	Contractor may claim financing charges if he does not receive payment in accordance with Sub-Clause 14.7	
15.3 Valuation at Date of Termination		Works, Goods and Contractor's Documents are valued after Employer has terminated Contract
15.4 Payment after Termination		Employer may claim losses and damages after terminating Contract
16.1 Contractor's Entitlement to Suspend Work	Contractor may claim an extension of time, Cost and reasonable profit if Engineer fails to certify or if Employer fails to pay amount certified or fails to evidence his financial arrangements, and Contractor suspends work	
16.4 Payment on Termination	Contractor may claim losses and damages after terminating Contract	
17.1 Indemnities	Contractor may claim cost attributable to a matter against which he is indemnified by Employer	Employer may claim cost attributable to a matter against which he is indemnified by Contractor
17.4 Consequences of Employer's Risks	Contractor may claim an extension of time, Cost and (in some cases) reasonable profit if Works, Goods or Contractor's Documents are damaged by an Employer's risk as listed in Sub- Clause 17.3	
18.1 General Requirements for Insurances	Contractor may claim the cost of premiums if Employer fails to effect insurance for which he is the "Insuring Party"	Employer may claim the cost of premiums if Contractor fails to effect insurance for which he is the "Insuring Party"
18.2 Insurance for Works and Contractor's Equipment (last paragraph)		Employer may claim payment of reduction in the cost of premiums if the Contractor's insurance of an Employer's risk becomes unavailable at commercially reasonable terms
19.4 Consequences of Force Majeure	Contractor may claim extension of time and (in some cases) Cost if Force Majeure prevents him from performing obligations	
19.6 Optional Payment, Termination and Release	Contractor work and other Costs are valued after progress is prevented by a prolonged period of Force Majeure and either Party then gives notice of termination.	
20.1 Contractor's Claim	The procedure with which the Contractor must comply when claiming an extension of time and/or additional payment.	

Table 4.16 mentions the provisions which are available for contractor and employer. These are the key conditions in the contract and it is very easy to handle the disputes, similar to the case study one (C_3, C_4).

4.3.3.1 Disputes and resolution methods

According to the four (04) case studies, table 4.17 explains the dispute and resolution methods for each case.

Table 4.17 Disputes and resolution methods

Disputes	Case Study				Resolution Method	Condition of Contract for Constrction	
	C1	C2	C3	C4		FIDC - Yellow Book (C1)	FIDC - Red Book (C2,C3,C4)
Conflict in delays of payments	√	√	√	√	ADR-Negotiation	Sub-Clause : 20, 14.4, 8.4	Sub-Clause : 20, 14.5, 14.8, 8.4
Delays in issuing certificates by the consultant	√	√	√	√	ADR-Negotiation	Sub-Clause : 20, 14.4, 8.5	Sub-Clause : 20, 14.5, 14.8, 8.5
Change of scope/Design changes (EOT)	√	√	√	√	ADR-Negotiation	Sub-Clause : 20.1, 13.3, 8.4	Sub-Clause : 20.1, 13.3, 8.4
Errors and mistakes in the design drawings	√	-	-	-	ADR-Negotiation	Sub-Clause : 2.5, 8.6, 8.7	-
Delay in progress due to the payment of sub-contractors by the main contractor	√	√	√	√	ADR-Negotiation	Sub-Clause : 20, 2.5, 8.6, 8.7	Sub-Clause : 20, 2.5, 8.6, 8.7
Poor Communication	-	√	√	√	ADR-Negotiation	-	Sub-Clause : 20.1 or 8.7

According to the Table 4.17 all construction conflicts are resolved by ADR-Negotiation method using the Conditions of Contract.

4.4 Discussion

The purpose of this section is to collate the research findings and to respond to the research questions of the study. The data presented in this chapter have been solely and fully taken from the research interviews. Existing theories are related to research topic were used here to support the research findings, to strengthen the research discussion. This section consists of the discussion of the results obtained from the analysis, mainly discussion based on the topics, an analysis of disputes related to earth retaining structure construction projects in Sri Lanka. The outcomes of the research show that the origin and acceptance of disputes vary during the life cycle of construction. However, that is the case most disputes, due to scope changes/design changes are root causes, appear to originate in the construction process.

