MINISTRY OF EDUCATION AND TRAINING

HANOI UNIVERSITY OF MINING AND GEOLOGY

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RESEARCH ON SOLUTIONS TO MINIMIZE OSH RISKS IN QUARRY MINES IN THE NORTHERN CENTRAL OF VIETNAM

SUMMARY OF TECHNICAL DOCTORATE THESIS

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The work is accomplished in Department of Surface Mining

Faculty of Mining, Hanoi University of Mining and Geology

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I. THE RATIONA

According to International Labour Organization (2019), there are about 2,78 million working accidents where the workers died in 2019, which means the number of people who died from work injuries, and occupational diseases are about 7,700 per day. Besides, about 374 million non-fatal injuries per year lead the workers to leave work long-term. In general, this is a clear depiction of the modern workplace where workers can suffer severe consequences while they are working only.

In this situation, the Vietnamese Communist Party and the government have issued several critical legal documents on occupational safety and health (OSH). They can prevail against and reduce the number of worker injuries. Significantly, they can bring benefits to workers who are working in mining and construction. Those activities must integrate safety measures. For example, it is obligatory for the mining workers to join OSH courses, engaging them in exchanging knowledge and practicing skills for the managers and employees, especially tools to identify, analyses, and assess risks and hazards. At the same time, advanced technology will apply to ensure OSH and environmental protection.

The quarrying industry brings significant benefits to society, such as jobs and mining workers' income. However, it is leading to the consequences of OSH and the environment. Therefore, the thesis "Research on solutions to minimize OSH risks in quarry mines in the Northern Central of Viet Nam" aims to solve OSH's existing problems in the quarrying industry in Vietnam, specifically in the Northern Central region. The research can help quarry mines in this area improve OSH resolutions for the safe, health, and well-being of the people.

2. THE RESEARCH OBJECTIVE(S)

This thesis's main objective is to research the solutions that can minimize the hazards and accidents in quarrying workplaces and protect our environment. The purpose is to prevent occupational accidents and diseases and propose indicators to evaluate OSH's level in quarry mines in the Northern Central of Viet Nam.

3. THE CONTENTS OF RESEARCH

The research includes five chapters:

- Analyzing and evaluating the current OSH systems of the mines on The Northern Central of Viet Nam.
- Researching and evaluating the level of hazards and risks on quarrying operations that relate to OSH.
- Studying the solutions to reduce the hazard level at the mines on The Northern Central of Viet Nam.
- Setting up the evaluation methods, managing the risks in open-cast quarry mines in the Northern Central of Viet Nam.
- Developing a set of criteria for assessing the OSH level in quarry mines.

4. RESEARCH OBJECTS AND SCOPES

- The OSH features in quarry mines, drilling, blasting, loading, transportation, and other resources such as human resource, investments, labor environment, natural disasters, fire protection, etc.

- The research is implemented in open-cast quarry mines in the Northern Central of Viet Nam.

5. RESEARCH METHODS AND APPROACHES

The author used conventional research methods of statistic method, analysis method, collective method, modeling, mathematical methods, and surveying.

6. HIGHLIGHT OUTCOMES OF THE THESIS

- The research overviewed state-of-the-art OSH in quarry mines in the Northern Central of Viet Nam.
- The research offered plausible solutions and models to minimize hazards and prevent occupational accidents and diseases in quarry mines in the Northern Central of Viet Nam.
- The research offered categories and indexes to assess the OSH situation in quarry mines and some experimental results in some of the mines.

7. FOCAL POINTS OF THE THESIS

7.1. The mining technology is the primary factor that influences the OSH on quarry mines (for construction materials).

7.2. The risk assessment is significant to improve OSH prevention and the sustainable development of quarry mines.

7.3. The establishment and quantification of impact factors to OSH in quarry mines are the fundamental criteria to assess OSH level. It is essential to legalize these criteria for OSH governance and safety audit.

8. THEORETICAL AND PRACTICAL SENSES OF THE RESEARCH

8.1. The theoretical sense: to fulfill the theory of risks assessment and OSH management in quarry mining, under the Vietnamese context.

8.2. The practical sense: the research results are fundamental to build technical guidelines to OSH management in mining, improving the OSH management capacity in Viet Nam.

9. THE THESIS STRUCTURE

In addition to Introduction, Conclusions and Recommendations, Relevant publication list, and Annex, the thesis consists of 138 pages of A4, illustrated by 29 photos and 27 charts and tables, including 4 chapters:

- **Chapter 1:** Overview of mining and occupational safety and health in quarry mines of the Northern Central of Viet Nam
- **Chapter 2:** Analysing and assessing occupational safety and health hazards and risks in quarry mines of the Northern Central of Viet Nam
- **Chapter 3:** Research on technical solutions to reduce hazards and risks in quarry mines of the Northern Central of Viet Nam
- **Chapter 4:** Establishing criteria and indexes to evaluate occupational safety and health and solutions for quarry mines of the Northern Central of Viet Nam

10. RELEVANT PUBLICATIONS LIST

During the research period, the Ph.D. student published 07 articles and scientific reports related directly to the thesis's content. Two articles are in ISI journals, one in

international scientific conference proceedings, and five papers are published in domestic journals.

CHAPTER 1

OVERVIEW OF MINING AND OCCUPATIONAL SAFETY AND HEALTH IN QUARRY MINES OF THE NORTHERN CENTRAL OF VIET NAM

1.1. Construction materials in Viet Nam and the Northern Central area: distribution, potential, and reserves

Our country has a very diverse stone resource, especially in the North, the Central, the Central Highlands. There is a lot of limestones, basalt, gabbro, granite, etc. The total resources are over 53 billion m^3 (estimated at around 44,739 billion tons), which are existed mostly in the regions of the country: the Northern Midlands and Mountains, the Red River Delta Region, the Northern Central and Central Coast, the Highland, the Southeast region, and the Mekong River Delta region.

1.2. The current status of quarry extraction, the classification of materials and demand in Viet Nam and the Northern Central region

- The current status of quarrying: there are about 2,377 stone mines and stone factories nationwide. They are all using surface mining technology, combining with processing on-site.

There are approximately 742 quarry mines in the Northern Central region, in which 460 quarries,18 cement quarries, 24 paving quarries, and 418 construction material quarries. The distribution is in various provinces, such as Nghe An (103), Thanh Hoa (232), Quang Binh (54), Ha Tinh (45), Thua Thien Hue (20), and Quang Tri (6).

- The categories to classify quarry mines are production scales, time of extraction, etc.

- The demand for materials usage: Currently, the total quarry excavation capacity on the standard building materials is about 120 million m3 per year nationwide. In addition, the national demand for construction stones in 2020 is estimated at 181 million m^3.

1.3. The state-of-art in mining technology and occupational safety and health at quarry mines

There are five mining technology options, which have been used commonly in quarry mines in the Northern Central region.

a. Vertical layers mining technology, conveyed by blasting (free stage mining)

In this mining technology, people use a hand-held hammer to drill holes and load mines into holes. After blasting, stone pieces will be scrolled down the mountainside and gather at the foot of the mountain. The advantages of this mining technology are simple and low cost. However, the disadvantages are hazardous, environmental pollution, waste, and loss of natural resources.

b. The layer mining technology, transporting by trucks

This technology is often applied to mines with a production capacity is over 100 thousand m3 per year. These mines can extend mechanization to all production processes and, consequently, expand the production capacity when the excavation reaches the layers near the foot of the mountain. The excavation is relatively safe, convenient for selective mining technology, and less destructive environment. On the

contrary, it is costly regarding investment capital, time to build mines, and production costs.

c. The mining technology by vertical layer moving

This method refers to a close relationship between the technical infrastructure parameters on the level (A, h) and the rock area at the mountain's foot. The excavation is simply operated and can be applied in rocky mountains of steep slopes. However, the usage has a disadvantage of output expansion and produces a high volume of dust.

d. The mixed mining technology

Quarry mines built in hills and mountains with a capacity of more than 500,000 m3 per year are applying this mining technology widely. The mixed mining technology supports the mechanization in all production stages, increasing excavation output at the lower part of the mountain, using selective shoveling. Consequently, production is safer and less polluted.

e. The mining system using wire saws cut in monolithic quarry mines

This system is applied in some block quarries in Yen Lam, Ha Trung in Thanh Hoa, and Quy Hop in Nghe An.

After the promulgation of the Law on OSH, the Mineral Law, and the Law on Environment Protection, illegal mineral exploitation activities, causing OSH issues and damaging the environment are gradually controlled.

Conclusion of chapter 1

1. The Northern Central of Viet Nam concentrates plenty of quarry mines, serving for construction and cement industry. The exploitation is relatively consistent with the standards and regulations on quarry mining techniques, complying with OSH and environmental protection, security, and order.

2. Quarry mines in this region have low capacity, old equipment and lack of safe structures; the mining technology is semi-mechanized or manual. In small mines, the production conditions do not ensure OSH, environmental protection, security, and social disciplines.