The soil nailing failures such as internal, external and mixed failures become dispute to the project. According to the authors (FHWA, 2003), Byrne (1998), (Carlos et al., 2015), (Kumarasawamy, 1997), (Ren et al., 2001), Diekmann & Girard (1995), and (Lowe & Leiringer, 2006), the review of the literature explain the soil nailing failures but still there were no failures, still, there were disputes, which is different to the theory. According to the theory, these kinds of disputes still can arise without event having failures. From the research finding, it was found that the common disputes in soil nailing projects. On the basis of findings of this study, the frequency of one type of dispute to another is not much different. Nevertheless, the ranking of various types of conflicts varies.

According to Kumarasawamy, dispute factors include such as access to the site, site conditions, approvals, administration and negligence. In the collected sample, possible factors such as interpretation of the contract, EOT claims, changes in scope and quality of the design, payment, budget, time and delay are the top frequency factors in practice.

According Henderson, Arditi and Patel and Betant et al, this study shows that during the implementation of the project, problems are identified and resolved. This should be interpreted as a clear indicator that the identification of potential disputes can be improved and conflict drivers previously in the project's life cycle in order to significantly reduce the loss of time and costs during the project's production. Using the correct procurement approach and condition of contract really be able to improve construction contracts and it is help to manage dispute - related issues. As this study indicates, interpretation of the contract, EOT claims, changes in scope and quality of the design, payment, budget, time and delay easily managed by the condition of contract (FIDC, ICTAD) also the first method of ADR. Nevertheless, if there were no provisions in the contract or if the provisions of the contract were contrary to the interests of the contracting parties, negotiations were mostly used to find a satisfactory solution for the major conflicting parties.

According to the literature it was stated that D&B procurement method is the most suitable method for soil nailing. However, according to the research findings, traditional procurement method used more option to resolving the disputes, because of the main reason is contractor do not have well-experienced design professionals and advanced software for the soil nailing works. By selecting the best and suitable procurement method, it can reduce disputes in terms of function and durability.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

This study has dealt with an analysis of disputes related to earth retaining structure construction projects and special attention on soil nailing technique. This section summarizes the entire thesis by drawing together the various factors contributing to the literature review's disputes and extracted from the interviews, concluding the study.

5.1 Conclusions

The overall aim of the research was to investigate the nature of disputes resolution in Earth Retaining Structure (ERS) constructions with special attention on soil nailing technique. In order to achieve the aim, four (04) research questions were formulated based on the objectives of the research and treated during this study as shown in chapter one (01). In three (04) sections below the answers to the research questions are presented and discussed. The discussion is based on the respondents' opinions and the researcher's reflections.

5.1.1 ERS Construction and applications

The Earth Retaining Structures (ERS) is a structure designed and constructed to resist the lateral pressure of soil and rock, when there is a desired change in ground elevation that exceeds the angle of repose of the soil. ERS can be classified according to their face inclination such as retaining gravity, sheet pile, cantilever, and anchored earth/ soil nailing mechanically stabilized earth (reinforced earth) walls and slopes. Soil nailing is one of the latest in-situ method or techniques used to improve the soil and in stabilize the slopes.

The soil nagging mechanism consists mainly of strengthening the natural soil using small bars or metal rods that are mounted in pre-drilled holes. This technique offers a broad array of applications for the stabilization of deep and steep excavations. Soil nail walls can also be used for roadway applications such as road cuts, expansion of roads under existing bridges, tunnel portals, repair and reconstruction of existing retaining structures, existing refurbishment buildings and hybrid soil nail systems. Procurement as a strategy to meet the development of the customer and operational essentials with respect to the provision of constructed facilities for a discrete life cycle. In this study traditional and design & build procurement system followed projects were used as case studies in collecting field data.

5.1.2 Dispute in ERS construction

The dispute is a simple disagreement, a consequence of rejecting a claim (Kumarasawamy, 1997). In the soil nailing construction disputes are arisen due to the failure modes such as external, internal and facing failure mode. External failure modes usually refer to the development of potential failure surfaces that pass through the soil nails or behind them. Internal failure modes simply refer to failure in the mechanisms of load transfer between the soil, nail, and grout. As the strength of the bond is mobilised, tensile forces are developed in the nail as mentioned earlier.

Bond strength and bonding stress distributions depend on the tensile strength and length of the soil - nail. Facing soil nailing in failure mode is often overlooked because in general the face does not resist the pressure of an earth. The pressure on the earth acting on the shotcrete face is small, the thickness of a nominal shotcrete and reinforcement is adequate for earth nailing works with slopes that have a relatively lower height and gentle gradient. Any failure of this kind has been suggested as a common cause for ERS disputes.

Different to the literature, even though there were no failure in ERS, there were disputes found in the case studies which are common disputes. Though this conflict is common in the construction industry, the causation is different from other construction to ERS (soil nailing projects). At the lower end factors are such as obtaining approvals, site access, negligence, and administration these factors scored lowest. The top factors are such as interpretation of the contract, EOT claims, changes in scope and quality of the design, payment, budget, time and delay

5.1.3 Dispute resolution approaches related to soil nailing construction

Methods, technologies and strategies for dealing with disputes in soil nailing projects have been taken into account to the protections, safeguards, and approaches that has been provided in the contracts and common tactical practice for dealing with project disputes. Using the correct procurement approach and correct condition of the contract really can help to improve construction contracts to help manage dispute - related issues. As this study point out, interpretation of the contract, EOT claims, changes in scope and quality of the design, payment, budget, time and delay are easily managed by the condition of contract (FIDC, ICTAD) and also with the use of the first method of ADR such as negotiation.

So all four (04) research case studies do not really repeat the assumption that there are inadequate methods, technologies and strategies for dealing with disputes in soil nailing projects. Nevertheless, what was noted here is that the standard forms of contracts apply to the resolution of certain conflicts, but if these specific provisions are contrary to the interests of both parties to the contract,but when such provisions are against the interest of both parties to the contract, the major parties use other methodologies to the resolution, which may even differ from the provisions of the contract, leading to the amendment of the contract in order to meet the interests of the parties.

Hence, in conclusion to the aim of the study which is to investigate disputes in ERS construction projects, conflict causing possible factors as well as how conflicts are managed there seem to be a number of problems and areas on which disputes arise in soil nailing projects. Among the most important areas of conflict are change of original scope, delays in payments by the client to the contractor, issuance of payment certificates by the consultants to the contractor, evaluation of the claims of the contractor, changes in design, lack of / poor communication, mistakes and errors in the project design, incompatibility here between the main contractor and subcontractors as well as assessment of claims of subcontractors. However, if there were no provisions in the contract or if the provisions of the contract were contrary to the interests of the contracting parties, negotiations were mainly used to find a satisfactory solution for the conflicting parties.

5.2 Recommendations

The following recommendations are proposed on the basis of the research findings, the real success of a soil nailing type of project obviously depends on several variables, in accordance with Diekman, et al (1994) is how the project participants approach the project's dispute. Disputes in a project can create an adverse environment, perpetrate distrust and completely undermine the cooperative real nature of project team members, so what is the importation of effective management in a construction process and resource coordination, communication and time.

This study identified a number of conflict-prone areas/issues, the different causes of conflict and how they are coped in these areas. Study also found that adequate mechanisms and tactics are available to address conflicts in soil nailing projects. But however, the project's successes are limited by the effects of conflicts as regards cost and time. As a result, it is really important to establish management strategies and management mechanisms and preventive measures of conflicts in a timely and cost-effective way if the soil nailing projects are to be successful. the causes of such disputes and management strategies mentioned in Chapter four.

Therefore, the following should be considered for effective conflict management in soil nailing projects.

1. A realistic and honest project budget and financial projection must be fully prepared in order to determine the financial commitment before the project begins. All of this will decrease the unnecessary lack of project funds.

2. Here the client really should be clear about the requirements as well as the scope of the project. This can be done through the preparation of a project brief with the help of a design team. All of this will hopefully reduce changes in the implementation phase of the project.

3. Clients should evaluate the quality performance, technical and financial performance of contractors. All of this will lead to a better understanding of the capabilities of the contractor.

4. Contracts of engagements must be clear and specific about the roles as well as the duties of each party to the contract and should provide remedies for failure to carry out the contract. All of this will minimise negligence conflicts, payment delays, and communication.

5. Contracts must provide certain economic incentives, protections and guarantees, and sureties in order to give each party trust and confidence in the contract. However, this decreases the risk of such opportunistic behaviour.

6. The design team and contractors should be selected on the basis of the ability and capacity to carry out the assignment. This can be actually achieved if the selection criteria are well established and the evaluation is carried out properly. All this will minimise disputes occurring from the bounded rationality of the design team and contractors.

7. All project participants must have mutual trust and understanding at all stages of the project. This would be accomplished anyway if relationship construction operations such as transparency and regular project meetings. All of this will generate an early stage forum for discussion and conflict resolution.