3. The labor management system is at a low level of skillful workers and experienced staff. The working environment is polluted, affecting seriously to the working atmosphere and the community.

CHAPTER 2

ANALYSING AND ASSESSING OCCUPATIONAL SAFETY AND HEALTH HAZARDS AND RISKS IN QUARRY MINES OF THE NORTHERN CENTRAL OF VIET NAM

2.1. Risk management

OSH management, in essence, is the management of OSH risks. OSH management is repeated in a cycle consisting of three steps: risk analysis, risk assessment and risk control.

(1) Risk analysis:

Risk analysis includes identification of workplace hazards and potential harms (injury/illness) that hazards can cause to employees such as occupational accidents, work-related diseases, and occupational diseases.

(2) Risk assessment:

Risk assessment is a process of estimating risks arising from some hazards, taking into account the effectiveness of the control measures, determining whether those risks are acceptable. The method includes risk estimation, assessment, and classification. The priority order to implement control measures is selected from the highest to the lowest level of risks, from which the risk control program will be developed.

(3) Risk control:

Risk control is implemented with the following measures: i) Prevention; ii) Protection; and iii) Minimization of damages (applied when preventive and protective measures fail, leading to occupational accidents or occupational diseases). Risk control measures are classified into: i) Technology measures; ii) Technical measures; iii) Management and administrative measures; and iv) Personal protective equipment measures.

2.2. Methods for OSH risk assessment

Quantitative method: risk determination by-product of the severity of injury/illness and probability of hazardous event/exposure occurrence. These two components are determined from the risk database of the industry.

Qualitative method: based on judgment and subjective assessment of experienced experts expressed in the form of descriptions by the level of risks, "high," "medium" or "low". This method is merely a way to simplify the determination of risk levels.

The semi-quantitative method: naturally, it is still a qualitative method, in which quantitative data on the hazard. Besides, there are flexible risk assessment methods, occupational health risk assessment methods introduced by the Viet Nam National Institute of OSH, etc.

2.3. Selection of risk assessment methods

a. Selection of risk assessment methods:

- For occupational safety hazards, an only qualitative assessment is applied. Meanwhile, there are 2 options for occupational safety and ergonomical hazards: the qualitative and semi-quantitative evaluation methods. Risk is assessed on a 7-level

scale: i) extremely high risk; ii) very high risk, iii) high risk, iv) medium risk, v) low risk, vi) very low risk; and vii) extremely low risk, which is in line with the risk rating scale for occupational health and safety dangers.

- The thesis chose and proposed quantitative assessment methods for quarry mines to study and develop assessment criteria and indicators.

b. Database of hazards

Based on survey and measurement results at ten establishments, the study has developed a database of hazards, presented in a separate report as a main output of the study.

2.4. The method, the procedure of risk assessment and the guidebook

2.4.1. The selection of risk assessment method

The OSH risk assessment method applicable to quarry mines includes: i) qualitative method for OSH hazards, and ii) a semi-quantitative method for OSH and ergonomical hazards.

2.4.2. Determining demand/need for risk assessment

The quarry mines are responsible for determining the demand/need for a risk assessment. The need for risk assessment occurs as requirements of Circular 07/2016/TT-BLDTBXH of the Ministry of Labor, Invalids and Social Affairs on risk assessment and control and other management system standard.

2.4.3. Setting up a team of assessment

The assessment team should consist of people who have been trained in assessment methods and procedures, having knowledge in technology, and experience in OSH.

2.4.4. Assessing OSH risks

The assessment team conducts a risk assessment according to approved documents. Before that step, the quarry mine has to approve its own risk assessment and control guidelines.

2.4.5. Reviewing results of OSH risk assessment

The Chief of the Safety Division and managers in charge of OSH are responsible for reviewing and verifying the assessment results to ensure that all workplaces have been properly evaluated, and then report to the executive director.

2.4.6. Determining and approving the "acceptable" risk level

The CEO is responsible for determining the "acceptable level of risk" on the basis of meeting the current legal requirements (national standards and regulations) and OSH rules of the business.

2.4.7. Classification of hazards by risk level

From the approved risk assessment results, and the "acceptable" level of risks, the head of the Division of OSH and the department heads proceed to classify the hazards by the level of risks.

Conclusion of Chapter 2

Quarrying is exposed to a very high OSH risk level. Therefore, it is critical to have exceptional attention to control hazards. A selection of a proper mining system, applying modern technology and equipment do not only improves the efficiency of quarrying, produces good quality of stones, and protect the environment but also

eliminates hazards;

- It is necessary to provide additional control measures to minimize the risks for all hazards with a higher risk level than the acceptable one;

- An OSH management system can be proposed based on the law on OSH and advanced standards, such as OSHAS 18001: 2007 and the typical organizational structure of the OSH establishments;

- It is significant to develop a process of assessing and controlling OSH risks for the quarrying facilities, and solutions to minimize risks, as well as quantifying risks.

CHAPTER 3

RESEARCH ON TECHNICAL SOLUTIONS TO REDUCE HAZARDS AND RISKS IN QUARRY MINES OF THE NORTHERN CENTRAL OF VIET NAM

3.1. The classification factors of OSH risk in quarry mines

In a quarry, while being exploited, the groups of factor at risk of OSH loss are classified broadly, as follows:

- Factors originate in the stage of project formulation, basic design and construction technique of quarry licensing
- Geological and engineering geological factors
- Factors of OSH risks originate in the development phase of the mine
- Factors of OSH risk originate in the implementation stage of regular exploitation technology

3.2. Research on risk control measures at workplaces

Main hazards in quarrying activities and risks are

(1) Landslide/movement of soil, rock, and mines due to out of control. The leading cause of landslide/rock displacement is determined to be due to the rock mass's instability at the slope, so survey the mine's geological structure, design the mine safe, ensure the extraction system's technique, and the sequence of the extraction are the prerequisites. Diamond wire cutting technology in sawn stone mining and processing facilities improves the mining efficiency and quality of the stone and eliminates several dangers since not having to preserve and transport and using explosive materials.

(2) Microclimate

The microclimate risks level is determined based on the orbital heat index, taking into account the simultaneous effects of the microclimate parameters, including temperature, humidity, wind speed, radiant heat of the sun, and the heat stress that workers suffer.

(3) Fall from a height

High risk of falling can occur to employees working at high altitudes: operating hand drills, self-propelled drilling machines, crushing and screening complexes, diamond wire cutting machines, machine/equipment maintenance, etc.

(4) Accidents caused by vehicles or equipment

Many vehicles such as trucks, forklifts, excavators, and hydraulic hammers are in jeopardy of causing accidents to themselves and those who work around them.

(5) Collision with the moving part of the machine

The collision risk with machine moving parts arises in both the slitting machine and the stone cutting machine.

(6) Noise

Most of the machines and equipment used in both quarry mining and processing areas generate noise. Thus, employees at those workplaces are heavily influenced.

(7) Vibration

Body vibration is also a risk in most machines/equipment used in quarry mining and processing.

(8) Electric shock

The electric shock risk arises mainly in the processing area, where many electric machines/equipment are installed and used.

(9) Got caught, stuck inside or between machine parts

At the position of cutting machines, grinders, miners, screen mills, machine/equipment maintenance, the employees are at risk of being entangled/dropped hair between the pulley and the belt due to the unsealed connection, or having the foot slipped between the grinding shafts of the jaw crusher.

(10) The object is spilled

Employees who operate diamond wire cutters are in danger of being thrown off by the diamond wire. Employees who work at the screen mill and drive the excavator in the screen grinding area to be thrown from the jaw clamping machine.

(11) Silicon dust

(12) Objects fall due to lifting and transport

If employees have to lift and transport machines and rocks by hand, they must be aware of the danger of objects falling.

(13) Slippery, slipping

Many obstructions and grease in the machine maintenance and repair areas can cause slippery and slipping risks.

(14) Cutting, rolling, clamping caused by tools

At the stone cutting machine's operating position, employees use crowds to trap stones, use small pieces of rock to lift large rocks, so there is a risk of pinching their fingers and hands.

3.3. Appropriate extractive methods for quarries in the Northern Central region

The technological solution should be suitable for different mines of field scope, and follow the legal regulations of Viet Nam. The classification of mines is according to B.B. Rjevski. Under Viet Nam rules, mines are classified into construction materials, exploiting, dredging, and fully exploiting river-bed

construction materials, mining solid minerals, mining and processing solid minerals containing toxic substances or using chemicals, processing solid minerals, etc.

3.4. Proposing a schematic of mining technology and suitable parameters for quarries in the Northern Central region

The preparation for deploying the appropriate technology model of extractive construction materials in small and medium mines with mountainous terrain and narrow mining-grade areas is as follow:

- Deploying the extraction sequence of areas at risk of unsafe landslide with high stability areas.
- Arranging the mining technology diagram rationally with the number of working routes, groups of mining stratum, drilling equipment, blast site size, blasting direction, stage and extraction sequence at different levels, etc.
- Deploying the layout of an appropriate and environmentally friendly excavation technology scheme with synchronized equipment.