5.3 Clear and Specific Contribution to Knowledge and Experience Obtained through the Study

This study's contribution to knowledge is as follows.

I. Identifying dispute of prone issues/areas as well as their causes in Sri Lanka's soil nailing projects.

II. Analysis of such dispute management approaches that are used in Sri Lanka's soil nailing projects.

III. Recommendation for more efficient and effective dispute management in Sri Lanka's soil nailing projects.

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APPENDICES

INTERVIEW GUIDELINES

<u>Part 01: General information</u>

Please add (√) as appropriate:

1. **Case Organization**

   ☐ Contractor ☐ Consultant ☐ Others

2. **Position**

   ☐ Project Managers ☐ Project Engineers ☐ Project Quantity Surveyors

   ☐ Projects Consultant ☐ Others

3. **Years of experience in the line of work**

   ☐ From 1 to less than 5 years ☐ From 5 to less than 10 years

   ☐ From 10 to less than 15 years ☐ From 15 to 20 years

   ☐ More than 20 years

4. **Qualification**

   ☐ Chartered ☐ Masters ☐ B.Sc. ☐ Diploma

5. **Project Cost**

6. **Project Duration**

7. **Number of dispute**

Part 02:

1) Explain about ERS & Soil nailing (that particular) project?

2) What kind of applications, techniques are used in this project? And when they have used?

3) What are the failures you have faced in this project? Whether it is internal or external failures?

4) What kind of dispute you had in relation to ERS (soil nailing)?

5) How the dispute was resolved?

6) What kind of condition you have under the procurement method? And under this conditions what are the provisions available?

7) Whether this guidance available from the procurement? And whether it was good in handling disputes?

Part 03:

INTRODUCTION

The conflict has been a state of opposition, incompatibility or disagreement between people or a group of people with ideas, beliefs, feelings, interests, behavior or objectives. As well in soil nailing development projects, a number of teams of participants form a project team to carry out a project in hand. There are conflicts between different team members. Actually based on your experience in different projects in soil nailing,

The following as areas of conflict in soil nailing projects

- Errors in design
- Contractual claims
- Scope Change/ Design change
- Payment delays
- Poor or Improper communication between the parties
- Excessive variations in the contract
- Errors in project documents

CONFLICT RESOLUTION APPROACHES

A. <u>Errors in design</u>

Negotiation…………………………………………….

Mediation……………………………………………...

Expert Determination………………………………….

Dispute Resolution Boards (DRB)……………………

Arbitration…………………………………………….

Please specify any another approach you may use in the following space.

B. <u>Contractual claims</u>

Negotiation…………………………………………….

Mediation……………………………………………...

Expert Determination………………………………….

Dispute Resolution Boards (DRB)……………………

Arbitration…………………………………………….

Please specify any another approach you may use in the following space.

C. **<u>Scope Change/ Design change</u>**

Negotiation…………………………………………… ☐

Mediation……………………………………………... ☐

Expert Determination………………………………… ☐

Dispute Resolution Boards (DRB)…………………… ☐

Arbitration…………………………………………… ☐

Please specify any another approach you may use in the following space.

D. **<u>Payment Delays</u>**

Negotiation…………………………………………… ☐

Mediation……………………………………………... ☐

Expert Determination………………………………… ☐

Dispute Resolution Boards (DRB)…………………… ☐

Arbitration…………………………………………… ☐

Please specify any another approach you may use in the following space.

E. **Poor or Improper communication between the parties**

Negotiation…………………………………………. ☐

Mediation…………………………………………... ☐

Expert Determination………………………………. ☐

Dispute Resolution Boards (DRB)…………………… ☐

Arbitration…………………………………………. ☐

Please specify any another approach you may use in the following space.

F. **Excessive variations in the contract**

Negotiation…………………………………………. ☐

Mediation…………………………………………... ☐

Expert Determination………………………………. ☐

Dispute Resolution Boards (DRB)…………………… ☐

Arbitration…………………………………………. ☐

Please specify any another approach you may use in the following space.

A. **<u>Errors in project documents</u>**

Negotiation……………………………………………. ☐

Mediation……………………………………………... ☐

Expert Determination…………………………………. ☐

Dispute Resolution Boards (DRB)…………………… ☐

Arbitration……………………………………………. ☐

Please specify any another approach you may use in the following space.

B. **In the space below, you can kindly comment on the situation of conflicts in soil nailing projects.**