3.5. Research on minimizing the OSH risk in using industrial explosives

The dangers, risks, and shortcomings of using industrial explosives in quarrying include two reasons: (1) Industrial explosive materials storage areas scattered would increase the complicated situation in industrial explosive materials, leading to the risk of secure in industrial explosive materials management and usage. (2) The employee's awareness of compliance with the laws of mining enterprises and observing the internal rules and regulations of safety during the working process of workers related to explosives is not high.

The causes of labor unsafety in quarries are enterprises have not really care of OSH, the management and supervision of extractive activities still have many limitations. Although many mines are not qualified for OSH, the mining area is not sufficient to apply the proper mining system but is licensed to mine. Besides, mining techniques and methods are outdated and unsafe. In additional, there is lack of safety training for workers when they work with industrial explosives, such as warnings when it comes to thunderstorms and lightning while blasting construction, etc.

Solutions to minimize the risk of OSH in usage of industrial explosives are institutional solutions, organizational and implementation solutions.

3.6. Research to minimize the risk of OSH by promoting a shared economic model in the provision of blasting and mining services to specialize and maximize resources

It is potential in the supply of industrial explosives to apply the shared economic model as this is a new activity. There should be specific regulations and policies to encourage firms such as MICCO, GAET and others to be more involved

in this economic model. The advantage is to minimize negative impacts during exploitation on the surrounding environment.

Conclusion chapter 3

1. Classifying detailing existing OSH risks mining of quarries; Typical mining technology is analyzed in advantages and disadvantages and the scope of application for small and medium quarries of the Northern Central region.

2. To exploit effectively and ensure OSH at workplaces, sustainable development, it is imperative to accurately calculate the technological parameters and determine a proper exploitation sequence.

3. Blasting service is provided in conjunction with the supply of explosives. It has been mainly deployed in mining in large-scale open-pit mines, including cement quarries, construction material stone. This service should be promoted to supply for small mines, contributing to ensuring OSH.

4. It is feasible to apply the shared economic model in the provision of blasting services and quarrying services on open-pit mines in Vietnam and the Northern Central Region.

5. Quarry mining in the Northern Central region requires a series of synchronous solutions to reduce OSH risks and protect the environment, from completing policies and laws in risk assessment and security audit to organizing the deployment of exploitation activities.

CHAPTER 4

ESTABLISHING CRITERIA AND INDEXES TO EVALUATE OCCUPATIONAL SAFETY AND HEALTH AND SOLUTIONS FOR QUARRY MINES OF THE NORTHERN CENTRAL OF VIET NAM

4.1. Theoretical and practical basis for the application of occupational safety and health criteria in quarry mining in Northern Central Viet Nam

Theoretical basis: The Law of Occupational Safety and Health regulated the risk control system at work. Using these criteria for the evaluation has become more prevalent in administration, production, business, environmental protection, security, human health, etc. From the Prime Minister's Directive No. 29/CT-TW on "Promoting the occupational safety and health in the era of industrialization, modernization, and international integration," OSH criteria and standards in organizations were released.

The application of OSH criteria in quarry mines in the Northern Central of Viet Nam: Several companies have set a decisive safety goal such as "no occupational accidents", thereby building the criteria and standards on numbers of "safe working hours" and "safe working days". Since the promulgation of Decree No. 58/2020/ND-CP, organizations also comply with the OSH legislation, decreasing the labor accidents as a basis for reducing the payment for occupational safety and health insurance.

4.2. Researching and establishing the criteria and indexes to evaluate OSH in quarry mines in the Northern Central of Viet Nam

Based on various impact factors to OSH level, such as mining technology, explosive materials, machine and equiptment system, management level, labor skills, type of minerals, each mineral activity project has different evaluated criteria.

Five groups of criteria are proposed as follows:

(I) Technology: (1) Mining technology system; (2) Drilling, preparing soil and rock; (3) Explosive and blasting materials; (4) Loading; (5) Transport; and (6) Application of digital technology and modernity of equipment. ***(II) Human resource***: (7) Managers force; (8) Labor force. ***(III) OSH management system***: (9) Safety management system; (10) Propaganda, education, rewards, and compensation; (11) Risk assessment; (12) Employee health care and welfare; and (13) OSH process, rules, and self-inspection**.** ***(IV) Environment - Fire prevention and rescue:*** (14) Working environment; (15) Fire protection and rescue; (16) Natural disaster prevention; (17) Ensure security, order, and community consensus. ***(V) Management and Resources***: (18) Matching with the Development Plan; (19) Investment resources; and (20) Maximize resources.

4.3. Safety evaluation by criteria scores

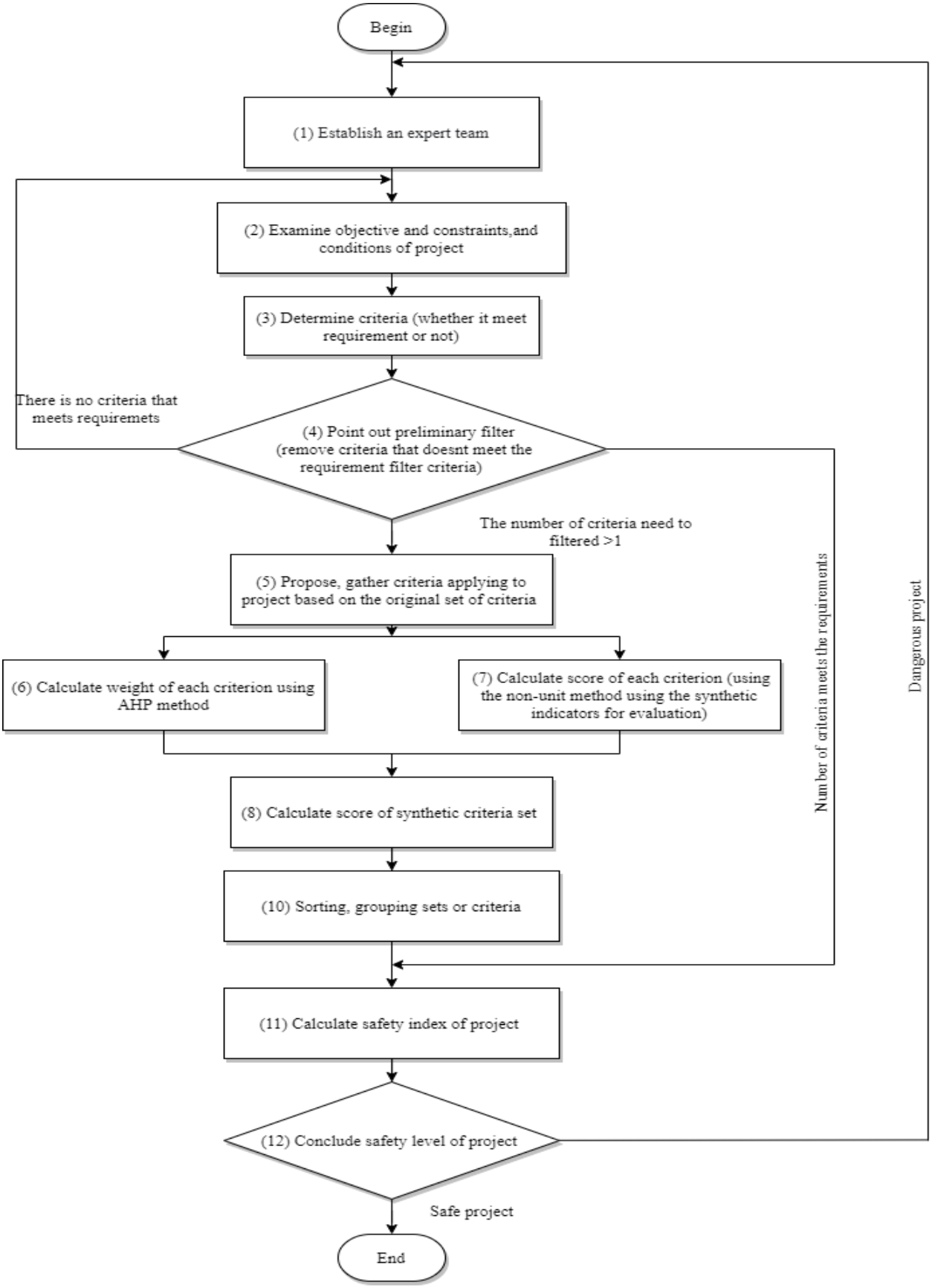
There are five levels of scores, which are (1) very high possibility of risks, (2) high possibility of risks, (3) consider of risks, (4) low case of hazards, and (5) safe. The scoring of risks and safety levels is conducted based on each criterion that the quarry project has achieved.

To assign a weight to the criteria for assessing the level of occupational safety and health, the AHP (Analytic Hierarchy Process) method is applied in combination with the non-unit way of using synthetic indicators.

AHP is one of the multi-objective decision-making methods proposed by Thomas L. Saaty - an Iraqi mathematician, in 1980. AHP is a quantitative method used to organize schemes, decide and choose an option that satisfies the given criteria.

The non-unit measurement method of aggregated criteria allows all indicators with different measurement units to be merged into one aggregated index and ranked plans for selection. If it is an expert opinion, it will be assessed through the score, including assessing the importance of the projects.

The process of applying the AHP method in combination with the non-unit method using the synthetic indicators for evaluation is describe in the following chart.


Begin
(1) Establish an expert team
(2) Examine objective and constraints,and conditions of project
(3) Determine criteria (whether it meet requirement or not)
There is no criteria that meets requiremets
(4) Point out preliminary filter (remove criteria that doesnt meet the requirement filter criteria)
The number of criteria need to filtered >1
(5) Propose, gather criteria applying to project based on the original set of criteria
(6) Calculate weight of each criterion using AHP method
(7) Calculate score of each criterion (using the non-unit method using the synthetic indicators for evaluation)
(8) Calculate score of synthetic criteria set
(10) Sorting, grouping sets or criteria
Number of criteria meets the requirements
Dangerous project
(11) Calculate safety index of project
(12) Conclude safety level of project
Safe project
End

The safety index of a quarry mining project "Ia" is the sum of the impacts on the safety level of the mining project by the magnitude of the impact and the safety level of the target's impact (i.e total safety assurance level of the project according to the strong impact and the safety assurance level of the factor to the object). It is determined by the formula:

$$Ia = \Sigma T_i \beta_i; \quad (i = 1, 2, 3)$$

Where: Ti is the value of safety of the "i" group with corresponding weight βi;

$$T_1 = A_1 + A_2 + A_3 + A_8 + A_9 + A_{11} + A_{20}$$
$$T_2 = A_4 + A_5 + A_6 + A_7 + A_{14} + A_{15} + A_{16} + A_{19}$$
$$T_2 = A_{10} + A_{12} + A_{13} + A_{17} + A_{18}$$

The mineral activities projects are classified according to the safety index:
Ia $= \Sigma T_i \beta_i < 60$: Safety level is very low, unacceptable;
Ia $= \Sigma T_i \beta_i = (61 \div 120)$: There is a high risk of unsafety that requires an immediate remedy;
Ia $= \Sigma T_i \beta_i = (121 \div 180)$: There is a moderate risk of loss of safety. Need to keep tracking;
Ia $= \Sigma T_i \beta_i = (181 \div 240)$: There is a low risk of unsafety. Need to keep tracking;
$300 \geq$ Ia $= \Sigma T_i \beta_i > 240$: Ensure safety;

With the above classification method, the safety index was evaluated for three quarries of Truong Son - M1 (Thieu Hoa, Thanh Hoa), Long Son - M2 (Bim Son, Thanh Hoa), and Hoang Mai - Nghi Son Cement Factory - M3 (Nghe An). The results are shown as follows:

Synthesize criteria and pollution index of mines

Mines	Score of targets																				Safety index			
	A 1	**A 2**	**A 3**	**A 4**	**A 5**	**A 6**	**A 7**	**A 8**	**A 9**	**A 10**	**A 11**	**A 12**	**A 13**	**A 14**	**A 15**	**A 16**	**A 17**	**A 18**	**A 19**	**A 20**	**T_1**	**T_2**	**T_3**	**I_a**
Truong Son (M_1)	1	2	3	1	1	1	1	2	4	4	1	3	2	2	3	4	3	*3*	2	1	16	15	15	**93**
Long Son (M_2)	5	5	4	5	5	4	5	5	5	5	3	4	5	3	5	4	5	5	3	5	32	34	24	**188**
Hoang Mai (M_3)	5	5	*5*	5	5	4	5	5	5	5	3	5	5	5	5	4	4	5	4	4	32	37	24	**194**

The results show that the Truong Son, Long Son, and Hoang Mai quarries have safety index "Ia" of 93, 188, and 194, respectively, which means the Long Son and Hoang Mai quarries are relatively safe. Still, Truong Son mine has a high level of insecurity, requiring special attention.

4.4. Application guidelines for the indicators

In the assessment of the OSH level in quarry mines, information is the prerequisite. Besides, other requirements are the capacity or methodology to identify and assess hazards, the engagement of multidisciplinary experts with the capacity to identify OSH risk preliminarily, and other working environment factors. However, there are some obstacles in *applying the criteria under the Vietnamese context.*

The overall risk assessment approach in Vietnam has not fully considered the quantification method. There is also a shortage of training programs to assess OSH risks, ready-to-use criteria, or data set of OSH incidents and accidents. It is also needed to improve and upgrade the current guidelines of MOLISA.

Conclusion chapter 4

1. Issuing OSH criteria and standards in organizations is a requirement of Directive No. 29-CT / TW and the Law on OSH.

2. OSH management in quarrying should have appropriate criteria for determining the OSH level in mining activities. The OSH criteria include 20 indexes related to technology, management system, human resources, resources, and other relevant indexes such as environment, fire prevention and rescue, etc. The criteria are highly predictable to help enterprises have timely measures and plan to overcome and eliminate risks and improve labor registration.

3. The State agency of OSH management can use this set of criteria to evaluate the OSH level, improving OSH's state management's efficiency, having fundamentals to implement flexible regulations on payment OSH insurance.

CONCLUSION

1. The Northern Central of Vietnam occupies a large reserves of quarry for construction materials and cement industry, taking to account of 50% licensed mines nationwide. Most of the mines in the region are small and medium sized, using semi-mechanized or artisanal mining technolgy, out-of-date machines, and equipment.

2. Consequently, productivity in the region is relatively low. The production is somewhat risky, causing possibilities of risks, less security, environmental pollution, loss of natural resources, and the social acceptance to operate.

3. Mining activity is the most OSH risk in quarry mines. Therefore, it is critical to control the hazards and dangers of this activity.

4. Quarry mining in the Northern Central of Vietnam requires a series of adequate solutions to reduce OSH risks and environmental protection, from the policy improvement in assessment and audit of safety to the deployment of implementation of mining, complying strictly with the legislations for sustainable development.

5. The dissertation offered reasonable criteria to assess OSH level in quarry mining, including 20 indexes from theoretical and practical fundamentals, matching with the context of quarry mines in the Northern Central region.

RECOMMENDATION

1. Ministries, industries, and provinces must improve the inspection to implement national regulation in minerals, OSH, and environmental protection in quarry mines. Besides, it is also essential to increase broadcasting activities and provide knowledge for OSH's labor force and ecological preservation.

2. Increasing training to OSH managers in assessment and solutions to OSH enhancement for better national OSH system capacity.

3. Motivating companies to expand their blasting service in quarry mines. Relevant Ministries, industries, and provinces provide necessary policies and regulations to support blasting and explosive materials under the shared economic model.

4. MOLISA composes a national program to promote OSH evaluation criteria to individual industries to issue legislative documents, recommending to the government in OSH governance and audit, adjusting the flexible scheme to payment of OSH insurance./.

LIST OF PUBLICATIONS

1. **Nguyễn Anh Thơ,** (2018) *"The state-of-the-art in occupational safety and health in Viet Nam in the context of the industrial revolution 4.0"*. The 5th international conference and the 9th national conference on Occupational safety and health and environment

2. **Nguyễn Anh Thơ**, Nguyễn Ngọc Bích (2020), *"Health and occupational safety in minerals excavation: the overview and recommendations"*. Pgs 135-141, Journal of Mining and Earth Sciences, No. 61, Vol. 5.

3. Nhữ Văn Bách, Trần Đình Bão, Phạm Văn Hòa, Nguyễn Đình An, **Nguyễn Anh Thơ**, (2020), *"Identification of appropriate scale of blasting in the construction of the spillway dam of Ho Nui Mot, Binh Dinh Province"*. Pgs. 119-124, Journal of Mining and Earth Sciences, No. 61, Vol. 5.

4. **Nguyễn Anh Thơ**, (2020), *"The current status in establishing the criteria to assess occupational safety and health in organizations"*. Pgs 12-13, Journal of Occupational safety and health, No. 5/2020.

5. **Nguyễn Anh Thơ**, (2020), *"Establishment of criteria for assessment occupational safety and health in companies: an active solution in prevention of occupational incidents and diseases"*. Journal of Labor – Society, No. 629, August 2020.

6. **Nguyễn Anh Thơ**, (2020), *"Promoting ideoligical values of President Ho Chi Minh in secure the labor safety in the context of the industrial revolution 4.0 and international integration"*. Journal of Labor – Society, No. 633, October 2020.

7. **Nguyễn Anh Thơ,** (2020), *"Research on blasting service and excavation model in Long Son quarry mine, Thanh Hoa – Some recommendations for the Northern Central region"*. Journal of Mining Industry, No. 5/2020.